MAGNITUDE OF ACOUSTIC REFLEX AND AMPLITUDE OF BRAIN STEM EVOKED RESPONSE

Register No. 8506

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Independent Project submitted as part fulfilment for First year M.Sc. (Speech and Hearing) to the University of Mysore.

All India Institute of Speech & Hearing
MYSORE- 570006.

MAY—1986

IN THE PROFOUND MEMORY OF

"JYOTI"

(MY YOUNGER BROTHER)

CERTIFICATE

This is to certify that the Independent Project entitled: MAGNITUDE OF ACOUSTIC REFLEX AND AMPLITUDE OF BRAIN STEM EVOKED RESPONSE, is the bonafide work, done in part fulfilment for First Year M.Sc, (Speech and Hearing) of the student with Register No.8506.

Dr.M.Nithya Seelan
Director
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CERTIFICATE

This is to certify that the Independent Project entitled "Magnitude of Acoustic Reflex and Amplitude of Brain Steam Evoked Response", has been prepared under my supervision and guidance.

Guide
Dr.M.N.Vyasamurthy
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Mysore - 570 006.

DECLARATION

I hereby declare that this independent project entitled MAGNITUDE OF ACOUSTIC REFLEX AND AMPLITUDE OF BRAIN STEM EVOKED RESPONSES, is the result of my own study under the guidance of Dr.M.N.VYASAMURTHY, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore   Register No.8506

Dated April 1986.

ACKNOWLEDGEMENT

I am extremely grateful to Dr.M.N.Vyasamurthy, Department of Audiology, All India Institute of Speech and Hearing, Mysore for the valuable guidance rendered by him at each and every step of this project. My sense of immeasurable indebtedness, in every page of this project to Dr.Vyasamurthy cannot be adequately expressed.

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INTRODUCTION

Relationship between acoustic reflex and loudness has been investigated by many investigators. Jepsen, 1963; Dallos, 1964; Jerger, et al., 1972; Peterson and Liden, 1972; Beedle and Harform, 1973; Margolis and Popelka, 1975; Kaplan, et al., 1977; Margolis and Fox,1977; Vyasamurthy and Satyan, 1977; Wilson and McBride, 1978) have shown that in normal hearing subjects, the threshold of the Acoustic reflex for pure tones occur at levels of 70-90dB HL (ISO, 1964). Also many investigators (Matz, 1952; Evetsen et al., 1958, Jepsen, 1963; Liden, 1969, 1970; Djupestand and Flottorp, 1970; Jerger, et al., 1972; Siminski, et al., 1977; Popelka, 1978; Rangasayee 1975 have reported that mild to moderate hearing loss of cochlear origin exhibit reflex thresholds for pure tones at 70 dB HL (ISO, 1964). Thus, this reflex occuring at reduced sensation levels in mild to moderate sensorineural hearing loss (cochlear pathology) is due to the abnormal growth of loudness that the patients demonstrate as the sensation level of a pure tone is increased. Measurement of threshold of acoustic reflex has been referred as the "Metz test of loudness recruitment (Ewertsen et al., 1958) and elicitation of acoustic reflex activity at reduced sensation levels has teen interpreted as an objective measure of recruitment of loudness" (Gorga et al., 1980).

In addition to the above observation there are studies (Anderson et al., 1969; 1970a, b; Cartwright and Lilly, 1979; Olsen et al., 1975; Jerger, 1974; Sheehy, 1977) which show that the patients with confirmed retrocochlear pathology exhibit 50% reflex decay at suprathreshold levels.

Block and Wiley (1979) examined acoustic reflex growth functions and loudness balance judgements for 3 normal hearing subjects with normal middle ear function. The hypothesis that acoustic reflex activating signals producing propositionally equal acoustic impedance changes are judged equal in loudness, was evaluated. The mean acoustic impedance and associated standard deviations were computed for the baseline (Static) and activator (reflex) portions of each reflex event. An acoustic impedance change exceeding and standard deviation of base line was defined as the criterion acoustic reflex response.

Ross (1967, 1968a, 1968b); tentatively propose the following conception of some of the mechanisms involved in the acoustic reflex and equal loudness judgement. The integrated number of neural impulses is directly proportional to the activation of the acoustic reflex and the integrated number of neural impulses is also directly related to the loudness associated with the stimulation, in such a way that two sinosoiadal stimulations are judged to be of the same loudness when they both produce the same integrated number of neural impulses. Gorga et al., (1980) studied the effect of activating signal band width upon the threshold of acoustic reflex in normal hearing subjects and measured the loudness for the same signals at same intensity levels. Based on the results of their experiment they suggested that signals at acoustic reflex threshold may be equally loud for listeners with normal hearing.

However some studies (Gorga et al., 1980} Vyasamurthy, 1982) show that there is no one-to-one relationship between acoustic reflex and loudness.

Although there may not be a one to one relationship between acoustic reflex and loudness, it is clear from the many studies that there does exist some relationship between acoustic reflex and loudness.

Many studies show that there are individual differences in the intensity amplitude function of the acoustic reflex. Stated differently, the growth of reflex with increase in intensity of sound varies from individual to individual.

It is now known whether the subjects show any similarities between the intensity amplitude function of acoustic reflex and intensity amplitude function of brain stem response.

The present study has been designed to find answers to the following questions:

1) Is there any correlation between the increase in the magnitude of reflex at 500Hz and the increase in the amplitude of III and V peaks (2KHz and 4KHz log on stimulus) of B.S.E.R.

2) Is there any correlation between the increase in the magnitude of reflex at lOOOHz and the increase in the amplitude of III and V peaks (2000Hz and 4000Hz log on stimulus) of B.S.E.R.

3) Is there any correlation between the increase in the magnitude of reflex at 2000Hz and the increase in the amplitude of III and V peaks (2000Hz and 4000Hz log en stimulus) of B.S.E.R.

4) Is there any correlation between the increase in the magnitude of reflex at 4000Hz and the increase in the amplitude of III and V peaks (2000Hz and 4000Hz log on stimulus) of B.S.E.R.

5) Is there any correlation between the increase in the magnitude of reflex (Mean of magnitude change at 500Hz, ICOOHz, 2000Hz and 4000Hz) and the increase in the amplitude of (Mean of amplitude change at 2000Hz and 4000Hz log on stimulus).

REVIEW OF LITERATURE

Brief review of literature about (1) BSER. (2) Acoustic reflex; and its relation to loudness.

1) Brain Stem Evoked Response:

Auditory brain-stem response technique has emerged as a vital adjunct to the clinical armamentarium of the Audiologist Otologists and Neurologists, who jointly determine hearing sensitivity, lesion site and central nervous system integrity, Pathology and maturation (Moore, 1983).

Brain Stem Evoked Responses:- According to Buchwald (1983):

1) BSER reflects graded post synaptic potentials rather than all-or-none action potentials discharged at the cell some or transmitted along the axonal projection.

2) BSER latency and amplitude measures reflect different physiologic processes which may interact.

3) BSER waves reflect functionally separable substrate system.

Brain-stem Auditory Nuclei:

Dobie (1980) reports, the "relay stations" between auditory nerve and cerebral cortex are, in ascending order.

1. Cochlear
2. Superior Olivary Complex

3) Nuclei of the lateral laminiscus

4) Inferior Colliculus; and

5) Medial geniculate body.

Each of these is actually a group of nuclei with complex structure and function. Within these neuclei, auditory information is analyzed and passed to motor neuclei where commands are issued that activate acoustic reflexes. In addition, binaural interaction occurs at all levels beyond the cochlear neuclei. Animals surgically deprived of auditory cortex can still perform relatively complex auditory discrimination tasks (Neff 1961).

BSER GENERATION:

Based on data from several species, there is general agreement that the:

1) First vertex positive potentials in the BSER sequence is produced by acoustic nerve activity (Cat, Jewett (1970), Hashimoto, Ishiyami and Yoshimoto (1981).

2) Data from a variety of different experiments consistently indicate that the cochlear neucleus contributes to and is essential for BSER wave-II (Buchwald, Huang, 1975).

3) In view of the direct and indirect links between MSO field potentials and wave-III, the principal substrate for Wave-III

generation is hypothesized as dendritic post-synaptic potentials of the MSO (Buchwald, 1983).

4) Wave-IV generation is postulated as PSP activity within the lateral leminiscus cell population (Buchwald, 1983).
5) Wave-V Result of lesion studies suggest that the deep ventrocochlear portion of the IC is particularly important for wave-V generation (Buchwald, 1983).
6) Wave-VI arises from medial geniculate body. It is consistently ranked hardest to recognize the BSER in a normal population, it is so irregularly present and variable in waveform that its clinical usefulness has been questioned (Chiappa, Gladstone, and Young, 1979).
7) Wave-VII arises from auditory radiations (Thalamocortical) and is also irregularly present.

Factors that can bring about is variation in normal response parameters are:

1) <u>Procedure effects:</u>
    a) Position of electrodes
    b) The use of filters (Bandwidth)
    c) Choice of response reference points for the computation of latency.
    d) Difference in stimulus transducer.
    e) Effect of masking and/or ambient noise levels.

2) <u>Subject Effects:</u>

a) State of the subject (awake, asleep, sedated or anasthetized).

b) Effect of temperature

c) Sex differences

d) Effect of change in muscle tone and attention

e) Effect of age.

3) <u>Stimulus Parameters:</u>

a) Derived response

b) Intensity

c) Rate of stimulus presentation

d) Stimulus transduction

e) Polarity

f) Binaural interaction

g) Tone-onset response

h) Frequency - following response

i) Threshold

According to Buchwald (1983) there is general agreement among investigators of both human and animal BSER upon the following points:-

1. The BSER are a series of volume-conducted neural potentials recordable from the scalp which originate from the primary auditory pathways of the brain stem (upto, and possibly including the inferior colliculus).

2) The BSER show (positive) peaks and (negative) troughs when the scalp electrode registers positivity against a second nocephalic or cephalic reference electrode.

3) The peaks and troughs occur with latencies of less than 10msec. following an intense auditory stimulus.

4)The intervals between positive peaks are approximately 1msec.

5) Peak latencies for any given subject are unchanging over successive trial blocks or recording sessions; and

6) BSER latencies and amplitudes are little affected by changes in arousal level or by sleep.

Effects of intensity on brain stem evoked response:

Stimulus intensity is related to the spatial configuration of neural aggregates and the number of active neural elements present. In other words, the intensity of a stimulus influences the frequency of neural firing, and the number of neural elements capable of firing. These relations can be represented in the BSER waveform as a function of different intensity levels. (Moore, 1983).

A distinct series of waves is accordingly labeled (for 4000Hz only) Each 10 dB decrease in the intensity of the stimuli shows a corresponding increase in the latency of each wave. Similar functions were generated by other frequencies also.

The salient feature of this illustration is that all five waves decrease in latency as a function of increasing intensity or conversely that there is an increase in latency as the intensity of the stimuli is decreased. This is seen over the entire range of intensities investigated and suggests an approximately linear relation to the logarithm of the stimulus intensity. In certain defenite regions, the increase in the variability measures (vertical bars) as intensity is decreased, and that the variability score also increases when comparing wave-I to wave-V. Further intensity decreases will increase the amount of the variability score and make it extremely difficult to identify wave components from the variations in background noise. The robustness of wave-V causes it to remain long after the other waves have receded (Moore, 1983).

INTENSITY:

Latency Effects:

When click intensity is reduced from 70 to 30 dB SL in adults, the magnitude of the latency shift is greatest in Wave-I and least in Wave-V. The largest shift usually appears between 50 and 40 dBSL where amplitude dominance is transferred from the first to the second major peaks of the VIIIth nerve action potential (AP), causing a sudden jump in latency (Eggermont and Odenthal, 1974a). This jump is not paralleled by the shift in wave-V. An abrupt decrease in the I-V IPL occurs at this paint.

Smaller but significant decreases are also Been in IPLs involving wave-1 between 70 and 60 dBSL (I-III, P 0.02), 60 and 50 dBSL (I-III, P 0.02, I-V, P 0.001), and 40 and 30 dBSL (I-V, P 0.01). Significant IPL alterations are also seen in newborns. These small, progressive decrease probably reflect, in part, the greater effects of travelling wave delay on wave-I than on later components, which appear to have contributions from a more extensive length of the cochlear partition than wave-1. (Terkildsen, Osterhammel,and Huisint Veld 1975a, 1975b). Non-linear shifts for the major components are seen in response to 10 decibel changes in stimulus intensity from 70 to 30 dB SL in adults).

It is noteworthy that the 0.28msec. (Sd 0.07) latency shift in wave-V/lOdB intensity change found in adults in this study, although in agreement with Pratt and Sohmer (1976) is well below the 0.4msec cited by Galambos and Hecox (1978). These authors state that a latency - intensity slope of less than 30msec/dB "Virtually ensures" a high frequency hearing deficit. Shallow wave-V latency - intensity function was also found in an audiometrically and neurologically normal subject. The discrepancy is probably mainly due to the lower intensity range (10 to 60 dBSL) used by these authors (Hecox and Galambos, 1974).

The conclusion to be drawn from this are that, when latency - intensity norms are applied, they must be specific for the intensity range tested and the portion of that range under consideration. Non-linearity of latency - intensity functions makes "slope" above an unreliable measure.

the intensity related shortening of interpeak latency cannot be duplicated by effective lowering of click intensity with the introduction of white noise masking, presented ipsi-lateral to click stimulation when the masking noise and broad band clicks are presented through the TDH-39 earphone, wave-I latency is unaltered; later components are prolonged, causing an increase in the IPLs involving wave-I. The resistance of Wave-I latency to ipsilateral masking noise in this experiment is consistent with the findings of Kiang, Watanable, and Thomas, et al (1965) in single-fibre auditory nerve recordings.

Amplitude Effects:

The amplitude of the IV-V complex is also less affected by stimulus intensity then are earlier components (Terkildsen, Csterhammel, and Huisin't Veld, 1973; Pratt and Sohmer, 1976). The change in mean amplitude from 0.49 V at 70 dB SL to 0.28 V at 30 dBSL in adults represents an average 41% reduction in amplitude over the 40 dB range. Wave-I amplitude over the same range is reduced by 81%. The most abrupt change in amplitude is seen between 60 and 70 dB, where wave-I doubles in amplitude in both newborns and adults. In many individuals, wave-I amplitude is lower at the "transitional" intensity (usually 45-55 dBSL) than at 30 dBSL (Moore, 1983).

Suzuki, T., Kcbayashi, K., Hirabayashi, M., measured spectral components of ABR as a function of stimulus intensity and stimulus interval in normal hearing subjects. At higher stimulus intensities, three peaks were observed at 0-100, 600 and 900Hz in the spectrum, of which the most prominent peak was around 1OOHz. With decrease of stimulus intensity, the power of all spectral components was regularly diminished. The power of low frequency spectral components upto 500Hz was kept unchanged with various stimulus intervals from 125ms to 11ms, while the power of higher frequency components tended to decrease with deceasing stimulus intervals.

2. Loudness And Acoustic Reflex:

Many investigators (Jepsen, 1963; Dallos, 1964; Jerger, et al., 1972; Peterson and Liden 1972; Beedle and Harform, 1973; Margolis and Popelka, 1975; Kaplan et al., 1977, Margolis and Fox, 1977; Vyasamurthy and Satyan, 1977; Wilson and McBride, 1978) have shown that in normal hearing subjects, the threshold of the Acoustic Reflex for pure tones occur at levels of 70-90 dB HL (ISO, 1964). Also many investigators (Metz, 1952; Evetsen et al., 1958; Jepsen, 1963; Liden, 1969, 1970; Djupestand and Flottorp, 1970; Jerger et al., 1972; sirr.inski, et al., 1977;

Popelka, 1978? Rangasayee, 1975) have reported that mild to moderate hearing loss of cochlea origin exhibit reflex thresholds for pure tones at 70.19 dB HL (ISO, 1964). Thus, This reflex occuring at reduced sensation levels in mild to moderate sensorineural hearing loss (cochlear pathology) is due to the abnormal growth of loudness that the patients demonstrate as the sensation level of a pure tone is increased. Measurement of threshold of acoustic reflex has been referred as the "Metz test of loudness recruitment" (Ewertsen et al., 1958) and elicitation of acoustic reflex activity at reduced sensation levels has been interpreted as an objective measure of recruitment of loudness" (Gorga et al., 1980).

In addition to the above observation there are studies (Anderson et al., 1969, 1970 a, b; Cartwright and Lilly, 1979; Olsen et al., 1975; Jerger, 1974; Sheehy, 1977) which show that the patients with confirmed retrocochlear pathology exhibit 50% reflex decay at suprathreshold levels.

Further many investigators (McCandles 1975; Tonnison, 1975; Snow and McCandles, 1976; Rapport and Tait, 1976; McLead and Greenberg, 1977; Woodford and Holmes, 1977) have used the acoustic middle ear muscle responses to estimate loudness discomfort level.

Block and Wiley (1979) examined acoustic reflex growth functions and loudness balance judgements for 3 normal hearing subjects with normal middle ear function. The hypothesis that acoustic reflex activating signals producing proportionally equal acoustic impedance changes are judged equal in loudness, was evaluated. The mean acoustic impedance and associated standard deviations were computed for the baseline (Static) and activator (reflex) portions of each reflex event. An acoustic impedance change exceeding 2 standard deviating of baseline was defined as the criterion acoustic reflex response.

Ross (1967, 68a, 68b); tentatively propose the following conceptions of some of the mechanisms involved in the acoustic reflex and equal loudness judgement.

The number of neural impulses generated in response to each cycle of a sinusoidal stimulation is directly proportional to the volume velocity of the cochlesr fluid and, possibly, to the maximum displacement amplitude of thebasilar membrane, at medium and high stimulating levels. For frequencies below about 300cps, each nerve fiber at the levels in question - responds to synchronously to each individual cycle of the sinusoidal stimulation; at higher frequencies, the response rate of each nerve fiber varies between its maximum rate i.e. about 300 impulses/sec, and half this value, depending on the ratio between the stimulating frequency and the maximum response rate. The total number of neural impulses generated in all affected fibers in response to a sinusoidal stimulation is summated (integrated) over a time interval in the order of 200msec. This integrated number of neural impulses is directly related to the activation of the acoustic reflex in such a way that the reflex is activated to the same degree by two sinusoidal stimulations that produce the same integrated number of neural impulses. For some subjects, the integrated number of neural impulses is also directly related to the loudness associated with the stimulation, in such a way that two sinusoidal stimulations are judged to be of the same loudness when they both produce the same integrated number of neural impulses. For other subjects, characterized by seemingly, "abnormal" equal loudness contours, this relation does not appear to hold.

Gorga et al (1980) studied the effect of activating signal band width upon the threshold of acoustic reflex in normal hearing subjects. Loudness measurements were made for the same signals at the same intensity levels that were required to elicit an acoustic reflex response. Based on the results of their experiment they suggested that signals at acoustic reflex thresholds may be equally loud for listeners with normal hearing.

Robert W. Keith (1978) studied the loudness and acoustic reflex in normal listeners and reported; the acoustic reflex to speech in the sound field was approximately 4 dB lower than were results of similar testing done with earphones (McCandless and Miller, 1972; Olson and Hipskind, 1973). It seems that it is possible to obtain consistent acoustic reflex data to speech even though speech is quite variable in its instantaneous sound pressure.

Results of loudness testing indicate an MCL of approximately 63 dB SPL with earphones. Kopra and Blosser (1968) also report an MCL of 62.9 dB SPL for connected speech dB course presented monaurally through an earphone to normal hearing subjects. The averaged sound field MCL of 69.6 dB SPL corresponds to the orthotelephonic reference level of 70 dB SPL (Pollack, 1948). This finding tends to support the clinical use of 70 dB SPL sound field speech as representing speech at an appropriate average level, sound field thresholds for pure tones are usually considered to occur at 6 dB lower intensity than do earphone thresholds (Sivian and White, 1933). Spondee thresholds has been reported at approximately 7.5 dB lower intensity in the sound field than under earphones (Tillman, et al 1966) and LDL for pulsed white noise has been reported at 8.6 dB lower SPL in the sound field compared to ear phones (Morgan and Dirks, 1974).

The MCL increased from 70 dB to 76 dB SPL when 55 dB of noise was introduced. Even though 100% discrimination of speech occurs at less favourable signal to noise ratios (Keith and Talis 1984), normal hearing listeners appear to prefer a more favourable signal - to - noise ratio for most comfortable loudness , in this case +21 dB. Because in noise the intensity of speech required for MCL increased whereas the AR threshold remained essentially the same, there does not seem to be an absolute relationship held between MCL for speech and the Acoustic Reflex Threshold, a finding that is consistent with statement made by Margolis and Popelka (1975). Nevertheless, in normal hearing persons there does scope to be an orderly relationship between loudness and the acoustic reflex, with the acoustic reflex threshold occuring at approximately equal intensities between the MCL and LDL measured in quiet.

Although the above mentioned studies clearly point out that the loudness and acoustic reflex are closely related there are also studies that point out that the acoustic reflex may not depend exclusively on the perception of loudness.

Margolis and Popelka (1975) tested the hypothesis that loudness is constant at acoustic reflex threshold. Acoustic reflex thresholds of 5 normal subjects was determined for octave frequencies from 250 to 4000Hz for a narrow band noise (BW=50Hz) centered at 500Hz and for a wide band noise. Acoustic reflex threshold was determined and the loudness of the reflex threshold stimulus was measured utilizing a monaural loudness balance procedure employing a lOOOHz comparison tone and a method of constant stimuli.

Results indicated that for the activating stimuli used in that experiment, loudness at acoustic reflex threshold varied over a 17 dB range. They have concluded that "the acoustic reflex is not dependent on some critical loudness of the activating stimulus and loudness may not be the key determinant of reflex activity.

Gorga et al (1980) investigated un acoustic reflex under binaural stimulation. They measured the magnitude of the acoustic reflex as a function of interaural phase for a 550Hz tonal activating signal. The level of this signatures varied over a range of + 10 dB relative to its acoustic reflex threshold and was always presented in a background of noise. They found that there was no difference in the magnitude of the acoustic-reflex response between homophasic and antiphasic conditions eventhough the antiphasic condition was judged louder (or more easily detectable). Thus the above result raised some doubts regarding one-to-one relationship between loudness and acoustic reflex.

METHODOLOGY

I. SUBJECTS:

8 normal hearing subjects from the student population of All India Institute of Speech and Hearing, Mysore-6, in the age range of 17 to 23 years were selected on random basis. All the subjects had normal hearing (<20 dBHTL ANSI, 1969). The subjects were selected on the following criteria:

1. They should not have had any history of ear discharge, tinnitus, giddiness, earache or any other otological complaints.
2. They should be able to relax and feel comfortable with electrodes on, within 10-15 minutes after their placement.
3. They should not have had any history of epilepsy or other neurological complaints.
4. Their electrophysiological input should come below 500 micro-volts within 10-15 minutes after eleccrode placement.

II. EQUIPMENT:

The following instruments were used in the study.

1. Electric Response Audiometry, Model TA-1000.

Brief description of the Instrument:

The TA-1000 system consists of the SLZ-9793, desk top console, the SLZ 9794 preamplifier and an accessory group.

The SLZ-9793 console contains all of the operating controls, indicators and read-outs for the system. It provides the patients an auditory stimulus and accepts patients electrical response from the preamplifier signal conditioning and digital averaging extract the patients BSER responses from the background noise. Oscillographic display and link-on-paper recording provides an ongoing monitor as well as permanent record of responses.

The SLZ 9794 preamplifier is an isolated EEC preamplifier with frequency response and gain specifically designed for ERA. Patients electrical response is sensed by a set of three electrodes and after amplification, is conducted to the console by an interconnecting cable.

Accessory group used was:-

1. A binaural air conduction headset with cord set.
2. Interconnecting cables, chart paper and pens.
3. Sets of electrodes, electrolyte gelly and electrode adhesive pad was substituted by Johnson Plast.

2. Electroacoustic portable impedance audiometer.

Make - Madsen Electronics

Model - ZS77-MB

Power - Directly from AC source of 220 volts.

Earphone - TDH-39 with MX41/AR cushion

III. TEST ENVIRONMENT:

The experiments were carried out in sound treated and centrally air conditioned room at the Audiology Department of All India Institute of Speech and Hearing, Mysore-6.

IV. PROCEDURE:

There were two stages in the experiments carried out in the present study. The two stages were:-
1) Impedance Audiometry (2) B.S.E.R.

1) Impedance Audiometry:- The tympanograms for both the ears were found. The reflex threshold of the phone ear and the middle ear pressure of the probe ear were determined for each subject.

Next the deflections of the B.M needle were noted for intensities in 5 dB steps, upto 15 dB above the Acoustic Reflex Threshold.

2) Electric Response Audiometry:-
Instructions:- The subjects were instructed to lie in relaxed position on an examination table. Subjects were told that the electrodes would be placed and they would be hearing intermittent sounds. The subjects were not sedated.

Electrode placement was as follows:-

Red (+) signal, to high forehead.

White (–) reference, at right mastoid.of the test ear.

Black : ground, at left mastoid of the non test ear.

Each electrode was placed into the correspondingly coloured receptade onthe patient electrode cable from the preamplifier.

Headphones were placed and the headset was positioned in such a way that it was comfortable to the subject.

E.R.A. was set as follows:-

1. Stimulus frequency on 2KHz and 4KHz, 20 pulses per second and 10 Ms sample time.
2. The scale switch on 2048 samples and 0.2μv/D.V.
3. Stimulus intensity at 60 and 100 dB HL.

B.S.E.R. waveforms were taken for each subject at two frequencies (2KHz and 4KHz) at two different intensity levels (60 dB and 100 dBHL) in right ear.

III and V peak latency readings were noted from the graph of B.S.E.R.A

Amplitude of B.S.E.R. was determined for III and V peaks. To determine the amplitude in microvolts (μ v), the marker amplitude 'M' was noted down. The scale switch amplitude S was .2 v/dlv.

For eg. a trace feature is 2.5 division high and the marker is 2 division high and the scale switches is set to .2/μv/div.

T = 2.5

M = 2.0

S = 0.2

Amplitude TS = 2.5 x .2

2 2

All the subjects were tested in the same manner.

RESULTS AND DISCUSSION

The data was subjected to relevant statistical analysis and the results are displayed in the Tables 1 to 15.

Table-1 shows the mean values or the magnitude of reflex with left ear as phone ear for 500Hz tone at:

a) Threshold level

b) 5dB SL

c) 1OdB SL

d) 15dB SL

Also, the difference in the magnitudes of reflex i.e. difference between 10 dB SL and 5dB SL, between 1OdB SL and OdB SL and between 15dBSL and OdB SL.

Table-2 shows the mean values of the magnitude of reflex with left ear as phone ear for lOOOHz tone at;

a) Threshold level

b) 5dB SL

c) 1OdB SL

d) 15dB SL

Also the difference in the magnitudes of reflex i.e. difference between 1OdB SL and 5dB SL, between 1OdB SL and OdB SL and between 15dB SL and OdB SL.

Table-3 shows the mean values of the magnitude of reflex with left ear as phone ear for 2000Hz tone at;

a) Threshold level

b) 5dB SL

c) 1OdB SL

d) 15dB SL

Also, the difference in the magnitudes of reflex i.e., difference between 10 dB SL and 5dB SL, between 10dB SL and OdB SL and between 15dB SL and OdB SL.

Table-4 shows the mean values of the magnitude of reflex with left ear as phone ear for 4000Hz tone at;

a) Threshold level

b) 5dB SL

c) 1OdB SL

d) 15dB SL.

Also, the difference in the magnitude of reflex i.e., difference between lOdB SL and 5dB SL, between 10d3 SL and OdB SL and between 15dB SL and OdB SL.

Table-5 shows the mean values of the magnitude of reflex with Right ear as phone ear for 500Hz tone at;

a) Threshold level

b) 5d3 SL

c) 1OdB SL

d) 15dB SL

Also, the difference in the magnitude of reflex i.e. difference between 10dB SL and 5dB SL, between 1OdB SL and OdB SL and between 15dB SL and OdB SL.

Table-6 shows the mean values of the magnitude of reflex with right ear as phone ear for lOOOHz tone at;

a) Threshold level
b) 5dB SL
c) 1OdB SL
d) 15dB SL

Also, the difference in the magnitudes of reflex i.e. difference between lOdB SL and 5dB SL, between 1OdB SL and OdB SL and between 15dB SL and OdB SL.

Table-7 shows the mean values of the magnitude of reflex with right ear as phone ear for 2000Hz tone at:

a) Threshold level
b) 5dB SL
c) 1OdB SL
d) 15dB SL.

Also, the difference in the magnitude of reflex i.e., difference between 1OdB SL and 5dB SL, between 10dB SL and OdB SL and between 15dB SL and OdB SL.

Table-8 shows the mean values of the magnitude of reflex with right ear as phone ear for 4000Hz tone at;

a) Threshold level

b) 5dB SL

c) 1OdB SL

d) 15dB SL

Also, the difference in the magnitude of reflex i.e., difference between 1OdB SL and 5dB SL, between lOdB SL and OdB SL and between 15dB SL and OdB SL.

Table-9 shows the amplitude of III and V peaks when Right ear was tested using 2000Hz logon stimulus at 60 dB HL.

Table-10 shows the amplitude of III and V peaks when right ear was tested using 2000Hz logon stimulus at lOOdB HL.

Table-11 shows, amplitudes of III and V peaks when Right ear was tested using 4000 Hz log on stimulus at 60dB HL.

Table-12 shows, amplitudes of III and V peaks when right ear was tested using 4000Hz tone at 100dB HL.

Table-13 shows magnitude of reflex at 4000Hz and amplitude change of III and V peaks at 4000Hz logon stimulus.

Table-14 shews magnitude of reflex at 2000Hz and amplitude change of III and V peaks at 2000Hz logon stimulus.

Table-15 shows Averaged magnitude of reflex (500Hz, 1OOOHz, 2000Hz and 4000Hz) and averaged amplitude of III and V peak at 2KHz and 4KHz logon stimulus.

Results of the analysis:

	Values
1. Correlation of magnitude of reflex (500Hz,+ lOOOHz + 2000Hz + 4000Hz) and amplitude of III peak (2000Hz + 4000Hz logon stimulus).	0.30
2. Correlation of magnitude of reflex (500Hz + lOOOHz + 2000Hz + 4000Hz) and amplitude of V peak (2000Hz + 4000Hz logon stimulus).	0.22
3. Correlation of magnitude of reflex at 2000Hz and amplitude change at III peak at 2000Hz logon stimulus.	0.48
4. Correlation of magnitude of reflex at 2000Hz and amplitude change at V peak at 4000Hz logon stimulus.	-0.33
5. Correlation of magnitude of reflex at 4000Hz and amplitude change at III peak at 4000Hz logon stimulus.	0.24
6. Correlation of magnitude of reflex at 4000Hz and amplitude change of V peak at 4000Hz. logon stimulus.	0.47

From the results it is clear that there is no correlation between the magnitude of reflex and the change in the amplitude of III and V peak. Since many studies have shown that there is some relationship (although not one-to-one) between magnitude of reflex and loudness and since the results of the present study reveal that there is no correlation between the magnitude of reflex and the amplitude change in the V and III peaks of B.S.E.R., it may be inferred that the brain stem responses do not reflect the loudness. This conclusion may be justified if one considers the nature of the brain stem responses . It is reported (Buchward, 1983) that the brain stem responses reflect the post synaptic potentials rather than the action potentials transmitted along the axons. Further it is known that brain-stem responses measure the synchrony of the auditory pathway function, but not hearing. Synchronous firing of the neurons can be expected from the neurons of the basal end of the cochlea. That is, the brain stem responses are mainly derived from the basal end of the cochlea. Since the the brain stem responses depend on the responses of the neurons of the basal end of the cochlea only, it is likely that the brain stem responses cannot represent loudness. To represent loudness, the responses of all the activated neurons should be considered. In the light of the above discussion, it can be concluded that the brain stem responses do not reflect loudness of the stimulus.

Additionally, the present study has revealed that the information regarding the changes in the amplitude of III and V peaks may not be useful for identifying the subjects who are susceptible to noise induced hearing loss. Ann Zachariah (1980) has reported that the magnitude of reflex can be used as a predictor of subject's susceptibility to noise induced hearing loss. Since there is no correlation between the magnitude of reflex and the changes in the amplitude of III and V peaks, the latter information maynot be useful for identifying subjects who are susceptible to noise induced hearing loss.

Table-1 shows the mean values of the magnitude of reflex with left ear as phone ear for 500Hz tone.

Subject	ART	Magnitude of reflex at thresh old value	Magnitude of Reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	lOdBSL - 5dBSL	lOdB SL -threshold	15dB SL - threshold.
1	80dB	1	2	2	7	0	1	6
2	85dB	1	4	6.5	7	2.5	5.5	6
3	95dB	1.5	2	2	2	0	.5	.5
4	80dB	1	2	5	6	3	4	5
5	90dB	1.5	4.5	6	6.5	1.5	4.5	5
6	90dB	2	3.5	5.5	7	2	1.5	5
7	90dB	1	2	3	4.5	1	1	5.5
8	85dB	1	4	6.5	7	2.5	3	6
Mean		1.25	3	4.56	5.88	2.08	2.63	4.67

* ART - Acoustic Reflex Threshold.

Table-2 : Magnitude of reflex with left ear as phone ear for lOOOHz tone.

Subject	ART	Magnitude of reflex at thresh old value	Magnitude of reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	1OdBSL-5dBSL	lOdBSL -threshold	15dBSL - threshold
1	75dB	1	2	3	5	1	2	4
2	85dB	2	4.5	6.5	7	2	4.5	5
3	90d.B	1.5	1.5	2.	2.5	0.5	.5	1
4	85dB	2	5	7	7	2	5	5
5	85dB	3	3	6.5	7	3.5	3.5	4
6	90dB	2	3.5	6	7	2.5	4	5
7	90dB	2.5	4	5.5	6.5	1.5	3.5	4
8	85dB	1	6	7	7	1	6	5
Mean Values		1.88	3.69	5.44	6.13	1.86	3.29	3.25
Mean Values		1.88	3.69	5.44	6.13	1.86	3.29	3.25

*ART - Acoustic Reflex Threshold.

*ART - Acoustic Reflex Threshold.

Table-3: Magnitude of reflex left ear as phone ear for 2000Hz tone.

Subject	ART*	Magnitude of reflex at threshold value	Magnitude of reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	lOdBSL - 5dBSL	lOdBSL -threshold	15dBSL -threshold
1	80dB	4	7	7	7	0	3	3
2	90dB	4	5	5	7	0	1	3
3	90dB	1	1.5	2	2	.5	1	1
4	80dB	2	3	6	7	3	4	5
5	85dB	3	3.5	6.5	7	3	3.5	4
6	90dB	1	1	5	7	4	4	6
7	85dB	3	5	5.5	6	.5	2.5	3
8	85dB	1.5	4	5.5	7	.5	4	5.5
Mean value		2.44	3.75	5.31	6.25	1.92	2.86	3

*ART - Acoustic Reflex Threshold.

Table-4: Magnitude of reflex left ear as phone ear for 4000Hz tone.

Subject	ART	Magnitude of reflex at threshold value	Magnitude of reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	lOdBSL-5dBSL	lOdBSL -threshold	15dBSL - threshold
1	80dB	3.5	6.5	7	7	.5	3.5	3.5
2	95dB	1	1.5	2.5	4	1	1.5	3
3	105dB	1	1	1	1	0	0	0
4	80dB	1.5	2	4	5	2	2.5	3.5
5	95dB	1	1.5	7	7	5.5	6	6
6	95dB	2	2.5	3	4.5	.5	1	2.5
7	85dB	1	2	2	2.5	0	1	1.5
8	120dB	1	-	-	-	-	-	-
Mean value		1.5	2.43	3.79	4.43	2.25	2.4	2.63
Mean value		1.5	2.43	3.79	4.43	2.25	2.4	2.63

*ART - Acoustic Reflex Threshold

Table-5: Magnitude of reflex with the right ear as phone ear for 500 Hz tone.

Subject	ART	Magnitude of reflex at thresh old value.	Magnitude of reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	lOdBSL-5dBSL	lOdBSL -threshold	15dBSL - threshold
1	90dB	1	2	3.5	6.5	1.5	2.5	5.5
2	95dB	1.5	5	7	7	2	5.5	5.5
3	3OdB	1	1.5	3	3	1.5	2	2
4	85dB	1.5	3.5	4.5	7	1	3	5.5
5	85dB	1	5.5	7	7	1.5	3	6
6	90dB	1.5	3	4.5	7	1.5	3	5.5
7	85dB	1.5	3.5	6	6.5	2.5	4.5	4
8	85dB	2	5.5	7	7	1.5	5	5
Mean Value		1.38	3.69	5.31	6.38	1.67	3.	4.5
Mean Valae		1.38	3.69	5.31	6.38	1.67	3.	4.5

ART - Acoustic Reflex Threshold.

Table-6 : Magnetude of reflex with the right ear as phone ear for lOOOHz tone.

Subject	ART*	Magnitude of reflex at thresh old value	Magnitude of reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	lOdBSL- -threshold	lOdBSL -threshold	15dBSL- threshold
1	85dB	4	4.5	6.5	7	2	2.5	3
2	95dB	1	5.5	7	7	1.5	6	6
3	90dB	1	1.5	3.5	3.5	2	2.5	2.5
4	85dB	1.5	5	7	7	2	5.5	5.5
5	95dB	6.5	7	7	7	0	..5	.5
6	90dB	1	3.5	5	7	1.5	4	6
7	85dB	4	5.5	7	7	1.5	3	3
8	90dB	2	6.5	7	7	.5	5	5
Mean value		2.62	4.88	6.25	6.56	1.88	3.63	2.75

ART - Acoustic Reflex Threshold.

Table-7: Magnitude of reflex with the right ear as phone ear for 2000Hz tone.

Subject	ART*	Magnitude of reflex at threshold value	Magnitude of reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	lOdBSL-threshold	lOdBSL-threshold	15dBSL-threshold
1	80<3.B	2	4	7	7	3	5	5
2	90dB	2.5	3	7	7	4	4.5	5.5
3	39 dB	1.5	2.5	3	4.5	.5	1.5	3
4	80dB	1	5	7	7	2	5	5
5	85dB	2.5	5	7	7	2	4.5	4.5
6	90dB	1.5	4	4.5	7	.5	3	5.5
7	85dB	3	5	6.5	7	1.5	3.5	
8	90dB	2	4.5	7	7	1.5	5	5
Mean Value		2.13	4.13	6.13	6.69	1.5	3.83	4

Table-8: Magnitude of reflex with the right ear as phone ear for 4000Hz tone.

Subject	ART*	Magnitude of reflex at thresh old value	Magnitude of reflex at			Magnitude change		
			5dBSL	lOdBSL	15dBSL	lOdBSL - threshold	lOdBSL - threshold	15dBSL - threshold
1	80dB	1.5	2	5	7	3	3.5	5.5
2	9OdB	2	3	3.5	7	.5	1.5	5
3	90dB	1	2	2	2	0	1	1
4	80dB	1	1.5	3.5	6	2	2.5	5
5	105dB	2	7	7	7	0	5	5
6	90dB	1	2	2	2.5	0	1	1.5
7	85dB	2	2	3	3.5	1	1	1.5
3	105dB	2	2.5	3	-	.5	1	-
Mean value		1.56	2.75	3.63	4.81	1.4	1.64	2.9

ART - Acoustic Reflex Threshold

Table-9 and 10 Amplitude of III and V peaks when right ear was tested using 2000Hz logon stimulus at 100 dB. and 60 dB

Subject	Intensity of the stimulus	Amplitude of		Intensity of the stimulus:	Amplitude of		Amplitude change of	
		III peak μv	V Peak μv		III peak μv	V peak μV	III peak μv	V Peak μv
1	100dB	0.25	0.7	60dB	0.08	0.44	0.17	0.26
2	"	0.15	0.36	"	0.12	0.28	0.03	0.08
3	"	0.16	0.5	"	0.18	0.7	-0.02	-0.2
4	"	0.15	0.82	"	0.05	0.04	0.1	0.42
5	"	0.15	0.42	"	0.05	0.12	0.1	0.3
6	"	0.16	0.5	"	0.08	0.21	0.08	0.29
7	"	0.2	0.9	"	0.13	0.36	0.07	0.56
8	"	0.25	0.75	"	0.16	0.62	0.09	0.13
Mean value		0.18	0.62	"	0.11	0.39	0.08	0.23
Standard Deviation		0.04	0.2		0.05	0.2	0.06	0.23

Table-11 and 12: Amplitude change of III and V peak using 4000Hz logon stimulus at 1OOdB and 60dB right ear as test ear.

Sub-jects	Intensity of the stimulus	Amplitude of		Intensity of the stimulus	Amplitude of		Amplitude change of	
		III Peak μv	V peak μv		III Peak μv	V Peak μv	III Peak μv	V Peak μv
1	100dB	0.3	0.6	60dB	0.1	0.3	0.2	0.3
2	''	0.3	0.65	''	0.05	0.2	0.25	0.45
3	''	0.24	0.5	''	0.01	0.05	0.23	0.45
4	''	0.3	0.32	''	0.1	0.2	0.2	0.12
5	''	0.3	0.57	''	0.15	0.35	0.15	0.22
6	''	0.27	0.6	''	0.15	0.15	0.12	0.45
7	''	0.62	0.88	''	0.04	0.3	0.58	0.58
8	''	0.35	0.75	''	0.14	0.18	0.21	0.57
Mean	''	0.34	0.61	''	0.09	0.22	0.24	0.39
Standard deviation		0.2	0.17		0.05	0.1	0.14	0.16

Table-13: Magnitude of Acoustic reflex at 4000Hz and amplitude change of III and V Peaks at 4000Hz logon stimulus.

Subject	Magnitude of acoustic reflex	Amplitude change of III peak μv	Amplitude change of V Peak μv
1	3.5	0.2	0.3
2	1.5	0.25	0.45
3	1	0.23	0.45
4	2.5	0.2	0.12
5	-	0.15	0.22
6	1	0.12	0.45
7	1	0.58	0.58
8	1	0.21	0.18

Table–14: Magnitude of acoustic reflex at 2000Hz and amplitude change of III and V peaks at 2000Hz logon stimulus.

Subject	Magnitude of acoustic reflex	Amplitude change of III peak µv	Amplitude change of V peak µv
1	5	0.17	0.26
2	-	0.03	0.08
3	1.5	-0.02	-0.2
4	0.5	0.1	0.42
5	-	0.1	0.3
6		0.08	0.29
7	3.5	0.07	0.54
8	5	0.09	0.13

Table-15: Averaged magnitude of reflex (500Hz, 1OOOHz and 4000Hz) and Averaged amplitude of III and V peak at 2KHz and 4KHz logon stimulus.

Subject	Averaged magnitude of reflex	Averaged amplitude of III peak μv	Averaged amplitude of V Peak μv
1	3.38	0.19	0.28
2	1.5	0.14	0.27
3	1.75	0.11	0.13
4	4	0.15	0.27
5	-	0.13	0.26
6	2.75	0.1	0.37
7	3	0.33	0.56
8	3	0.15	0.16

SUMMARY AND CONCLUSIONS

Many investigators have studied the relationship between acoustic reflex and loudness. Some studies show that there is no one-to-one relationship between acoustic reflex and loudness. Although there may not be one-to-one relationship between acoustic reflex and loudness; it is clear from the many studies that there does exist relationship between acoustic reflex and loudness.

Many studies show that the growth of reflex with increase in intensity of sound varies from individual to individual.

It is not known whether the subjects show any similarities between the intensity - amplitude function of acoustic reflex and intensity-amplitude function of brain stem responses.

To study the correlation between "Magnitude of acoustic reflex and amplitude of brain stem responses", this experiment was carried out.

Eight normal hearing subjects with no history of otological disorder were selected. Acoustic reflex thresholds were established, and growth of magnitude of reflex were measured at 5dBSL, lOdBSL, and 15dBSL. Further, brain stem responses III and V peaks of the same subjects were obtained using 2000Hz and 4000Hz logon stimulus at 60d3HL and 1OOdBHL.

From the results of the present study, no correlation is found between the magnitude of reflex and the change in the amplitude of III and V peaks, of brain stem responses, it may be inferred that the brain stem responses do not reflect the loudness. It is reported (Buchwald 1982) that the brain stem responses reflect the post synaptic potentials rather than the action potentials transmitted along the axons Further, it is known that brain stem responses measure the synchrony of the auditory pathway functions, but not hearing. Synchronous firing of the neurons can be expected from the neurons of the basal end of the cochlea. That is, the brain stem responses are mainly derived from the basal end of the cochlea. Since the brain stem responses depend on the responses of the neurones of the basavend of cochlea only,it is likely that the brain stem responses cannot represent loudrtess.

Additionally the present study has revealed that the information regarding the change in the amplitude of III and V peaks may not be useful for identifying the subjects who are susceptible to noise induced hearing loss. Anne Zachariah (1980) has reported that the magnitude of reflex can be used as a predictor of subjects susceptibility of noise induced hearing loss. Since there is no correlation between magnitude of reflex and the changes in the amplitude of III and V peaks of Brain stem Evoked Response. Hence this information may not be useful for identifying subjects who are susceptible to noise induced hearing loss.

Conclusions:

1. There is no correlation between the magnitude of reflex and the changes in the amplitude of III and V peaks of brain stem responses.

2. Brain stem responses may not be useful for identifying subjects who are susceptible to noise induced hearing loss.

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