STANDARDIZATION OF BRAIN-STEM ELECTRIC RESPONSE AUDIOMETRY FOR BONE CONDUCTION LOGON STIMULI

Regd.No.8510

AN INDEPENDENT PROJECT WORK SUBMITTED IN PART FULFILMENT FOR FIRST YEAR M Sc (SPEECH AND HEARING) TO THE ' " UNIVERSITY OF MYSORE

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE-570 006

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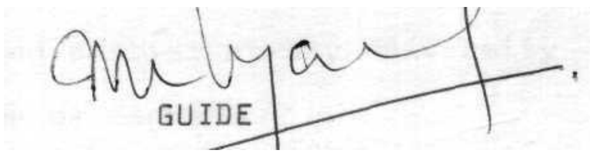
TO MY MUMMY AND DADDY ,

C E R T I F I C A T E

This is to certify that this Independent Project entitled "Standardization of Brain-Stem Electric Response Audiometry for Bone Conduction Logon Stimuli" has been prepared under my supervision and guidance.



DECLARATION

I hereby declare that this Independent Project entitled "Standardization of Brain-Stem Electric Response Audiomhe result of my own study under the guidance of etry for Bone Conduction Logon Stimuli" is tDr. M. N. Vyasamurthy, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other diploma or degree.

Reg. No. 8510

Mysore,
Dated May, 1986.

ACKNOELEDEGEMENT

I express my sincere gratitude to Dr. M. N. Vyasamurthy for his patient listening, help and invaluable guidance in my work.

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INTRODUCTION

INTRODUCTION

The Brain-Stem Electric Response Audiometry (BSERA) has been widely used in most of the audiology clinics. It has gained clinical importance because of the stable reponses. Many studies have demonstrated that brain-stem responses are not affected by sedatives because of this great advantage the hearing sensitivity of non-cooperative children can be objectively assessed using Brain–Stem Electric Response Audiometry.

In addition to finding A.C. thresholds, B.C. thresholds can also be determined objectively using Brain-Stem Evoke Response Audiometry.

The objective assessment of B.C. thresholds specially with children with atresia is of utmost importance.

The use of bone donducted signals in electro cochleography has been reported by Yoshie who indicated that the separation of the air conduction input-output and latency-intensity functions from the analogous bone conduction functions provided an estimate of the behavioural air bone gap. In addition, Yoshie described a difference in waveform between the compound action potentials elicited by air conducted and bone conducted signals. He also noted that the bone conduction latency–intensity function was somehwat different than the normal air conduction latency-intensity function. Yoshie suggested that differences in the air conduction and bone conduction click spectra might contribute to these observed dissimilarities in the action potentials recorded with the two signals. (Mauldin, Jerger,1979).

Aim of the Study:

Standardization of Brain-Stem Electric Response Audiometry for B.C. Logon Stimuli.

Need for the study:

" The effects of conductive hearing loss on the auditory brain-stem evoked response (ABR) have been reported in a general manner. In conductive loss, the ABR to air conducted clicks have been reported to be affected in three says:-

i) the threshold is elevated,
ii) the amplitude is decreased, and
iii) the latency to high intensity clicks is increased (due to a shift in the latency-intensity function).

The degree of conductive hearing loss on a given patient has been predicted to be the amount that the patients air conduction latency-intensity curve is shifted from the normal latency-intensity function for air conducted signals ". (Mauldin, Jerger, 1979).

If the ABR can be recorded with bone conducted signals, then the air-bone gap on a patient with conductive hearing loss, can be predicted from the separation of the air conduction and bone conduction latency-intensity functions as in electro cochleography.

The goal of the present study is to evaluate the use of bone conducted logon stimuli in subjects with normal hearing. Specific attention is focussed on the comparison of V peak air conduction and bone conduction latency-intensity functions.

Since the calibration of B.C. vibrator for logon stimuli is difficult, an alternate method has been used to standardise BSERA for bone conducted logon stimuli. In this method the B.C. vibrator is required to be connected to the A.C. socket.

After connecting the B.C. vibrator to

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the A.C. socket, it is necessary to find the latency valus of the V peak in normal hearing subjects when the dial setting is 100 dBHL. The next step is to find the hearing level of the A.C. logon stimulus which produces the same latency value as that of the B. C. logon stimulus at the dial setting of 100 dBHL (B.C. vibrator is connected to the A. C. socket). Thus it is assumed that 100 dBHL B.C. logon stimulus (B.C. vibrator is connected to the A.C. socket) is equivalent to xdBHL of A.C. logon stimulus (where xdBHL is the level of the A.C. logon stimulus which produces the same latency value as that of the 100 dBHL B.C. logon stimulus).

In brief, the present study aims to establish the hearing level of the A.C. logon stimulus producing a latency value (V peak) which is equal to that of the B.C. logon stimulus at 100 dBHL (where B.C. vibrator is connected to the A.C. socket).

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REVIEW OF LITERATURE

REVIEW OF LITERATURE

1.1 History and Development of Brain-Stem Evoked Response:

It is always instructive to glimpse backward when considering contemporary issues such as electro cochleography (ECochG) and auditory brain-stem evoked responses (ABR). In order to put the past into proper perspective, several lines of historical evidence must be examined. One line of historical importance is the discovery of bio-electrical potentials in animals, first described by Galvani, Circa, 1971. In 184S, du Bois Reymond published his seminar paper on the discovery of negative action potentials in nerves. This was followed in 1875 by the first published evoked potential recordings by Caton. Following this, the first recordings of brain electrical potentials from the human scalp by Berger in 1929 which came to be known as the electro—encephalogram or EEG (Moore, 1983).

1.2 Far Field Potentials:

The FFR was first demonstrated by Tsuchitani and Budreau (1964) and Boudreau (1965a, 1965b) followed by Marsh and Warden (1968) and Marsh Warden and Smith (1970).

(Jewett and Romano 1972, Jewett and Williston, 1971, Jewett et al 1970) in United States introduced the concept of far field recordings. This engineering term was used to describe the situations where electrodes on the surface of the scalp recorded the activity of distant neural generators.

Early Description of the Response:

Jewett and Williston (1971) demonstrated that the normal human ABR consisted of five to seven vertex positive waves occuring in the first nine msec, following a click stimulus.

The most prominent of the series of "fast" CNS responses recorded from electrodces on vertex and mastoid or ear is a vertex positive wave with a latency of 5-9 msec, following a click. It is ascribed to the inferior colliculus and is a good candidate for assessing the response of the basal turn of the cochlea. (Hallowell, 1976).

Wave V - its latency is short enough to avoid masking by the first Sonomotor response that often begins at 10 msec, yet long enough to avoid confusion with cochlear microphonic or stimulus artifact. The voltage of this wave is very small of the order of 0.1 uV but as with the middle responses rapid repitition rates are permissible. The chief disadvanage of JV is its low voltage which requires complete relaxation of the patient as in light sleep to avoid masking by muscle potentials. If not masked, it can be identified at 10 dBSL (Hallowell, 1976).

1.3 **Anatomical Origins** of Response Components:

There are various speculations about the origin of ABR component waves. The I and II waves are perhaps reflected activity of the bi-polar cells of the acoustic nerve, but later waves were only suspected to reflect activity of brain-stem auditory structures (Fria, 1980).

Human Studies:

Lev and Sohmer (1972) speculated the similarity between the cat and human ABR suggested similar neural generators.

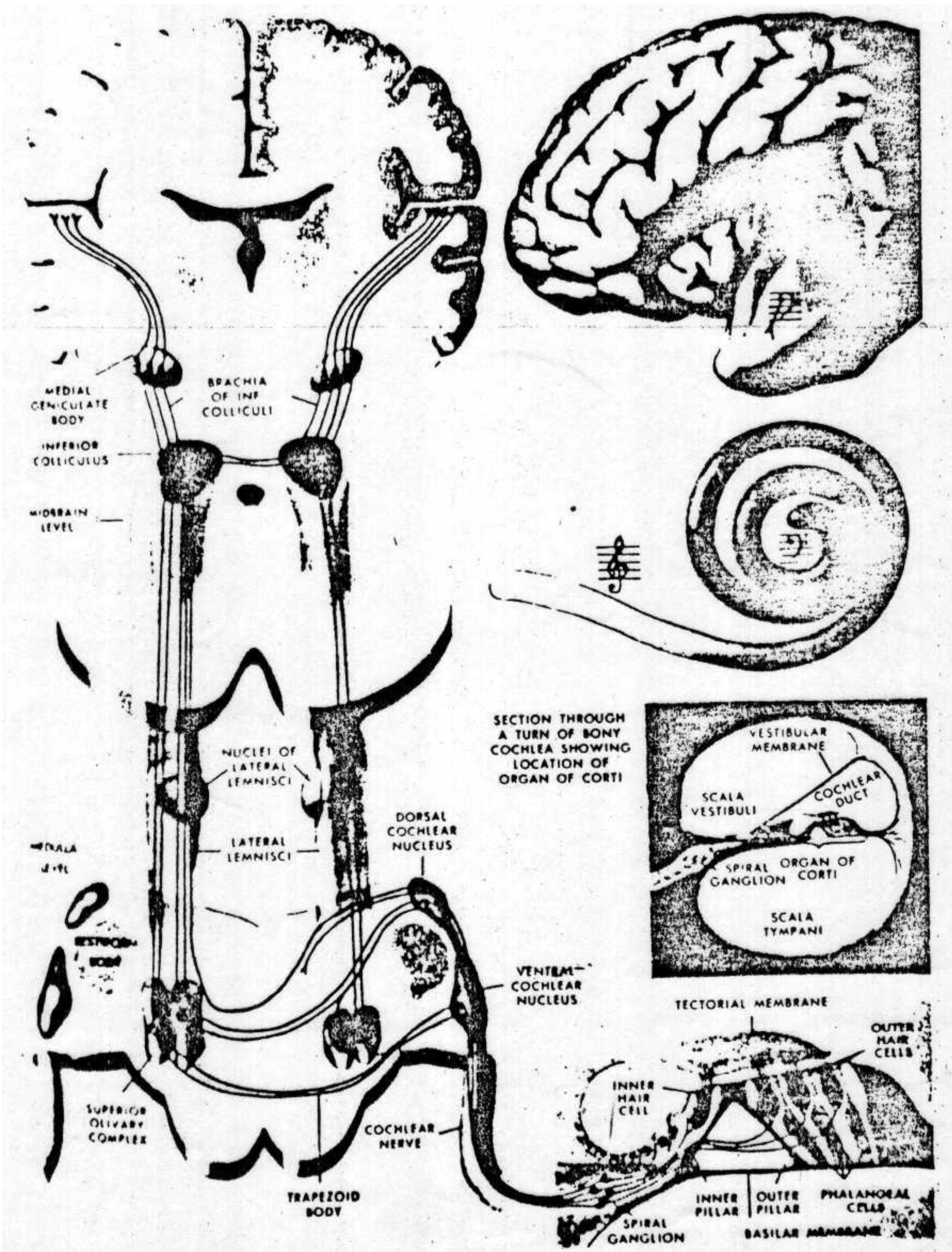
Topographical analysis of scalp distributions of human ABRs have been conducted by several investigators (Martin and Coats, 1973 Martin and Moore, 1977, Picton et al 1974). Picton et al (1974) for example found that wave I was restricted to the ipsilateral (relative to the stimulated ear) mastoid and it was very similar to the N_1 potential recorded with transtympanic needle electrode. They concluded that wave I originated in the auditory nerve wave components between I and IV reversed polarity between ipsilateral and contralateral mastoids, consequently these components appeared to reflect horizontally oriented dipoles perhaps in the cochlear nucleus and suprior olivary complex. Wave V appeared to be a far field reflection of lateral lemnissus or inferior colliculus components. The auditory pathway which classically shows the "relay stations" between cochlea and cerebral cortex are, in ascending order - auditory nerve, cochlear nuceli (CN), superior olivary complex (SOC), nuceli of lateral lemnissus, inferior colliculus (IC), and medial geniculate body (MGB), from where the fiberes travel in the auditory radiation to primary auditory cortex i.e. the Heschel's gyri deep in the temporal lobe, (Dobie R.A., 1980). Fig.1a gives the auditory pathway.

Goff et al (1977) data from normal young adults undergoing elective non-neurological surgery, strongly indicated a sub-cortical leminiscal origin for the ABR wave components.

A composite impression of the data reviewed above has motivated investigators to assign a specific correspondence between a given ABR component waves and specific neural generators. A diagrammatic representation of this correspondence is shown in Fig.1b. The figure suggests a correspondence between:-

Wave I and the Eighlh Cranial nerve; wave II and the Cochlear Nucleus; wave III and the Superior Olivary Complex, wave IV and the Lateral Lemniscous; wave V and the Inferior Colliculus (mid-brain); wave VI and the Medial Geniculate (Thalamus); Wave VII and the Auditory Radiations (Thalamo—Cortical).

Figure 1(a).Diagram of the Auditory Pathway.



(Adapted from Ciba, 1970)

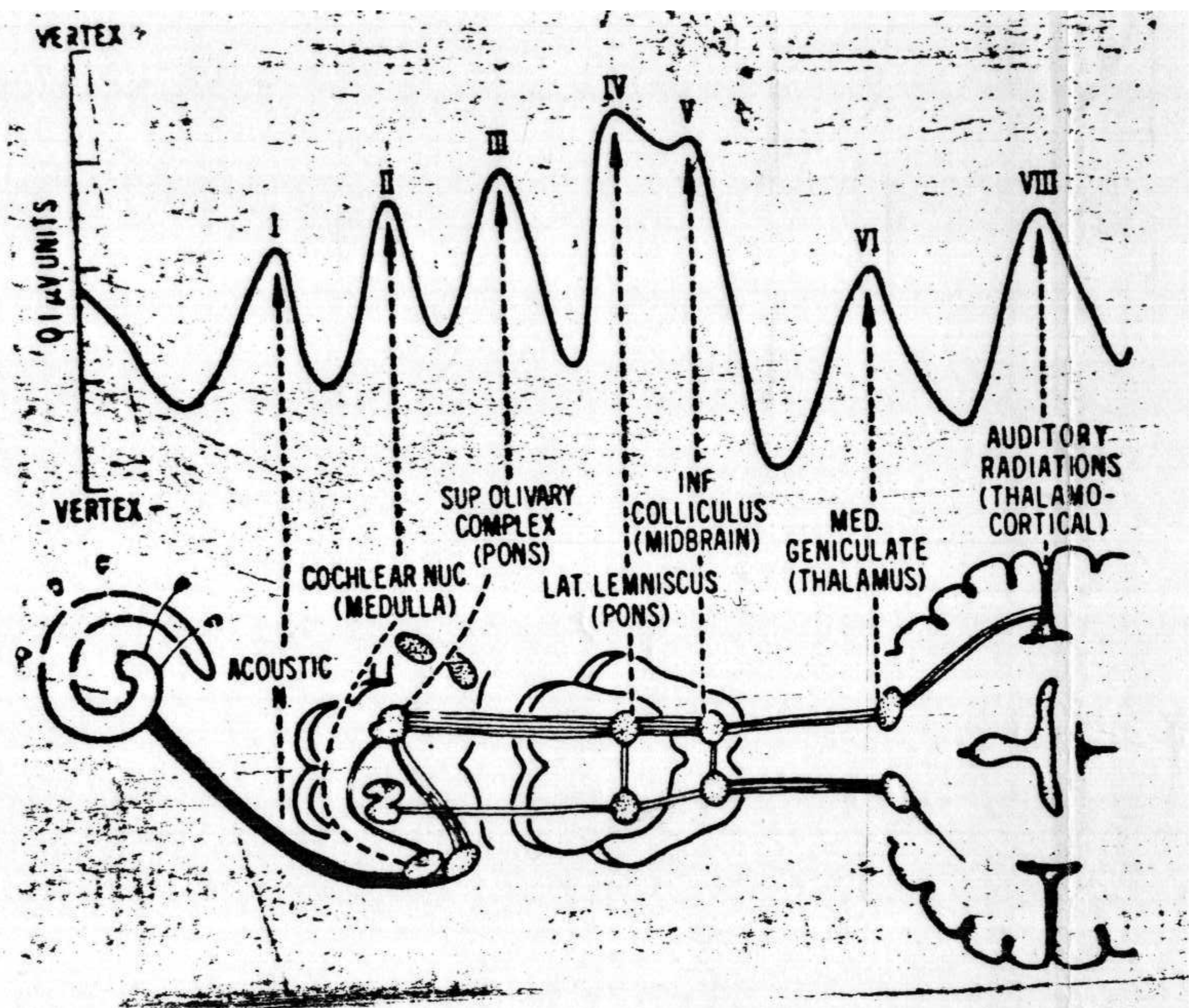


Figure 1 (b). The presumed correspondence between BER component waves (I through VII, up of the figure) and anatomical structure in the primary ascending auditory (lower position of the figure).

Consequently, the relationship depicted in Fig.lb is highly simplified and it must be recognised that several neural generators interact to produce ABR waves II thru V. (Fria, 1980).

1.4 Classification of Response:

Evoked neuroelectric responses from the auditory system may be classified according to the source of potential, the recording site, or the relative latency of the response.

Fig.2 illustrates the nerve action potential at the coclea, the brain-stem, and middle and late cortical reponse potential. The latency periods that characterize the various measures are: cochlear potentials, 0.5 - 5 msec; brain-stem response, 1 - 10 msec; middle electroencephalic response, 10 — 15 msec; late or slow electro— encephalic response, 50 — 500 msec. (Rose, 1978).

Characteristics of Electrophysiologic Responses:

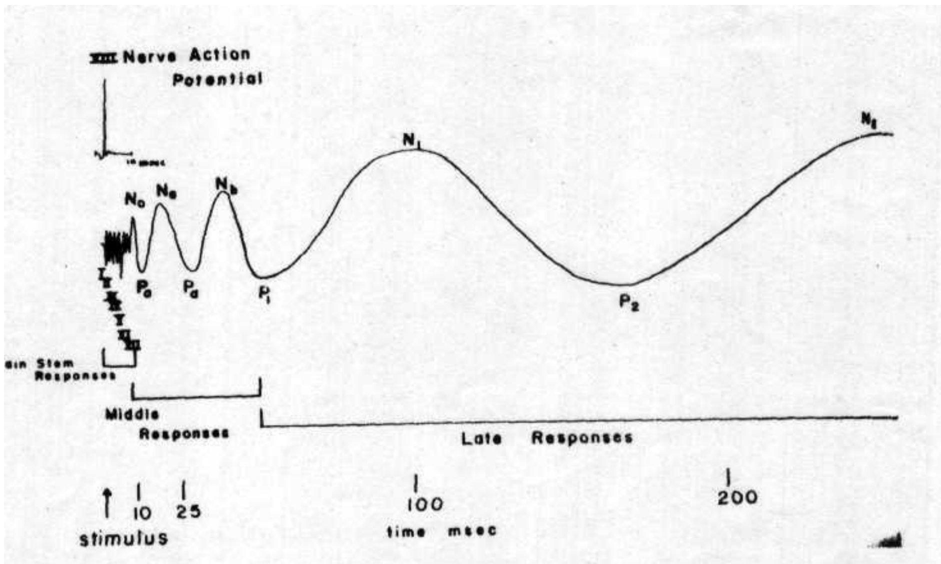
Response latency classifi-cation	5ite of Origin	Response waveform	Response Latency msec.	Amplitude in uV
ECOG	Auditory nerve	fast	1 to 5	0.1 -10
Early	Brain-stem	fast	4 to 8	0.01 -1
Middle	Brain-stem/Primary cortical projection	fast	8 to 50	1.0 -3
Late	Primary cortical projection and secondary Associa-tion area	slow	50 to 300	8.0 -20
Very Late	Prefrcntal cortex and Secondary Association areas	very slow	300 and beyond	20 -30

(Newby, 1979)

1.5 Normal Response Parameters: (Fria, 1980)

Clinician needs to recognise the normal ABR characterstic to use ABR for clinical purpose which

Figure 2. Schematic Representation of the Types of Auditory Evoked Potentials.



involves the recognition of the abnormal results. The ABR parameters of value are - morphology, latency, and amplitude.

Response Morphology:

It is a subjective parameter than either latency or amplitude, because morphology as in this context refers to visual appearance of the waveform. It cannot be specified in measurable units such as milliseconds or microvolts.

In Fig. 3a, there appears discrepancy in the studies in terms with the morphology. Although most investigators display positive waves at the vertex as unpward deflections, same display the same waves as downward deflections. To avoid confusion, this minor point should be kept in mind while comparing published waveforms in the literature (Fria, 1980).

Chiappa et al (1979) described 6 variant forms in normal young adults in Fig. 3b. The variants include:—

a) a single peak with no separation of waves IV and V,

b) separate IV and V waves with V of greater height than IV,

c) separate waves with IV of greater height than V,

d) wave V appearing as an inflection on IV,

e) wave IV appearing as an inflection on V, and

f) separate waves of the same height.

In normal adult subjects, wave V is the most frequently observed component of the ABR and waves II and IV are often poorly defined responses. Wave III is often prominent (Fria, 1980). Waves I, III, and V are given main focus in the present study.

Figure 3(a). Positive and Negative Waveform.

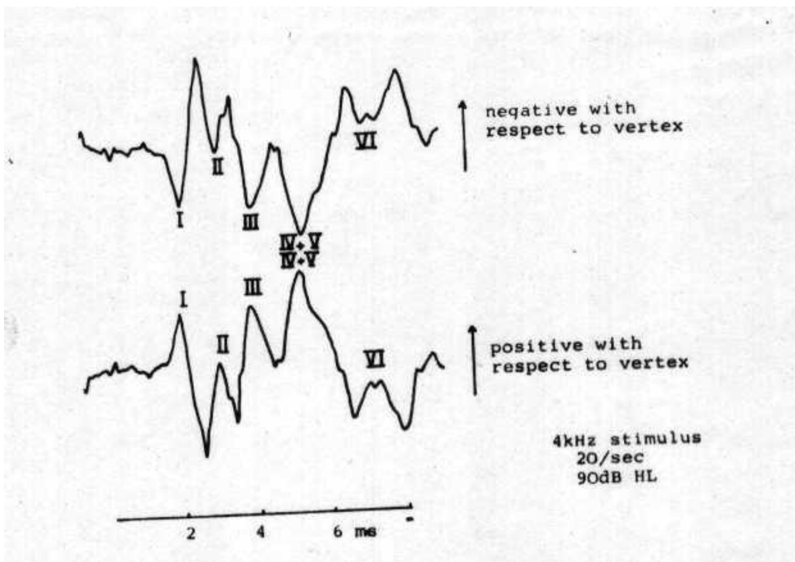
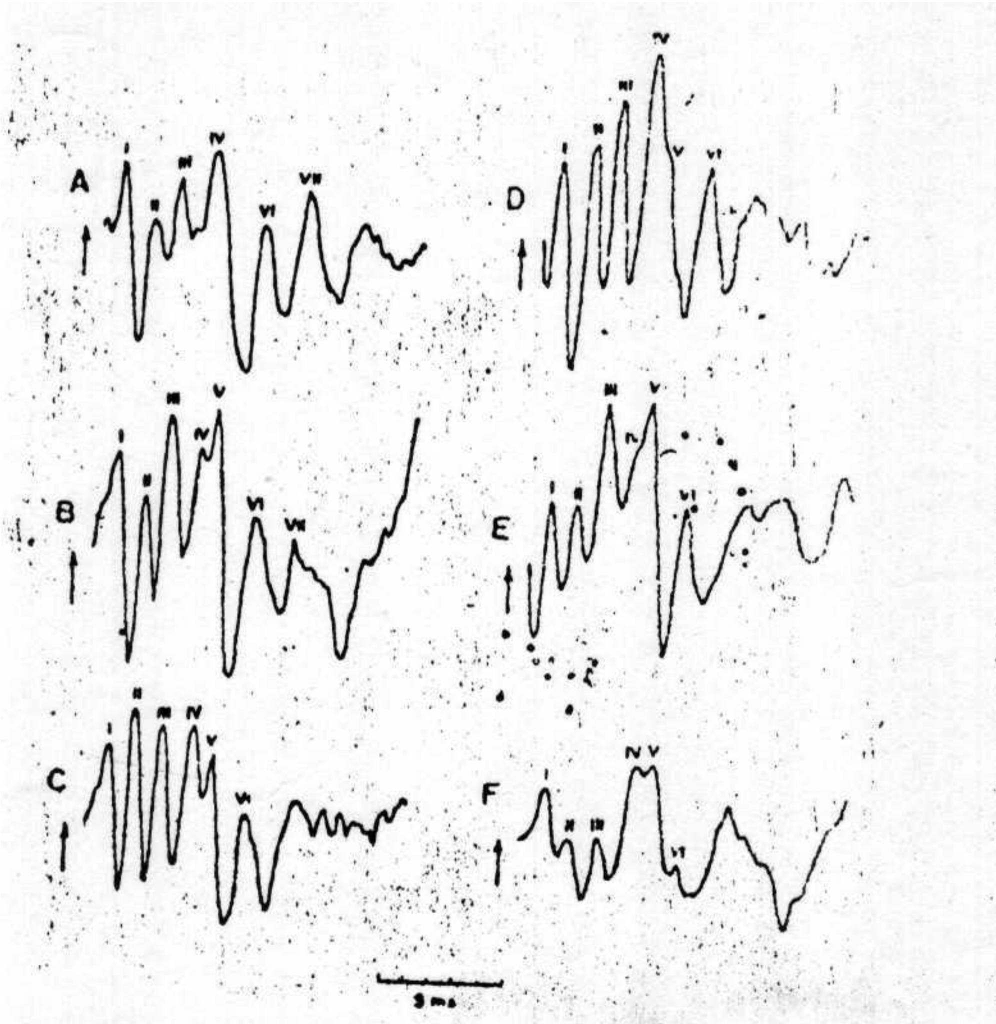


Figure 3(b). Possible Variations in the Morphology of the IV-V complex for normal adult subjects.



(As reported by Chiappa et al (1979)

Response Latency:

It is the time relationship between the response and the stimulus eliciting that response. This time is referred to as latency.

In ABR, this parameter is designated as :-

i) absolute latency, and
ii) Interwave latency.

Fig.4 shows the distinction between the two. Interwave latency refers to the time difference between two component waves, e.g., III - V interwave latency, while absolute latency conforms to the traditional definition, i.e. the time relationship between stimulus onset and associated response.

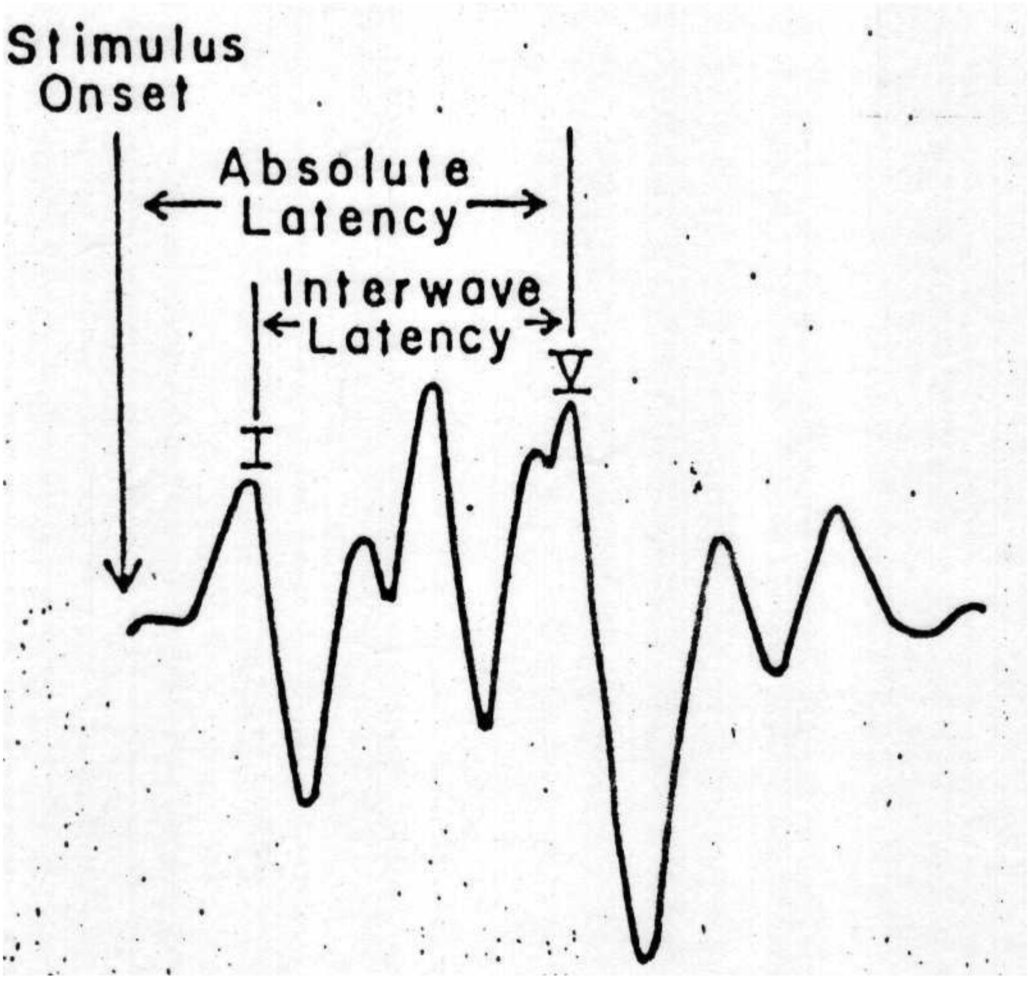
Absolute latency and interwave values are typically spcified in milliseconds (msec). This parameter using similar stimuli is remarkably constant among adult subjects.

Response Amplitude:

Measured in micro volts (uV) it is the height from peak of the wave to the following trough (assuming that vertex positive waves are displaced as upward deflection). This is also termed as "absolute amplitude". When expressed in relation to one wave with another, it is termed as "relative amplitude". The distinction is apparent in Fig.5. Relative amplitude is ths ratio of the absolute amplitudes for 2 ABR values.

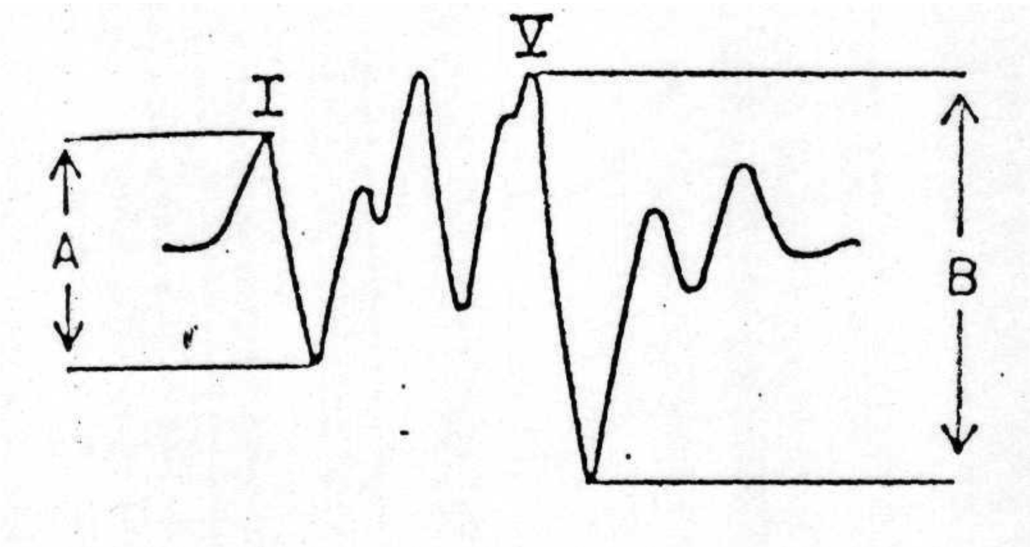
Absolute amplitude measures show wide variation between and within subjects. Relative measures are more consistent and are better indices for comparing amplitude phenomenon between and within subjects on different occasions. (Starr & Achor, 1975).

Figure 4: Absolute and Inter-wave LatencyDistlnc-
tion in BER.



(Adapted from Fria, T., 1980)

Figure 5. Absolute and Relative Amplitude Distinction in BER.



(Adapted from Fria, T., 1980)

1.6 The Effects of Certain Stimulus Parameters on the Evoked Auditory Response:

i) the choice of stimulus,
ii) the effect of frequency stimulus on the evoked response,
iii) the effect of stimulus intensity on the evoked response,
iv) the effect of stimulus loudness on the evoked response,
v) the effect of stimulus duration on the evoked response,
vi) the effect of stimulus rise-decay time on the evoked response,
vii) the effect of the number of stimuli on the evoked response,
viii) the effect of stimulus presentation rate and inter-stimulus interval, and
ix) the effect of stimulus repetition.

(Reneau, 1975).

The Choice of Stimulus:

It has been observed that it is easier to evoke a response in clicks than to pure tones.(Davis, 1965) has used tone pips, which are filtered clicks at different frequencies. More recently it was pointed out that although agreement between voluntary thresholds for pure tones and tone pips is generally good, it tends to be poorer for persons with steeply sloping hearing losses. He suggests using brief bursts of pure tone with 20 msec rise and decay times. In contrast (McCandless and Best, 1965) state there is no difference for pure tone or clicks when an averaging response computer is used. (Chueden (1972) studying the effect of masking noise and pure tones on the evoked response, observed that the N_1- P_2 amplitude increased with intensity varying the intensity of white noise, however, did not affect the N_1- P_2

amplitude but N_1 was typically a plateau and not a spike as when the case of pure tone stimulation. Chueden in conclusion stated that the evoked potential amplitude does not show a relationship to the loudest stimulus (i.e., the masking noise) but does show a relationship to the pure tone even at a relatively low intensity level. (Spoor, Timmer and Odenthal, 1969) examined the evoked responses for short tone bursts, intensity modulated tones, and frequency modulated tones. They interpret this to indicate that the auditory mechanism utilised in the perception of frequency modulated tones are different from the auditory mechanisms utilised in the perception of intensity modulated tones.

(Butler, 1972) attempted to determine whether the evoked response reflects the frequency spectrum of an amplitude modulated signals or the modulation rate of this amplitude modulated signal. He concluded that the response to a low pitch may not be mediated by those neural units most sensitive to signals of low pitch, but instead by the units sensitive to the frequency spectrum of the signal.

The Effect of Stimulus Frequency on the Evoked Response:

Many investigators have stated that the frequency of the stimulus does not affect the form of the evoked response. (Suzuki and Taguchi, 1965) observed no difference in response of detectibility with changes in stimulus frequency.

Vetter and Horvath,(1962) observed that low frequency stimuli are more effective in evoking a K complex in sleeping subjects.

Other investigators state that the frequency of the stimulus affects the form of the evoked response. Beagley and Knight, (1967) found that stimuli at 500 HZ, 2000 HZ, and 4000 HZ collectively produced significantly smaller amplitudes than did the stimuli at 1000 HZ when intensity exceeded 30 dB. Peak to peak amplitude decreased under condition of equal loudness and equal sensation level as frequency increased. No consistent changes in response latency could be attributed to changes in frequency.

Evans and Deatherage, (1969) also observed a progressive decline in evoked response amplitude as frequency increased and they speculate that this relationship may be present because the lower the frequency, the larger the area of disturbance along the Basiliar membrane.

More specifically, when the signals were swept in an upward direction, mean amplitude was larger. In addition, latency of N_1 component was shorter when the signals were swept in a downward direction.

The Effect of Stimulus Intensity on the Evoked Response:

Rapin and her associates (1966) observed that the amplitude of the N_1- P_2 component of the click response (N_1 peak latency 90 - 150 msec, P_2 peak latency 180 - 200 msec) increased with intensity in an irregular and non-uniform manner. In contrast, the increase in amplitude of the evoked response to tones was more regularly and definitely related to changes in stimulus intensity.

Graham using bone conducted tone bursts observed that the relationship of amplitude to intensity was not an orderly one.

When McCandless and Best, (1966) presented subjects with tones varying in frequency and intensity, the relationship between amplitude of the response and intensity of the stimulus was clear for some subjects and not clear for others. They suggest that the difference may be due to differences in psychophysical states.

Latency of the evoked response decreases with intensity of the air and bone conducted signals.

Rapin et al (1964, 1965 and 1966) compared the latencies of response to clicks and pure tones of varying intensities, and found that the latency of the N_1 component and P_2 component remained constant for clicks, but at 50 dBSL, the latency for tone bursts was 10 - 15 msec greater for clicks of the same intensity. With decrease in intensity they observed difference was progressively greater.

The Effect of Stimulus Rise-Decay Time on Evoked Response:

Goodman et al (1964) observed that a faster signal rise time is more effective in evoking an EEG response from sleeping neonates. If too slow a rise time is employed, a response may not be evoked.

Longer rise times at all intensities were associated with longer latencies. The observation was true particularly at the lower intensity levels. This suggests that latency has a double dependence on intensity and rise time. In conclusion, it is stated that N_1- P_2 amplitude is not particularly affected by the stimulus rise time unless the rise time of the stimulus is equal to or longer than the latency of N_1. Amplitude is reduced when signal rise time is increased and when signal intensity is reduced. This suggests a temporal integration at some point in the auditory system.

The Effect of Stimulus Repetition:

Davis and Zerlin, (1966) hypothesize that fatigue and habituation do not constitute significant problem. A parameter of stimulation that is very important for ERA is the stimulus presentation/repetition rate or the inter-stimulus interval (ISI). ISI is a measure of the time elapsed between end of one stimulus and beginning of the next. The number of stimuli delivered usually per second is called the stimulus rate. If the length of the stimulus is known one can relate ISI and stimulus rate.

The findings of Eggemount and Spoor, (1973a) are as follows:-

1. The amplitude of the AP remains at approximately 100% of its value for rates upto 7 (sec (ISI approximately . 140 msec) and only alters fractionally at rates upto 14/sec (ISI 70 msec). A general reduction in amplitude of the N_1 components of AP at faster ISI/ rates is noticed.
2. The latency of N_1 component of the AP increases with shorter ISI (rapid rate).
3. The width of N_1 component of AP increases.

Zollner et al, (1976) found a decrease in amplitude and an increase in latency for all the waves N_1 - N_1. The latency shift was larger for the later waves. Morphological changes in HER as stimuli repetition rate was increased from 2.5 to

25 clicks/sec was first observed by Jewett and Williston (1971). The waveform degradation was slight at 10 click/sec but quite noticeable at rate of 20/sec. N_5 component was found to be little affected. In fact, increase in amplitude of N_5 was reported at higher stimulus rate.

Wave V dominence appears to be resistent to rate effects (Chippa et al 1979; Jewett and Williston 1971); Rowe 1973; Stockard et al 1978, Pratt and Sohmer 1975; Terkildsen et al, 1976) but Gibson reported that NIV and NV tend to merge at faster rates.

Fig.6 shows the effect of varying the stimulus presentation rate on ABR waveform.

"In general an increase in absolute latency of all BER component wave is associated with an increase in stimulus repetition rate. Chippa et al. (1979); Don et al, (1977); Acton et al, (1977), Rosenhamer et al (1978); Stockard et al (1978); Weber and Fujkawa, (1977)'; Fria, (1980).

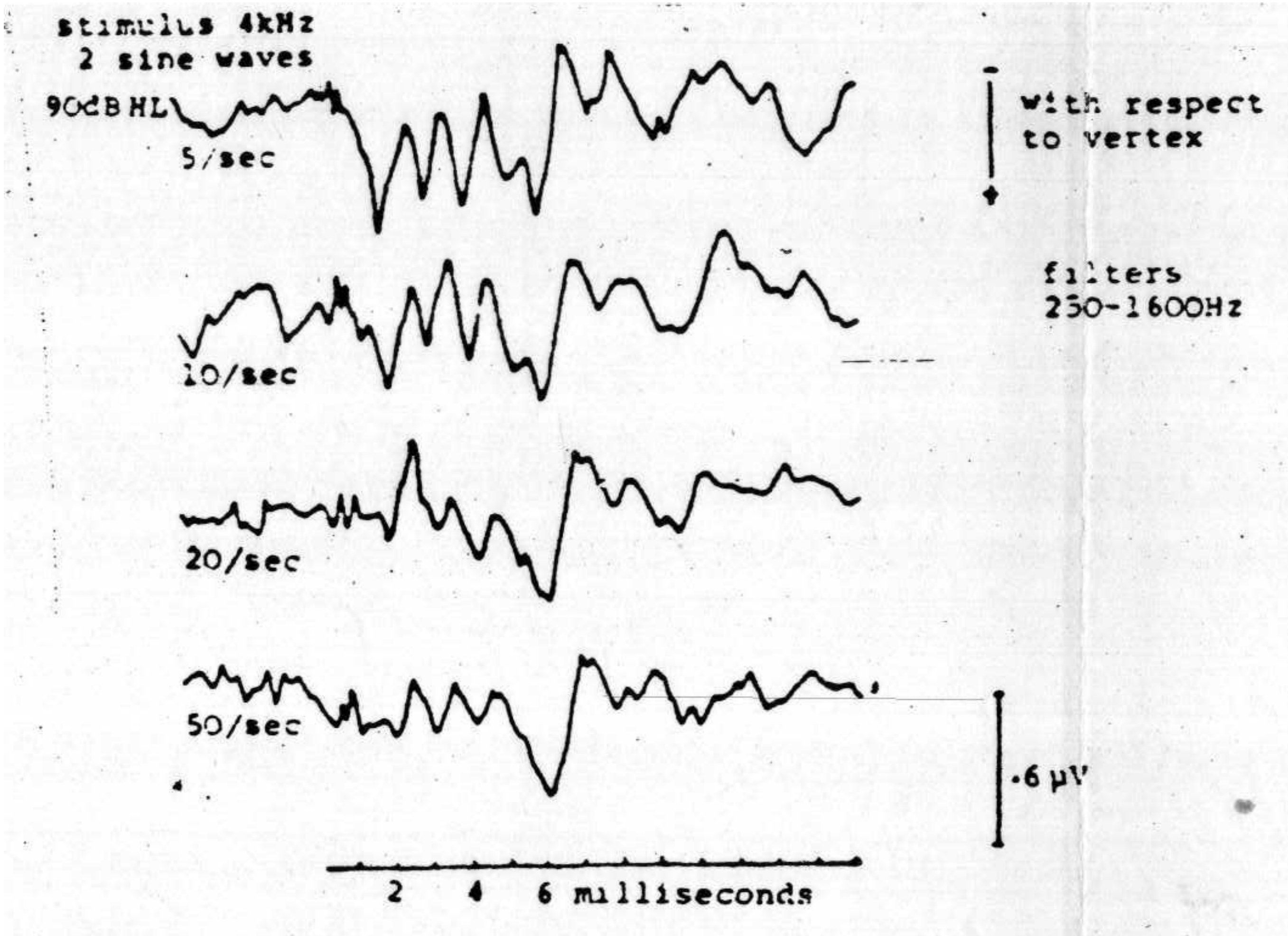
The physiological basis can be exaplained through this. Sensory system requires finite time to recover their responsiveness following an adequate stimulus. If subsequent stimuli occur before recovery is complete the system response will be altered.

Adaptation or fatigue may be the cause of this latency shift induced by rapid stimulation (Fria, 1980).

Procedure Effects include :—

a) position of electrodces.
b) use of filters (band width).
c) choice of response reference points for the compilation of latency and amplitude.
d) difference in stimulus.
e) the effect of masking and or/ambient noise levels.

Figure 6. Effect of varying the stimulus presentation rate on the BER waveform



(Adapted from Gibson, WPR, 1978)

The Effects of Certain Subject Parameter on Evoked Response"

- state of the subject (awake, sleep, sedeted/anesthetized).
- effect of temperature.
- sex.
- age.

(Fria, 1980).

Thus it is seen that the review of literature shows considerable variability in the results with reference to the various parameters affecting ABR.

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CALIBRATION OF BONE CONDUCTION VIBRATOR

CALIBRATION OF SOME CONDUCTION VIBRATOR

Calibration of any measuring instrument is a prerequisite for precision in clinical and research measurements. The aspect of calibration is crucial because without calibrated earphones and bone conduction receivers it is impossible to :—

i) to know whether thresholds of patients are contaminated by faulty equipment,

ii) to know whether apparent changes in hearing over time for a patient are due to true differences in his performance or to variations in the equipment, and

iii) to accurately compare results obtained in one clinic or laboratory with those found in another clinic or laboratory (Wilber & Goodhill, 1967a).

Bone conduction refers to the response of the bones of the skull to audio frequency vibrations, and to the transmission of such vibrations to and reception by the auditory organ (Tondorf, 1972).

Not much affected by the problem of impedence matching, tHe bone conduction results from direct contact between the skull and a vibrating object.

The bone conduction that results from airborne sounds does not occur until the sound pressure is about 60 dB above the air conduction threshold. (Bekesy, 1948). This low sensitivity is result of gross impedence mismatch between the skull and the surrounding air.

The source of error in bone conduction

thresholds arises from :-

1) individual differences in the mass of the head; the thickness, density and elasticity of the bones of the skull; and the thickness of the skin over the mastoid or forehead,
2) ambient noise in the testing room,
3) difficulties in masking the non—test ear,
4) occlusion effect,
5) the type of vibrator employed,
6) the force exerted by the vibrator, and
7) the location of the vibrator on the skull.

Added to this is the lack of international standards for bone conduction calibration and no satisfactory procedure.

2.1 Biological Calibration of Bone Conduction Vibrator:

There are three biological calibration methods:-

1) a loudness balancing procedure advocated by Beranak (1949),
2) averaging the bone thresholds exhibited by subjects with normal hearing and applying the appropriate correction if their air conduction thresholds deviate from ASA 1951, or ISO 1964 norms for air conduction (AMA 1951, Hedgecock 1961), and
3) Testing subjects with pure sensori neural losses for air and bone conduction thresholds using an audiometer with a calibrated air conduction system. (Carhart, 1950).

1. Loudness Balancing Procedure:

It is advocated by Beranek (1949).

In this method the tone delivered by a calibrated earphone is matched in loudness to that of the bone conduction receiver to be calibrated. The correction to be applied to bone vibrator is the discrepancy between the dial reading of the air and bone conduction systems.

2. Averaging Bone Conduction Thresholds:

Exhibited by subjects with normal hearing was specified in the AMA. The AMA requirements define the reference threshold, at each test frequency, as the hearing loss setting of the audiometer representing the average of the bone thresholds obtained on six subjects with normal acuity. Test environment should be free from extraneous sounds of sufficient intensity to initiate the measurements. It was later suggested that appropriate corrections be applied if the air conduction thresholds of the subjects deviated from the ASA 1951 norms for air conduction (Hedgecock, 1961).

3. Testing Subjects with Pure Ssnsori Neural tosses for Air and Bone Conduction Thresholds Using an Audiometer with a Calibrated Air ConductiOn System:

The method was advocated by Carhart (1950) assuming that pure sensori neural loss possesses the same impairment whether tBsted by air or by bone. The procedure involves obtaining both air and bane conduction thresholds (of the better ear), in a reasonably quiet room, on a group of ears with impairments of the sensori neural variety. Using a calibrated air conduction system, the discrepancies between the average air and bone conduction thresholds (at each frequency) represents the correction to be applied to the bone conduction system.

Since these methods have their own disadvantages added to which they are time consuming, physical calibration by artificial mastoids has proved useful as a means of bone conduction calibration.

2.2 Physical Calibration of Bone Conduction Vibrator:

It is the means by which bone conduction system is calibrated using artificial mastoid which stimulates the mechanical impedence of the skin, flesh and bone of the human mastoid. The artificial mastoid is previously calibrated in terms of its output voltage for a given acceleration or force applied to its surface, it is possible to express the human threshold as an equivalent acceleration or force on the artificial mastoid by transferring the bone vibrator to an artificial mastoid.

The requirements for an artificial mastoid were summarised by Dahm (1973) as follows:—

i) the vibrator under test must be presented to the same mechanical impedence as the average human mastoid over the required frequency range, which is usually from 250 HZ to 4000 HZ., and

ii) when the bone vibrator is pressed against the artificial mastoid in the same manner as when fixed to the human mastoid,the motion of the bone vibrator should be indicated in terms of vibration amplitude, velocity acceleration or force by means of a built-in vibration transducer, and

iii) the elements of the artificial mastoid should be stable with time.

The present study has been designed to Compare the bone conduction response and air conduction response when the bone conduction vibrator was connected to the air conduction output jacket.

It is assumed that the hearing level of air conduction and bone conduction which yields same latency value are equal.

The present study establishes the hearing levels for air conduction and bone conduction which produce the same latency valve in the normal hearing subjects.

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METHODOLOGY

METHODOLOGY

3.1 Subjects:

12 subjects (11 females and one male) in the age range of 17 to 23 years were selected for the purpose of this study. The subjects satisfied the following criteria:-

1. They should have audiometrically and otologically normal ears, that is:—
   a) no history of any ear discharge, earache, tinnitus, giddiness, headache, brain damage or exposure to loud sounds, and
   b) hearing sensitivity within 20 dBHL (ANSI, 1969) in the frequencies 500 HZ, 1 KHZ, 2 KHZ, 4 KHZ.
2. no family history of hearing loss, and
3. negative history of epilepsy or other neurological complaints.

3.2 Equipment:

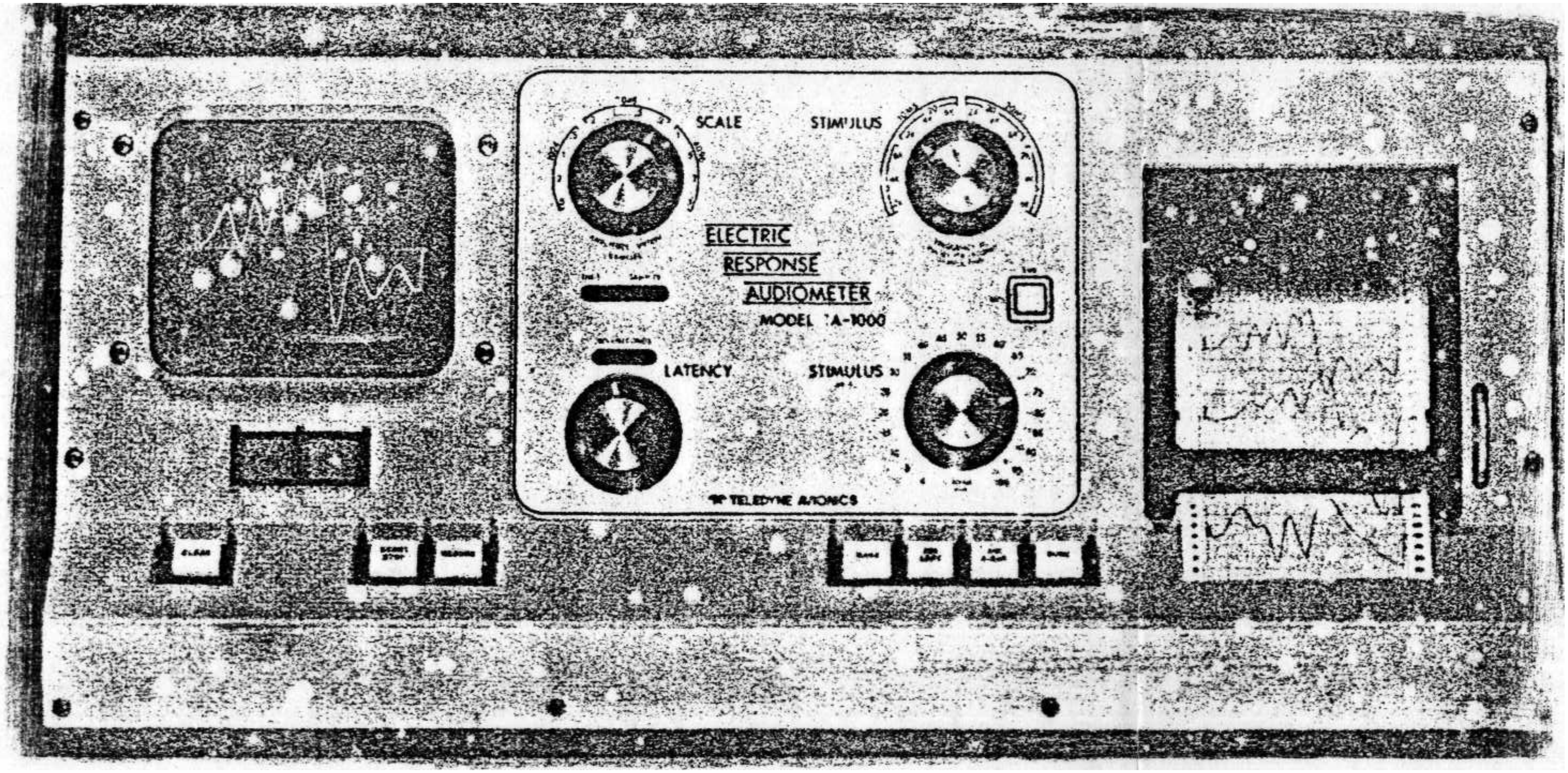
To measure auditory brain-stem evoked responses, an electric response audiometer model TA-1000 was used.(Fig.7)

The equipment consists of a stimulating system (a stimulus generator which feeds the stimuli to a transducer earphone or a bone conductor) and a recording system. The latter consists of electrodes, amplifiers, filters, averager and display together with some device for obtaining a permanent record.

Brief Description of the Equipment:

It consists of a SLZ-9793 desk top console which contains all of the operating controls, indication and readouts for the system. SLZ-9794 preamplifier which is an isolated EEG preamplifier with frequency response and gain specifically designed for ERA. Also a set of standard silver cholride electrodes, TDH-39

Figure 7. Electric Response Audiometer Model TA-1000.



earphones and circumaural cushion MX–41/AR. Calibrated paper to record the responses, electrolyte gel, adhesive tape, spirit and bone conduction vibrator.

Controls and their Operation:

TA-1000 operates on 4 knobs and 9 push button switches.

All knobs are marked to indicate their functions. All such buttons indicate, by means of internal lamps, the active state of the selected function.

The knobs are :-

1) the stimulus function knob which permits selection of frequencies 2 KHZ, 4 KHZ or 6 KHZ at a repetitive rate of 5 or 20 stimuli per second, and patient's response intervals of 10 msec or 20 msec immediately following the acoustic logon stimulus,

2) stimulus attenuation knob permit to establish the presentation level from 0 dBHL to 100 dBHL.

3) the scale function knob which permits selection of system senstivity and number of average response samples, i.e., for 2048 samples 0.2, 0.5, 1 and 2 uV per div. sensitivities are available. for 1024 samples 0.5, 1 and 5 uV per div. sensitivities are available. For 4096 samples 0.1 uV, 0.2 uV, 0.5 uV and 1 uV per div. sensitivities are available, and

4) the latency control knob provides a cursor mark on the oscilloscope display of the BSER wave for a precise determination of latency. Readout of latency in msec to 0.1 msec is displayed in digital form directly above this control.

The Push-Button Switches:

These are:-

1) Power Switch energizes the system and indicates the system status,

2) score switch controls the oscilloscope display,

3) clear push button clears the micro processor averager, memory resets the sample display counter and coc- rects the microprocessor operating mode to correspond to the current control status,

4) start/stop push button initiates the micro processor average function. As the number of samples accumulates, the averager can be stopped to evaluate intermediate results and restarted with- out disturbing the averager action. The averager function is automatically terminated when the selected number of samples has accumulated, or when any average memory channel is full; automatic termination requires a clear to permit restart,

5) record push button indicates the plotter readout of the averager is not active,

6) mask push button applies broad band noise masking to the contralateral ear only when either air left or air right stimulus is active,

7) air left stimulus to left earphone,

8) air right stimulus to right earphone, and

9) bone push button stimulus to bone vibrator transducer.

TA-1000 also has facilities for the following functions besides the ones mentioned earlier:—

i) paper thumb wheel for the chart paper,

ii) limit indicate which is very active at high sensitivities.

iii) TWF/RUN/EEG - normally RUN position is used. When in TWF position after clear, the oscilloscope will display a characterstic test waveform to confirm oscilloscope operations. In EEG position, after clear, the oscilloscope will dis- play the ongoing patients EEG activity, the raw signal from which the averaged response is derived.

3.3 Test Environment:

The study was carried out in an acoustically sound treated dimly lit room. The room was well ventilated so that the subject and the tester were comfortable.

- the test room was away from noise source and electrical appliances such as fans etc. were put off.
- the test room was away from excessive vibrations.
- curtains were drawn to avoid direct sun-light.

3.4 Test Procedur:

Screening at 20 dBHL was carried out to determine the pure tone thresholds.

Subject was asked to relax on a bed with pillow under the neck to encourage the neck muscle to relax. They were required to feel comforbable with electrodes on within 10 -15 msec after their placement.

Surface electrodes were placed. Before placement of the elctrodes the skin and the electrodes was cleaned with spirit. Electrode gel was smeared on the electrode. Each electrode was then fixed to the skin with the help of adhesive tape.

The placement of the 3 electrodes being as follows:-

- Red or signal electrode on high forehead.
- White or reference electrode on mastoid of test ear, i.e. right ear.
- Black or ground electrode on mastoid of non-test ear, i.e. left ear.
- Only right ear was tested.

The earphone for AC logon stimuli and BC vibrator for BC logon stimuli were placed after the red light on the preamplifier and beside the sample counter disappeared.

The power switch was on. The TWF/RUN/EEG Switch was on "RUN" position. The scale switch was set to 2048 samples and 2uV/ division. A sample time of 10 msec was chosen, Since early response of brain-stem was required.

Twelve subjects were divided into three groups of four subjects in each. Each group was tested for a single frequency. The frequency under test was 2KHZ, 4 KHZ and 6 KHZ respectively.

Rate of presentation of stimuli was kept constant throughout the experiment as 5/sec. The experiment was divided into two stages. The first stage involved placement of the vibrator which was in turn connected to the AC socket.

Determination of V peak latency was the aim hence presentation started with the intensity level of 100 dBHL, following which latency values at 80 dBHL and 70 dBHL were also noted.

It was observed that the V peak was not clearly visible after 70 dBHL for BC logon stimuli.

The second stage involved presentation of AC logon stimuli through ear phone at intensity level of 40 dBHL and 20 dBHL so as to find the same latency as that obtained at 70 dBHL BC logon stimuli.

Subjects were tested in a single session lasting for about one hour.

The test data was rejected when :-

i) the limit light flickered often during the testing, and

ii) the counter stopped before reaching 2048 samples.

3.5 Treatment of Data:

The following were determined:-

a) Latency: The latency was measured in msec by positioning the cursor on the desired wave. The calibrated latency Cursor appears on the oscilloscope trace as a function of latency control. The computor provides a digital readout of the cursor's position and this was noted from the display as the respective latency for each peak.

b) <u>Amplitude</u>: Amplitude was measured in uV (micro-volts), the marker amplitude M(l/2/3/4 div) and the amplitude of the desired trace feature 'T' was noted. The scale switch amplitude 'S' (2 uV/div) was noted.

The formula used: Amplitude = TS

From the data so obtained computation for the fallowing was done:-

1) absolute latency value for I, III and V peaks for AC and BC logon stimuli.
2) absolute amplitude value for I, III and V peaks for AC and BC logon stimuli, and
3) absolute latency difference for V peak for AC and BC logon stimuli.

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RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The aim of the study was to establish the norms for BSERA for BC logon stimuli.

The data collected were analysed so as to obtain means and standard deviations for different peaks at different frequencies at constant rate of 5 stimuli/sec.

Table 1 shows the absolute latency values obtained for peak I, III, V at three different intensities of B.C. logon stimuli at 100 dBHL, 80 dBHL and 70 dBHL respectively. The data were collected for three frequencies 2 KHZ, 4 KHZ and 6 KHZ logon stimuli.

Table 2 gives the absolute amplitude values for the B.C. logon stimuli of three groups of subjects for different peaks and frequencies.

The absolute latency and absolute amplitude for different intensities of the A.C. locgon stimuli at 40 dBHL and 20 dBHL for the three groups of subjects at 2 KHZ, 4 KHZ and 6 KHZ respectively. The values fqr I, III and V peaks respectively are shown in Table 3.

The means and standard deviation of absolute latency and absolute amplitude for AC logon stimuli at 40 dBHL and 20 dBHL are shown in Table 4.

Table 5 shows the means and standard deviation of absolute latency and absolute amplitude for BC logon stimuli at 100 dBHL, 80 dBHL and 70 dBHL.

The means and standard deviation of absolute latency and absolute amplitude for AC logon stimuli at 20 dBHL and BC logon stimuli at 70 dBHL are shown in Table 6.

The significance of difference in latencies between AC logon stimuli at 20 dBHL and BC logon stimuli at 70 dBHL is illustrated in Table 7.

It was computed using Wilcoxon matched pairs signed rank test (Siegel, 1956).

Discussion:

The result shows that there is no significant difference in the latency values obtained for AC logon stimuli at 20 dBHL and BC logon stimuli at 70 dBHL.

In other words the BC logon stimuli at 70 dBHL is equivalent to AC logon stimuli at 20 dBHL.

Thus, the present study has established the relationship between AC and BC logon stimuli, which yielded same latency values.

From this study it follows that a BC response obtained at 100 dBHL BC stimulus (the BC vibrator is connected to AC socket) is equivalent to BC threshold of 50 dBHL.

To put it clearly a response to BC stimulus of XdBHL is equivalent to the BC threshold of (X-50)dBHL.

Example I:

If a response is obtained to BC stimulus of 90 dBHL (the BC vibrator is connected to AC socket), it should be interpreted as a response to the BC stimulus of 40 dBHL i.e. 90-50 = 40 dBHL.

Example II:

If a response is obtained to BC stimulus of 80 dBHL (the BC vibrator is connected to AC socket), it should be interpreted as a response to the BC stimulus of 30 dBHL, i.e. 80-50 = 30 dBHL.

Since many studies show that the absolute amplitude values are not reliable, the amplitude values are not considered in this study.

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TABLE 1: Absolute Latency Values for I, III and V Peaks for BC Logon Stimuli.

Peak	Intensity of BC logon stimuli (dBHL)	Gr.I	2K	Gr.II	4K	Gr.III	6K
I	100	1		l		1	
		2		2	not clear	2	not clear
		3	1.3	3		3	
		4		4		4	
	80	1		1		1	
		2	2.3	2	not clear	2	not clear
		3		3		3	
		4		4		4	
	70	1		1		1	
		2	not Hear	2	not clear	2	not clear
		3		3		3	
		4		4		4	
III	100	1	2.7	1		1	3.9
		2	3.5	2		2	
		3	3.3	3		3	
		4	—	4	4.5	4	
	80	1	4.6	1		1	
		2	4.1	2	not clear	2	not clear
		3		3		3	
		4		4		4	
	70	1		1		1	
		2		2	not clear	2	not clear
		3		3		3	
		4	5.8	4		4	
V	100	1	5.6	1	5.5	1	5.6
		2	5.6	2	5.8	2	5.4
		3	5.3	3	6.0	3	5.7
		4	5.8	4	5.7	4	5.8
	80	1	7.4	1	6.8	1	6.5
		2	7.3	2	6.9	2	6.4
		3	7.4	3	6.2	3	6.5
		4	7.0	4	6.5	4	6.5
	70	1	7.5	1	7.2	1	7.3
		2	7.2	2	7.4	2	7.0
		3	7.5	3	6.7	3	7.5
		4	7.5	4	6.9	4	7.0

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TABLE 2: Absolute Amplitude Value for I, III and V Peaks for BC Logon Stimuli

Peak	Intensity of BC logon stimuli (dBHL)	Gr.I	2K	Gr.II	4K	Gr.III	6K
	100	1		1	not clear	1	not clear
		2		2		2	
		3	0.03	3		3	
		4		4		4	
	80	1		1	not clear	1	not clear
		2	0.03	2		2	
		3		3		3	
		4		4		4	
	70	1	not clear	1	not clear	1	not clear
		2		2		2	
		3		3		3	
		4		4		4	
III	100	1	0.20	1	not clear	1	not clear
		2		2		2	
		3	0.03	3		3	
		4		4		4	
	80	1	0.20	1	not clear	1	not clear
		2	0.01	2		2	
		3		3		3	
		4		4		4	
	70	1		1	not clear	1	not clear
		2		2		2	
		3		3		3	
		4	0.04	4		4	
V	100	1	0.15	1	0.17	1	0.10
		2	0.05	2	0.04	2	0.13
		3	0.06	3	0.63	3	0.26
		4	0.30	4	0.15	4	0.08
	80	1	0.30	1		1	0.10
		2	0.05	2	0.28	2	0.20
		3	0.23	3	0.30	3	0.20
		4	0.13	4	0.10	4	0.08
	70	1	0.20	1	0.13	1	0.17
		2	0.02	2	0.20	2	0.12
		3	0.27	3	0.30	3	0.05
		4	0.10	4	0.15	4	0.12

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Peak	Inten-sity-AC logon stimuli (dBHL)	Gr. I	2K (Ampli-tude (uV)	2K Laten-cy (msec)	Gr.	3K Ampli-tude (uV)	3K Laten-icy (msec)	Gr. III	6K Ampli-tude (uV)	6K Late cy (msec
1	40	2 3 4	not	clear	1 2 3 4	not	! clear	1 2 3 4	not cl	ear
	20	1 2 3 4	not cl	ear	1 2 3 4	not cl	ear	1 2 3 4		
III	40	1 2 3 4	not clear	4.6	1 2 3 4	not cl	ear	1 2 3 4	not cl	ear
	20	1 2 3 4	no clear	5.9	1 2 3 4	not cl	ear	1 2 3 4	not cl	ear
V	40	1 2 3 4	0.40 0.44 0.33 0.56	6.4 6.3 6.3 6.3	1 2 3 4	0.17 0.30 0.47 0.20	6.2 6.3 6.2 6.2	1 2 3 4	0.23 0.44 0.10 0.30	6.3 6,7 6.3 6.1
	20	1 2 3 4	0.13 0.23 0.25 0.17	7.1 7.2 7.2 7.6	1 2 3 4	0.04 0.26 0.18 0.13	7.0 7.5 6.4 7.0	1 2 3 4	0.08 0.03 0.01 0.18	7.3 7.2 7.1 7.1

TABLE 4: Mean and S. D. for Absolute Latency and Absolute Amplitude for AC Logon Stimuli.

Peak	Intensity	2K				4 <				6K			
		Latency		Amplitude		Latency		Amplitude		Latency		Amplitude	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D;	Mean	S.D.
1	40												
	20												
III	40												
	20												
V	40	6.32	0.04	0.43	0.08	6.22	0.64	0.28	0.12	6.35	0.22	0.27	0.12
	20	7.28	0.19	0.20	0.05	6.98	0.39	0.15	0.08	7.18	0.08	0.08	0.07

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TABLE 5: Mean and S.D.for Absolute Latency and Absolute Amplitude for BC Logon Stimuli.

Peak	Intensity	2K				4K				6K			
		Latency		Amplitude		Latency		Amplitude		Latency		Amplitude	
		Mean	5.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
I	100	1.3											
	80	2.3		0.03									
	70			0.03									
III	100	3.17	4.35	0.12	0.09	4.5				3.9			
	80	4.35	0.25	0.10	0.10								
	70	5.8		0.04									
V	100	5.58	0.18	0.14	0.10	5.76	0.18	0.24	0.21	5.63	0.15	0.14	0.07
	80	7.28	0.16	0.18	0.10	6.60	0.27	0.23	0.09	6.48	0.04	0.14	0.08
	70	7.4	0.13	0.15	0.10	7.05	0.27	0.20	0.06	7.20	0.21	0.11	0.04

TABLE 6: Mean and S.D. for Absolute Latency and Absolute Amplitude for AC and BC Logon Stimuli.

Peak	Intensity	2K				4K							
		Latency		Amplitude		Latency		Amplitude		Latency		Amplitude	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	
V AC	20 dBHL	7.28	0.19	0.20	0.05	6.98	0.39	0.15	0.08	7.18	0.08	0.08	0.07
BC	70 dBHL	7.4	0.13	0.15	0.10	7.05	0.27	0.20	0.06	7.20	0.21	0.11	0.04

TABLE 7: Significance of Difference in Latencies between AC and BC Logon Stimuli for V Peak.

	Intensity	2K	4K	6K
AC	20 dBHL	*	*	*
BC	70 dBHL	*	*	*

KEY: * Indicates no significant difference (P>0. 01)

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The study aimed at establishing the norms for BSERA for BC logon stimuli.

Twelve subjects with normal hearing in the age range of 17 years to 23 years were selected for the purpose of the study. Three groups with four subjects in each were used. Each group was tested for a single frequency. The frequencies under test were 2 KHZ, 4 KHZ and 6 KHZ respectively. BC logon stimuli at 100 dBHL, 80 dBHL and 70 dBHL and AC logon stimuli at 40 d3HL and 20 dBHL were used. The response latency and amplitude of 1, III and V peaks of BSERA at rate of 5/sec were recorded. The response of 2048 stimuli was summed up.

While determining the BC thresholds using TA-1000 ERA system, the BC vibrator is to be connected to the AC socket.

A 50 dB correction should be applied to the hearing level at which responses are observed. Since 50 dB correction is to be applied, the maximum hearing level which can be tested for bone conduction testing is limited to 50 dBHL, i.e., 100-50= 50 dBHL.

Implication of the Study:

In addition to furnishing an estimate of the air bone gap in adults with conductive hearing loss, ABR by BC can contribute valuable information in certain difficult to evaluate cases where ABR by air conduction alone is ambiguous. (Mauldin and Jerger, 1979).

Clemis and Mitchell, 1977 "recently described problems that arise from conductive hearing loss, when ABR is used in the diagnosis of acoustic tumor. Latency increase due to conductive losses can be a source of false positives in this application of ABR. The use of BC signals offer a solution to this problem. For inter-aural latency comparison the ABR to BC clicks may be recorded separately for each ear with the use of appropriate masking. The two intency-latency functions may be directly compared before or after latency correction. In addition, the corrected BC latency-intensity function on the ear in question may be compared with the latency-intensity function of normal subjects. The use of AC alone does not allow these comparisons to be made".

Another area where ABR by BC can be of great value is in the evaluation of infants, Wave V latency increases as gestational age decreases and also conductive loss increases Wave V latency. This may confuse the investigator dealing with infants. A valid estimate of air bone gap is thus indicated (Mauldin and Jerger, 1979).

In mixed loss cases, the cochlear loss will result in elevation of the ABR threshold. Further the summed threshold elevation may exceed the output capability of the AC signal system. BC signal is not affected by the conductive loss and needs to only exceed the cochlear threshold to elicit a response. It thus allows prediction of cochlear sensitivity. This way be important in a young child with congenital atresia where other technique of estimating cochlear function cannot be used (Mauldin and Jerger, 1979).

Limitation:

ABR with BC is not without its limitations. The maximum output of BC is less than AC output. At higher intensity levels electrical artifacts from signal transducer may present a significant problem. BC signals in ABR delivered by BC result in binaural stimulation. To record ABR one ear (non-test) must be masked.

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