INTERAURAL AMPLITUDE AND LATENCY DIFFERENCES IN BRAIN-STEM EVOKED RESPONSE IN NORMAL HEARING SUBJECTS

Reg. No 11

An Independent Project Work as 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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D E D I C A T E D

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M Y G R A N D F A T H E R

C E R T I F I C A T E

This is to certify that the Independent Project entitled:

"Interaural Amplitude and Latency Differences in Brain Stem Evoked Response in Normal Hearing subjects".

is the bonafide work, done in part fulfilment for First year M.Sc., Speech and Hearing, of the student with Register Number.

DIRECTOR
All India Institute of Speech & Hearing,
Mysore - 570 006.

C E R T I F I C A T E

This is to certify that the Independent Project entitled:

"Interaural amplitude and latency differences in Brainstem evoked response in normal hearing subjects"

has been prepared under my supervision and guidance.

DECLARATION

This independent project entitled "Interaural amplitude and latency differences in brainstem evoked response in normal hearing subjects"

is the result of my work undertaken under the guidance of Mr, M.H. Vyasamurthy, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore - 570 O06, and has not been submitted at any University for any other Diploma or Degree.

MYSORE Register No.

DATED:

A C K N O W L E D G E M E N T S

I express my deep gra€itude to Mr. M.N. Vyasamurthy, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore for his invaluable guidance.

I take this opportunity to thank all the people who helped in the completion of this project at various stages.

Dr. N.Rathna - Director, All India Institute of Speech and Hearing, Mysore.

Dr.(Miss) S. Nikam, Prof, and Head, Department of Audiology, All India Institute of Speech and Hearing, Mysore.

My grateful thanks fere due to all the subjects, Mr.Bhushan and my friends for their help, encouragement and moral support.

I extend my grateful thanks to Ms.Rajalakshmi R.Gopal and Mr.Ramakrishna R.Gopal who patiently deciphered, typed the manuscript and bound.

CONTENTS

INTRODUCTION

Since Catan described the electrical activity of the brain in 1875, Neurophysiologists have slowly accumulated a significant amount of information regarding the neuro-physiology, anatomy and bioacoustics of hearing.

The aim of Electric Response Audiometry is to record the potentials which arise in the auditory system as a result of sound stimulation.

There are 3 types of Electric Response Audiometry(ERA)!

1. Electrocochleography.
2. Brainstem evoked response audiometry.
3. Cortical evoked response audiometry.

In Brain-stem Evoked Response Audiometry (BERA) far field, specifically generated. Electrical Impulses thought to reflect neurophysiologic events which take place in the auditory pathway in response to sound stimuli are recorded within 10 ms. The key to Brainstem responses is synchreni-sation.

Because of its relative lack of variability and its immunity to such non-auditory factors as attention, state of conciousness and sedation, the Auditory Brainstem Response (ABR) which is generally recorded from the vertex has attracted increasing interest as a diagnostic tool (i.e. in establishing the hearing threshold in infants and subject unco-operativeness for the routine audiometry and in otoneuro-logical diagnosis).

The effect of neurologic dysfunction on atleast three Auditory Brainstem Response(ABR) latency measures have been reported.

1. Absolute wave V latency
2. Interaural wave V latency difference (ILD)
3. Interwave latency between waves I and III; III and V; and/or I and V.

Emphasis on the Interaural latency difference (ILD) is a common method in studies, which deal with the effects of cerebellopontine angle lesions (Clerais and Mc.Gee, 1979; House and Brackman 1979; Selters and Brackman 1977, 1979; Thomsen et al 1978; Rosenhamer 1980).

Interwave latencies are the primary response criteria in studies of patients with lesions affecting the entire auditory pathway (Black et al 1979; Ochs et al 1979; Starr 1976, 1977; Starr and Achorl975? Starr and Hamilton 1976; Stockard and Rossiter 1977; Stockard et al 1976, 1977; Uzil and Benezech 1978). (as cited in Fria 1980)

The Interaural latency difference (ILD) measure (when compared with those of other special tests) demonstrates the best true positive rate (around 93%) Clemis and Curtis 1977).

When it can be applied, the ILD is a more sensitive measure than absolute latency (Clamis and McGee 1979).

The nature of the stimulus, recording procedure and subjects evaluated all have associated effects on the ABR.

Rowe (1978) observed morphological differences between ears.

Absolute amplitude [measures show wide variation between and within subjects (Amadeo and Shagass, 1973; Starr and Achor 1975). Relative amplitude measures are more consistent

between subjects and within the same subject on different occasions (Starr and Achor 1975; Stockard et al 1978b).

ABR changes related to stimulus intensities have been studied by various authors (Jewett and Williston 1971; Jewett et al 1970; Hecox and Galambos 1974; Picton et al 1977; Starr and Achor 1975; Yamada et al 1975; Rowe 1978; Stockard et al 1978b, 1979; Wolfe et al 1978).

Brainstem responses have frequency components distributed in a frequency range that extend from about 10Hz to 2KHz (Elberling 1979; Osterhammel 1981). Most workers agree that frequency specific responses may be obtained using tone bursts of 2KHz or higher. (Davis and Hirsch 1975; Parker 1976; Weber and Folsom 1977; Mair et al 1980; Cobb et al 1978) found no apparent frequency effect on the ABR.

The difference between ABR properties for male and female subjects haw been investigated by many authors (Beagley and Sheldrake 1978; Stockard et al 1978b, 1979; McCoelland and McCrea 1979; Jerger and Hall 1980).

The ILD is non-contributory in cases with bilateral lesions. In "the ILD is more likely to lead to ambiguities when the patient's audiometric loss is unknown and criteria based on ILD assume that a series connection is the only linkage between neural generators of the response. Stockard et al (1977) point out that the neural generators of the ABR are connected in parallel as well as in series.

The detection of ABR abnormalities compatible with neurologic lesions can be based on the following criterion response measures.

(1) I-III, III-V and I-V interwave latency.
(i) The difference between ears for these interwave latencies (f.stockard et al 1978b) and
(3) the relative amplitude ratio of waves V and I.

The application of these response measures to the clinical setting requires the selection of cut-off values that are anticipated to distinguish normal and abnormal results with minimal error.

The variation in ABR parameters between studies emphasizes that normative values are not comparable across laboratories using different equipments.

The need for the present study:

1. Clinical utility of the ILD test has been demonstrated previously by many studies. (Selters and Brackman 1977, 1979; Clemis and McGee 1979; Thomsen et al 1978; Rosenhamer 1980; Mair et al 1980).

2. Normative data for ABR have been found to vary with regard to the type of equipment used; hence there is an urgent need for establishing the normal ILD using TA-1000.

The study was focussed on the following questions:

1. What is the range of the Interaural amplitude and Interaural latency differences in normal subjects?

2. What would be the mean values of Interaural latency difference, Interwave latency; Interaural Interpeak latency and relative amplitude in normal hearing subejcts?

TERMS USED:

Response Latency:- The time relationship between any response and the stimulus eliciting that response.

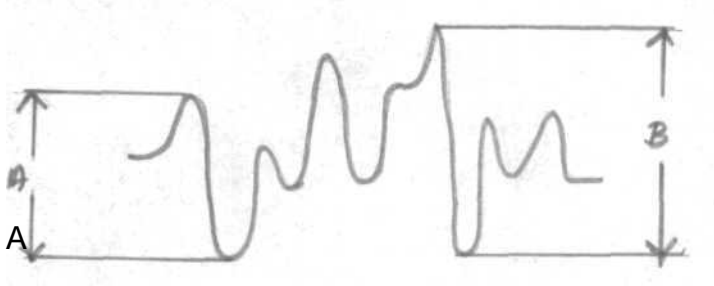
Absolute latency:- Refers to the time relationship between stimuli onset and associated response.

Interwave Latency:- Refers to the time difference between(Interpea latency,(IPL)used synonymously with Interwave latency)2 component waves(expressed in M.secs.).

Interaural absolute latency difference (ILD):- Refers to the difference in absolute latencies of the ABR response between the 2 ears, at idental stimulus parameters.

Response amplitude:- Refers to the height of a given wave component (usually measured in micro volts), i.e. measured from the peak of the wave to the following trough.

Relative amplitude:- The absolute amplitude of ABR components waves are expressed in relation to one another.



A & B = absolute amplitude

Relative Amplitude= B

Interaural Amplitude Difference (IAD):- Refers to the difference in amplitude for the ABR between the 2 ears at identical stimulus parameters.

Interaural Interpeak Latency Difference (IIPL):- Refers to the difference in Interpeak latencies for ABR between the 2 ears.

Interaural Relative Amplitude Difference (IRAD) :- Refers to the difference in relative amplitudes for the ABR between the 2 ears.

REVIEW

The brief review in this capter cavers the following aspects:

1. History

2. Anatomical origins of Response Components.
   a) Human studies
   b) Animal studies

3. Technical aspects of ABR

4. Normal Response Parameters:
   a) Response Morphology
   b) Response Latency
   c) Response Amplitude.

5. Factors affecting Normal Parameters.
   a) Stimulus Effects
   b) Procedure Effects
   c) Subject Effects

6. Clinical Application

History:

The presence of electrical potentials in the brain was first noted by Eaton (1875) who recorded electrical changes in the exposed brain of rabbits and monkeys. The history of the Brainstem responses began in 1967 with the work of Sohmer and Feinmesser in Jerusalem. Jewett (1970) postulated on the basis of cat recordings that there were 4 positve waves following action potential which he related to specific generators within the Brainstem. Jewett and Williston (1911) showed that acoustically generated "early" potentials could be detected from a wide area of the skull.

Further studies in humans by Jewett, Romano and Williston, Sohmer and Feinnesser and associates, Hecox, Galambos (1974) and associates, Starr and Achor (1977) and others have shown that these responses are reliable clinical indicators of both normal and pathological conditions in the peripheral auditory system.

Hecox and Galambos (1974) used the term Brainstem auditory Evoked responses; Later on they changed it to Acoustic brainstem electrical responses. The international ERA study group (Davis 1971) favour the term electric response audiometry.

The commonest abbreviation in recent literature is brain-stem Electrical Responses - BSER or BER.

Anatomical Origins of Response Components:-

Since a long time, various investigators have speculated about the origin of ABR components.

Animal studies:-

Many investigators have investigated the neural generators in animals. (Jewett 1970: Lev and Sohmer 1972: Buchwald and Huang 1975, Starr and Achor 1978; Allen and Starr (1978). as cited in Fria 1980).

Human studies:-

Martin and Coats 1973; Martin and Moore, 1977; Picton et al 1974; studied the topographical analysis of scalp distributions of human ABRs.

Picton et al concluded that waves I through IV represented activity of the auditory nerve and Brainstem nuclei, but the ABR waves recorded from vertex to mastoid reflected the composite contribution of multiple generators. Goff et al 1977 strongly indicated a subcortical lemniscal origin for the ABR wave components.

Many investigators (Jewett 1970; Lev and Sohmer 1978; Achor and Starr 1978) assign a specific correspondence between given ABR component waves and specific neural generators.

A diagrammatic representation of this correspondence is shown in the figure as described by Jewett 1970; Starr and Achor 1978.

It is a fast wave, polyphasic response with a latency from about 1-10 m.sec. and a peak to peak amplitude from about 50 manovolts to over /microvolt. Largest amplitude occurs at peak V which is robust against stimulus rate (Hyde et al, 1976) and the effects of masking (Parker and Thornton 1978a) and it shows little adaptation(Thornton and Coleman 1975) and cam be detected at stimulus levels close to audiometric threshold (Lev and Sohmer 1972).

Summary of some physiological features relevant for interpretation of ABR in man in physiological and anatomical terms:

The generators of ABR are localised to nerve cell bodies in the relays of the auditory pathway. The major source is depolarisation of the cell bodies, excitatory and inibitory post synaptic potentials and depolarisation of presynaptic

FAR-FIELD RECORDING OF AUDITORY BRAIN STEM RESPONSES

LATENCIES MEASURED IN HUMAN SUBJECTS

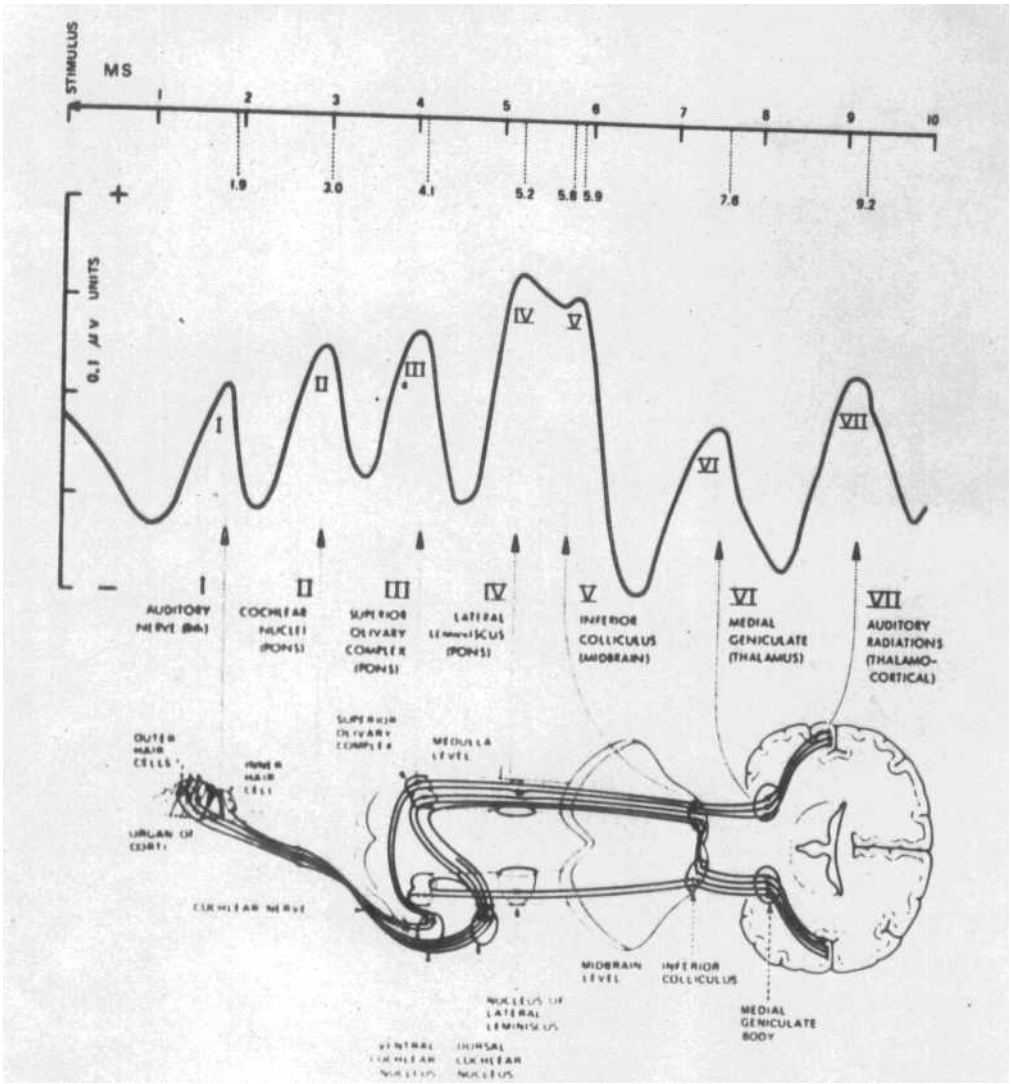


Fig:- Anatomic correlation of components of short latency auditory evoked response (ref.Keith, R.W., Central auditory dysfunction. New York, Grune and Stratton, INC, P.11, 1977).

terminals may contribute. The time schedule for the leading volley of action potentials following a click stimulus is the framework needed for interpretation of ABR in morphological terms.

A click stimulus is transformed to a transient oscillation on the basilar membrane (Prior to the sound reaching the inner ear, it is influenced by the resonant characteristics of the sound transmission system).

It generates a volley of a action potentials the leading front of which, generated in the high frequency region sets up a field potential.

In the brainstem relays especially superior olivary complex, several groups of synchronised units fire with some delay causing multiple local field potentials. These oscillating potentials summate vectorially to form the surface recorded far field potential (ABR) Wave II to V are generated by activity in several relays.

Technial aspects of ABR:

Basically the equipment consists of one part which records the responses (electrodes, amplifiers, filters, averager, display and permanent recording device) and a separate part which provides the necessary sounds to evoke the response (an audio-

meter which feeds the sounds to a transducer - eg. earphone or bone conductor).

The test environment:

The subject is best tested in a relaxed position which will minimise any myogenic activity. Usually the subjects are asked to relax on a coach and the testing is performed in a darkened room.

The stimulus generation:

Stimulus requirements:

BER can only be satisfactorily obtained by using a very brief stimulus with sharp onset characteristics. At present clicks, filtered clicks and tone bursts are being used to obtain BER.

Stimulus signal:

Broad Band Click:

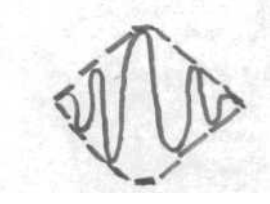
(Unfiltered Click) This stimulus is usually generated feeding a rectangular electric impulse most often with a duration in the range 0.1 to 0.2 ms. to the earphone. Such an electric impulse has a very well defined time course and a broad and flat frequency spectrum.

Filtered Click:

A filtered click is a rectangular impulse fed to a band-pass filter with a certain center frequency and Bandwidth . Thus activated the filter output will be a series of center frequency equal to the filter center frequency, with very brief - rise and an exponentially decaying amplitude.

Tone Pips:

It is generated by feeding one period of a sinusoid of a certain frequency into a band pass filter centered at the same frequency. (Davis and Hirsh 1979).

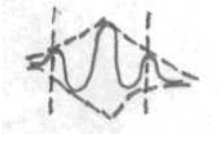


Constantly 2 periods during rise/ decay and 1 period duration.
(=Logon approximation)

Tone burst:

The term tone burst implies a brief tone pulse with controlled envelope i.e. rise time, plateau or duration and fall time. The longer these times are, the more narrow is the frequency spectrum of the signal.

Logon Stimulus:-



Pure tone modulated with a gaussian distribution/curve.

Disadvantage: Starting point is not defined.

Dennis Gabor (1947) showed that the simplest acoustic signal (mathematically) with the most efficient compromise between epoch ("point in time") and defenite frequency, is what he calls a "logon".

A logon is a pure tone that is amplitude modulated in time by a Guassian probability function. The standard deviation of this envelop may be large or small.

The simplest method to produce this is to excite or "ring" a passive electrical narrow band filter with a rectangular pulse of appropriate duration. The high pass and low pass cut off frequencies are set to allow only a narrow pass-band, and the duration of the pulse is about a cycle of the centre frequency of the pass band.

Stimulus transducer:

Care has to be taken to shield the transducer with mu-metal which reduces the magnetic field and earphone types with high electric impedance help to over came artefacts. (as cited in Lundborg These may be piezoelectric earphones (Hughes & Fino 1980) or electrostatic earphones (Talkin et al 1980). If a loudspeaker is used (Thornton 1975a) an anechoic test chamber is essential.

Stimulus presentation through Bone conduction is a possibility in ABR. Mauldin and Jerger cited in Frier (1979). Masking of the non test ear is necessary.

Stimulus Repetition rate:

It is permissible to use a stimulus repetition rate of 50/sec. The problem of using stimulus rates in excess of 50/sec. is that myogenic responses such as post aural response become superimposed on the recordings making inter-pretation hazardous.

When ABR is to be employed as a neuro-otological tool, where in it is necessary to obtain all the peaks, a rate of 10/sec. is advised. In clinical practice repetition rates in the range of 10-20 /sec are most commonly used.

Stimulus polarity:

In practical use, stimulus is very often presented with alternating so that any stimulus artefact, that may be picked up by the recording electrodes is effectively cancelle out in the averaging of responses to an/equal number of +Ve ar -Ve going stimuli.

Stimulus Level:

It can be expressed in (1)dBHL (2) dBSL (3) dB Pe SPL.

Stimulus calibration :

Most workers use a physiological calibration for the transient stimuli and once this calibration is made, a physical means of maintaining the accuracy on a day to day basis is followed. Calibration in 5dB steps is adequate.

Masking Random Noise:

The apparatus must include provision for the application of masking noise to the non-test ear if monoaural information is sought.

For clicks, wide band masking is necessary, for tone bursts or pips narrow band masking is required. High and low pass masking can also be used to increase the frequency selectivity of BSER.

The recording equipment:

Recording or pick up electrodes most commonly used are the disc type attached to the surface of the intact scalp. It is critical that the surface of the scalp be carefully that the surface of the scalp be carefully) cleaned chemically in the areas where electrodes are to be attached. Electrode paste is used to serve as an electrolyte to conduct the potentials between the scalp and the electrode. Usually the active electrode or pick up electrode is placed on the vertex. The

reference electrode is placed on a relatively inactive area usually on the mastoid. The voltage or the potential changes between these electrodes provide the input for the amplifier and are the first stage inthe input. A third electrode is used to ground the subject to reduce the effect of the body as an antenna. The electrode impedance should ideally be 2.5K or less.

Electrode Polarity:

ABR is a bipolar recording and the electrodes are defined as plus and minus electrodes. This defenition is based on how they are connected to the amplifier. International Electric Response Audiometry recommends positi vity on the scalp to be displayed upwards.

Amplifiers:

The characteristics of the amplifier input stage are of vital importance with regard to noise generation, signal distortion, and sensitivity to external electrical artefacts.

Preamplifier specifications:

1. High gain, not less than 100dB
2. High common mode rejection not less than 100 dB.
3. High input impedance not less than 200 Mohms.

Filter settings:

The high pass filter is commonly set at 100-500Hz, which helps exclude low frequencies which may contain artefacts for eg. 50 Hz mains interference. Digital filtering may be performed by the computer before or after the averaging of responses (Doyle & Hyde 1981).

Analog to digital conversion:

The amplified bioelectric signal is a continuously varying voltage an analog signal. The signal analysis to follow is based on digital technique and consequently, analog A/D conversion has to be performed. This conversion of continuous data into discrete numbers is done in 2 steps.

Sampling of the analong signal with a certain sampling frequency, which has to be chosen with regard to the bandwidth of the analog signal.

The II step of the A/D conversion is the quantisation, where the observed value of a sample is converted to a numeric value.

The Averager:

Averaging is the type of signal analysis most commonly used to improve the S/N ratio sufficiently to allow a response

to be identified. It summates and stores the incoming results from the pre-amplifier. Main memory should have sufficient number of bits/addresses to avoid overflow of the and consequent clipping of the response. The analysis period required varies from 20 m.secs. for young babies to 10 m.sec. for the majority of adult work.

The Monitor Oscilloscope:

The ongoing record is mainly a mixture of EEG signals and myogenic activity. Once experience has been gained, it becomes quite simple to detect abnormalities and sudden changes of this signal which may lead to artefacts contaminating the averaged response.

Artefact refection facilities:

Automatic artefact rejection eliminates sweeps where the amplitude exceeds a certain limit, presumably due to noise or movement artefacts.

Permanent recording of results:

Permanent records of the averager display may be of 2 types:

1. Pen recording provided by the so called X-Y Plotter.

2. Photographic Prints: Photographing the response as it is displayed on an oscilloscope.

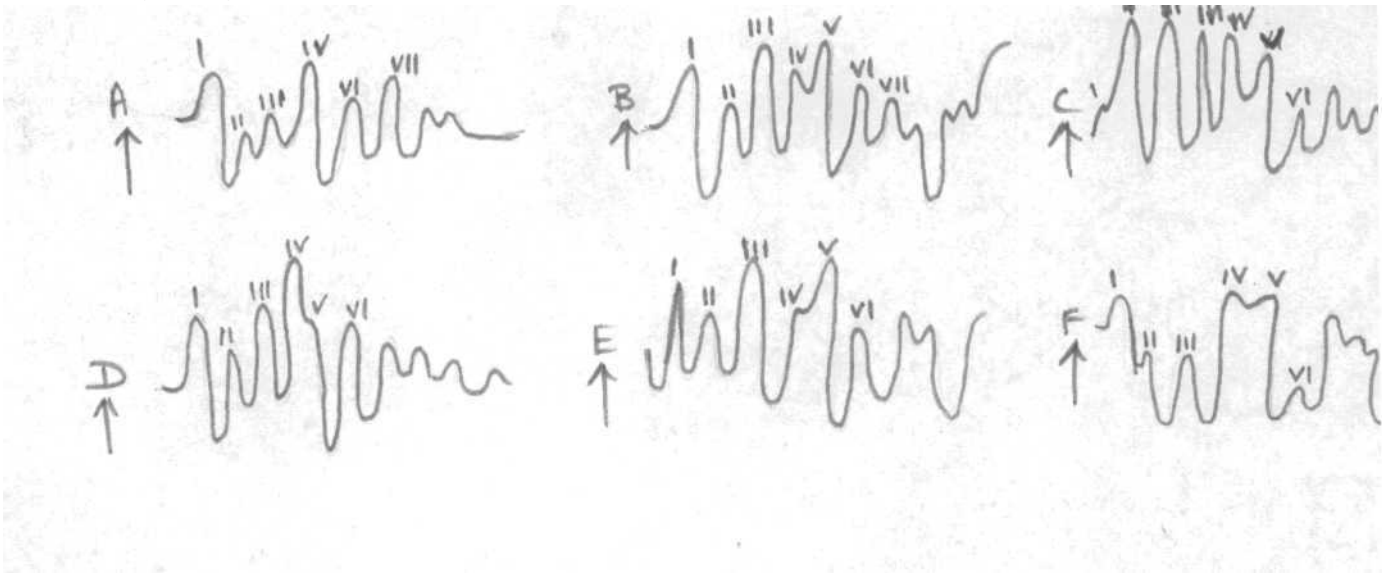
Normal Response Parameters:

The appropriate use of the ABR in the clinic involves the recognition of abnormal results which inturn depends on a knowledge of normal ABR characteristics. The clinician must also be aware of the variability of normal characteristics between and within subjects and the variability due to non-pathologic factors such as the nature of the stimulus, recording procedure, subjects etc.

Response Morphology;

Morphology refers to visual appearance or waveform. It is a subjective parameter.

Chiappa et al (1979) described 6 variant forms in normal young adults. - ^ t ^,



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

B) separate IV and V waves with wave IV lower than Wave V;

c) separate waves with wave IV higher than V;

D) Wave V riding on wave IV;

E) Wave IV riding on wave V;

F) Separate waves of the same height.

Rowe (1978) observed morphological differences between ears in approximately 20% of the 25 normal adult subjects evaluated waves I through V were clearly defined in the right ear responses, but waves II and IV were poorly defined in left ear responses.

Response Latency:

The time relationship between any response and the stimulus eliciting that response is commonly called latency.

Absolute latency:

Refers to the time relationship between stimulus onset and associated response.

Interwave latency:

Refers to the time difference between 2 component waves. The unit of measurement for latency is mili seconds.

Several authors noted in the table below reported the mean absolute latency values for normal young adults.

Normal ABR latencies from ten different labs:-

	Click intensity						
	dBSL	I	II	III	IV	V	VI
Jewett & Williston(1971)	70	1.5	2.6	3.5	4.3	5.1	6.5
Lev & Sohmer(1972)	65	1.5	2.5	3.5	-	5.0	6.7
Picton et al (1974)	60	1.5	2.6	3.8	5.0	5.8	7.4
Starr & Achor(1975)	65	1.6	2.8	3.8	4.8	5.5	7.1
Stockard & Rossiter(l977)	60	1.9	3.0	4.1	5.2	5.9	7.6
Rosen hamer et al(1978)	60	1.7	2.9	3.9	5.2	5.9	7.6
Rowe(l978)	60	1.9	2.9	3.8	5.1	5.8	7.4
Stockard et al(1978)	60	1.8	2.9	3.9	5.2	5.8	-
Chiappa et al (1979)	60	1.7	2.8	3.9	5.1	5.7	7.3
Bergholtz(1981)	65	1.8	2.9	4.0	5.2	5.9	

Starr and Achor, 1975? Rosenhamer et al 1978; Rowe 1978; Stockard et al 1978a; Chiappa et al 1979 observed approximately the same standard deviation for all ABR component waves which was around o.3 m.sec or less. Contrary to this Lev and Sohmer (1972), Amadeo and Shagess, 1973; observed greater standard deviations for waves beyond III and this may be attributed to the IV-V complex being labelled as one wave.

The variation between studies for at given ABR latency may be due to several reasons:

(1) Number of subjects evaluated

(2) Stimulus used

(3) Stimulus intensity

(4) Filter settings

(5) Various choices of stimulus and response reference points.

Response amplitude:

Response amplitude refers to the height of a given wave component, and it is usually measured in microvolts.(µV) - from the peak of the wave to the following trough (if the vertex +Ve waves are displayed as upward deflections). This measurement is called absolute amplitude.

Relative amplitude:

Here the absolute amplitude of ABR component waves are expressed in relation to one another.

Relative amplitude is the ratio of the absolute amplitudes for 2 ABR waves.

In this fig. Relative amplitude = B
A

Absolute amplitude measures show wide variation between and within subjects. Amadeo and Shagass, 1973; Starr and Achor 1975. Relative measures are more consistent and are better indices for comparing amplitude phenomena between subjects and within the same subject on different occasions (Starr and Achor 1975, Stockard et al 1978b).

Factors affecting Normal Parameters:

The nature of the stimulus, recording procedure and subjects evaluated all have associated effects on the response.

Stimulus Effects:

Pertinent stimulus characteristics include intensity, repetition rate, polarity, envelope (rise fall time and duration) and presentation mode (Monaaural vs Binaural) certain characteristics have an isolated effect on the response but there is evidence (Stockard et al 1979) that stimulus factors can exert an interactive influence.

Intensity:

A decrease in stimulus intensity is associated with an increase in component wave latencies (Jewett and Williston,1971:

Jewett et al 1970; Hecox and Galambos, 1974; Picton et al 1977; Starr and Achor, 1975; Yamada et al 1975; Rosenhamer 1977).

Rowe (1978) and Stockard et al (1978b) observed minimal change in interwave latency when stimulus intensity was decreased.

Stockard et al (1979) reported that wave I latency increased more than waves III and V when stimulus intensity was decreased. The general reduction in ABR amplitude with decreasing stimulus intensity has been recognised.

With increasing stimulus intensity the amplitude of the first wave increases. The amplitude of the later waves from the Brainstem nuclei increases little with increasing stimulus intensity and at high intensities (above 70 dB ISO) the amplitude occasionally is decreased (Picton et al 1970).

The waves of ABR both in animals and man, typically become more distinct at higher sound levels and exhibit shorter delay. This correlates to the effect of increase of level on fixing in brainstem auditory neurons: Latency decreases, discharge becomes more secure and the first action potential occurs more precisely timed.

Click Polarity:

Changing Click polarity from rarefaction to condensation has been reported to have an influence on the morphology of the IV-V complex.

Differences exist on the reported effect of stimulus polarity on ABR parameters some authors have reported essentially no difference between mean values for rarefaction versus condensation clicks (Rosenhamer et al 1978; Teskildson et al 1973; Coats and Martin 1977; and few others have found significant individual variation within groups Elberling and Salomon 1971; Ornitz and Walter 1975; Peters and Worthington 1975; Stockard et al 1978b, 1979).

Stockard et al (1978b) discourage the use of alternating clicks because they produce a blurring and distortion of the response peaks and unpredictable effects in the presence of cochlear disease. But then the use of alternating clicks is sometimes advocated to eliminate electromagnetic stimulus artefact.

Frequency compositions

The frequency composition of the acoustic signal produced by a click delivered to an earphone is determined

by the resonant characteristics of the earphone, further on that of the ear canal, the middle ear and the inner ear (Davis 1976).

Terkildson et al (1979) demonstrated by digital filteration and power spectra analysis that main energies of different components of human brainstem auditory evoked potentials are concentrated in the following frequency bands: 400-1000Hz for wave I and II; 100-900 Hz for wave III and 100-500Hz for waves IV-VI.

Responses to tone pips and bursts of various frequencies have been studied by a number of investigators(Brama and Sohmer 1977; Coats et al 1979; Davis 1976; Davis and Hirsh 1976, 1979; Klein and Teas 1978; Kodera et al 1977; Mitchell and Clemis 1977; Picton et al 1979? Seitz et al 1979; Stillman et al 1976; Suzuki et al 1977; Terkildson et al 1975; Water and Falsom 1977;) as cited in Fria 1980). These investigators have observed th latency, in response to a given stimulus intensity, is inversely related to the frequency of the stimulus. The wave V latency inresponse to low frequency tone pips or bursts is longer than that associated with unfiltered clicks. Brama and Sohmer 1977 speculate this as due to the fact that lower - frequency stimuli excite more apical regions of the cochlea with a corresponding longer travelling wave delay.

Response morphology and amplitude are also influenced by stimulus envelope characteristics. Responses to low frequency tone pips or bursts are significantly smaller and less clearly defined than responses to unfiltered clicks.

Hecox et al (1976) concluded that the ABR was an onset response i.e. its properties largely dependant on stimulus onset characteristics.

Lane Kupperman and Goldstein found that none of the rise-decay and duration combinations(rise times of 5,10 and 25m.sec. and durations of 20 & 40m.sec). affected latency of the early components of the evoked response.

Cobbs (1978) presented tonal pips at 250, 500, 1000, 2000, 4000 and 8000Hz at 40 dBSL and no frequency effect was apparent.

Interstimulus Interval (ISI):

Rosenhamer (1978) found that changing the Interstimulus interval (ISI) made no difference to I, III and V latencies or wave V amplitude supremacy.

Hyde et al 1976; Hewett and Williston 1971; Picton et al 1974; Skinner and Glattke, 1977; Terkildson et al 1973;)

Thornton and Coleman 1975; Zollner et al 1976: as cited in Rosenhame have shown that a reduction of the ISI results in a decrease in the amplitudes of the waves preceding wave V.

Mode of presentation:

In neurologically normal subjects with the same hearing in both ears, binaural stimulation usually results in a response of increased amplitude (Blegvad 1975; Jewett and Williston 1971; Starr and Achor 1975; Stockard et al 1978b).

Procedure Effects:

Recording technique:

Variations in this can influence the parameters of obtained ABRs. A number of investigators(jewett and Williston 1971; Martin and Moore 1977; Picton et al 1974; Plantz et al 1974; Stockard et al 1978b; Terkildson and Osterhammel 1981;) have demonstrated that electrode locations around the ear should be considered active for stimulus related neurogenic activity .

Filters are commonly used to eliminate low and high frequency information for noise reduction prior to computer averaging.

The selection of band pass filter cut-off points has a noticeable influence on ABR parameters, (jewett and Williston 1971; Sohmer and Feinmesser 1970? 1973? Starr and Achor 1975;

Stockard and Rossitor 1977; Stockard et al 1978b)

Davis (1976) and Suzuki and Horiuchi (1979) reported that filter slope for eg. 6 or 12 dB/octave versus 24dB/octave can influence obtained ABRs.

Procedural differences between studies can have considerable influence on the reported normal values for ABR latency and amplitude.

Several authors have reported variations of the ABR whether recorded from the ipsilateral earlobe or the contralateral mastoid process (Stockard et al 1978b; Terkildson et al 1973; Thornton 1975). Using contralateral recordings wave I and III decrease in amplitude and are usually absent wave II is often large.

The difference in stimulus transducer can/account for varied reports of normal ABR parameters.

Subject Effects:

Normal ABR parameters in awake and asleep human subjects have been compared in/several investigations (Amadeo and Shagass, 1973; Goff et al 1977; Sanders et al 1979; Sohmer et al 1978; Stockard et al 1978a). Amadeo and Shagass (1973)

found that natural sleep had no significant effect on ABR amplitude or latency.

Stockard et al 1978b found prolonged interwave latencies in some humans recovering from enflurance anaesthesia.

The ABRs do not appear to be affected by sedatives or even by general anaesthetic agents and relaxants Bryant(1976).

The difference between ABR properties for male and female subjects has been investigated by several authors. (Beagley and Sheldrake 1978; Thomsen, Terkildson and Rosterhammel 1978; Stockard et al 1978b, 1979; McClelland and McCrea 1979; Rosenhamer et al 1980; Jerger and Hall 1980).

Thomsen Terkildson and 0sterhammel(l978)found that women exhibited significantly lower latency values of J_5 than men approximately 0.25 m.sec. Rosenhamer et al 1980 found significant differences among the young subjects but not among the old ones, the differences in young subjects being of the order of 0.15 m.sec.(wave I), 0.25 m.sec.(wave III) and 0.30 m.sec. Wave V. Using the same kind of slimulation Beagley and Sheldrake (1978) report highly significant differences in favour of females having shorter wave V latencies than males by 0.2 - 0.4 m.sec. In Thomsen's study (1978) the difference was inthe order of 0.25 m.sec.

Jerger(l980) found that in both normal (98) and Hearing impaired (221); Female subjects showed consistently shorter latency and larger amplitude at all age levels. Wave V latency was about 0.2 ms. shorter and wave V amplitude was about 25% larger in female subjects.

To sum up there seems to be on agreement that females atleast under the age of 50 exhibit significantly shorter peak latencies than men and that these latency differences between males and females are found to be non-significant above the age of 50. As to sex differences, dissimilarities concerning the spatial dimentions of the wave generating system and the volume conductor embedding it should prove to be of greater importance than basic electrophysiological diversities.

Stockard et al (1978b) suggested that separate norms for male and female subjects should be generated in order to avoid diagnostic errors, that in reality could be attributed to sex differences. There are no apparent sex differences in peak latencies or IPLs in infants (Rowe 1981).

Influence of Age:-

Rowe (1978), Thomsen et al(l978), Rosenhamer et al(l980) found latency differences between old and young subjects. The older subjects exhibiting longer latencies. Thomsen et al (1978)reported that wave V latency increase to be 0.1 m.sec/decad

A decrease in absolute latency with increased age has been observed through the second year of life (Hecox and Galambos 1974; Salamy and McKen 1976; Salamy et al 1975). Paludettiet al 1981).

(Paludetti et al 1981) No increase in latency as a function of age reported by Beagley and Sheldrake (1978).

Wave replicability seem to deteriorate with age Rosenhamer et al,1980:

The maturation of peripheral and central auditory structures could account for the age related latency changes (Jewett and Romano 1972; Starr et al 1977; Schulman-Galambos and Galambos 1975).

The differential effect on early versus later waves implies that peripheral maturation precedes central maturation (Salamy and McKeanl976; Starr et al 1977).

Studies of newborn and infant responses have also revealed age related changes in morphology and amplitude (Liebermann et al,1973; Salamy et al 1978).

Starr et al (1977) reported that wave V amplitude increased with maturation.

Test-Rest reliability:

Rosenhamer et al(l975b, 1978)tested subjects on 2 different occasions and found statistically significant test-retest relia-

bility. However the standard deviations of the amplitudes were much larger than those of the latency values. This may be due to the variance of the background noise Thomton(1975b).

Diagnostic errors can be minimised by knowing the effect that technical and subject related factors can have on normal reponse parameters.

Clinical Application:

The understanding of how pathologic conditions affecting the auditory system can influence normal ABR parameters is needed. These 2 conditions include:

(1) Impairments of hearing (Audiologic)
(2) Disorders of neural function(Neurologic)

Audiologic application:

This involves the estimation of hearing in pediatric patients as well as adults who cannot be tested behaviourally due to several reasons.

ABR serves to monitor responsivity of neuronal elements in the peripheral and brainstem auditory tract.

Limitations:

(1) A child who cannot integrate sound at cortical level may yield normal ABR.

(2) A failure to elicit ABR does not always indicate hearing loss, since synchronous firing of neurons required for the response is not necessary for a behavioural response to pure tone signals.

Type of Hearing Loss:

Galambos and Hecox 1977, 1978; Picton et al 1977; Picton 1978; Yamada et al 1975; have suggested that the distinction between conductive and sensorineural impairment can be made on the basis of ABR latency - intensity functions.

Several investigations have demonstrated that normal subjects yield ABRs to stimulus intensities that closely approximate their subjective threshold for the stimulus. This has been reported for click stimuli (Hecox and Galambos, 1974; Picton et al 1977; Phatt and Sohmer 1978; Starr and Achor 1975; Yamada et al 1975) and for tone pips and bursts (Davis 1976; Davis and Hirsh, 1976, 1979; Mitchell and Clemis, 1977; Picton and Smith, 1978; Picton et al 1979; Seitz et al 1979; Weber and Folsom, 1977).as cited in Fria 1980.

Tone pips or burst stimuli appear to have improved frequency specificity in normal subjects, and related ABR thresholds are within 10 to 15 dB of audiometric thresholds at a given frequency (Coats et al 1979; Davis and Hirsh, 1976; Kodera et al 1977; Mitchell and Clemis 1977; Seitz et al 1979; Suzuki et al 1977; Terkildson et al 1975);

Audiologic application of the ABR must include an assessment of neurologic status in the context of interwave latency and relative amplitude measurements, because the presence of neurologic disorders can reduce the accuracy of audiologic predictions. The converse is also true.

Neurologic applications:

ABR can provide information of value from both an audiologic and neurologic stand point. The neurologic status of the patient can influence ABR estimates of hearing impairment and vice-versa.

The Effect of Hearing Loss:

The Effect of neurologic dysfunction on atleast 3 ABR latency measures has been reported.

(1) Absolute wave V latency.
(2) Interaural wave V latency difference (ILD)
(3) Interwave latency between waves I and III. III and V, and/or I & V.

These measures can vary with the patient's audiogram. In normal hearing subjects the I-V interwave latency decreases with stimulus intensity (Coats 1979; Stockard et al 1979). Conductive hearing loss can directly influence absolute wave V latency and indirectly influence interwave latency values. In

the presence of unilateral sensorineural hearing loss the ILD will increase with the degree of loss (Selters and Brackman 1979; Yamada et al 1979).

Emphasis on the ILD is a common method in studies of the effects of cerebellopontine angle lesions (Clemis and McGee 1979; Clemis and Mitchell 1977; House and Brackman 1979; Selters and Brackman 1979; Thomsen et al 1978).

Interwave latencies are the primary response criteria in studies of patients with lesions affecting the entire auditory pathway (Black et al 1979; Ochs et al 1979; Starr 1976, 1977; Starr and Achor 1975; Starr and Hamilton 1976; Stockard and Rossiter 1977; Stockard et al 1976; 1977; Uzil and Benezech 1978; Elberling and Saloman 1979?)found that 56 (96%) had I-V interwave latencies that exceeded 4.3 m.sec. Large cerebellopontine angle tumours have been associated with an increase in the III-V interwave latency in the ear opposite the tumour and with ABRs that have all waves subsequent to wave I, either poorly defined or absent(Selters and Brackman 1979; Starr and Achor 1975). Lesions involving the 8th nerve Brainstem and Midbrain can alter normal ABR parameters significantly.

The ILD is unacceptable as a Primary Criterion Measure for atleast 3 reasons

(1) The ILD is non-contributory in cases with bilateral lesions,

(2) The ILD is more likely to lead to ambiguities and
(3) Criteria based on ILD assume that a series connection is the only linkage between neural generators of the ABR are connected in parallel as well as in series. In other words, the latency of wave V and (1-V interwave latency) can be normal despite a prolonged I-III interwave latency.

The detection of ABR abnormalities compatible with neurologic lesions can be based on the following criterion response measures.

(1) I-III, III-V and I-V interwave latency .
(2) The difference between ears for these interwave latencies (cf. Stockard et al 1978b) and
(3) The relative amplitude ratio of waves V and I.

Although absence and/or poor definition of waves beyond a given wave is nota quantifiable measure, this feature should also be noted.

Selters and Brackman (1977) observed that in acoustic tumour cases the wave V was outside the normal range, and one particular case they tested had a normal T_5. So they questioned themselves whether this meant the tumour had no effect on latency or was there perhaps a delay that was too

small to exceed the normal range. Hence they speculated, that if it could be shown that normally a person had equal latencies in his 2 ears, then a unilateral increase in latency would appear as a difference in the latencies for the 2 ears. Interaural T_5 differences were reviewed for a group of 20 normal listeners and found it to be 0.1 m.sec. for 18 subjects and 0.2m.sec. for 2 subjects. When this new measure was applied to that particular tumour patient, the ILD was 0.4m.sec and thus they concluded that latencies tend to be equal bilaterally in normal hearing subjects.

Thomsen et al(l978)confirmed that the main indicator of retrocochlear vs cochlear disease is the ILD of the Jewett$_5$. They stated that ABR-TT_5 value exceeded 0.3 m.sec. in Acoustic Neuroma cases unilateral Acoustic Neuroma cases.

The interpretation of very common examinations may be difficult. Minor pathological abnormalities around the internal auditory meatus will often be missed if the tomograms are not of perfect, quality and in particular if the examiner is not highly experienced (Fisch and Jenkins 1980). There are many pitfalls in ABLB testing (Simmons & Dixon 1960). The outcome of caloric vestibular testing may be ambiguous if we are not concerned with massive abnormalities. Thus the reliability of test results becomes a very critical factor and

here the ABR-IT_5 rates high in the diagnosis of acoustic neuroma cases With proper techniques it is usually easy to evaluate and is very safe as a screening procedure (Terkildson 1980).

In his study, a few patients with meniere disease who had hearing loss exceeding 60dBHL at 2KHz produced an IT_5 that exceeded 0.3 m.sec. for normality but in other individuals such severe losses were still compatible with completely normal IT_5 values.

Rosenhamer et al(l980)established the ILDs in normal hearing subjects N-=20 and in patients with symmetric Cochlear loss (N=22) as not exceeding 0.2 m.sec.

They found that in patients with a symmetric cochlear loss on one hand that the ILDs at 90dBHL calculated after correction according to Brackman and Selters (1979) exceeded 0.2 m.sec. in 4 cases (i.e a false +Ve rate of 9%) but on the other hand the ILDs were never +Ve. i.e the latency was never longer on stimulation of the poorer ear at click SL corresponding to 90dBHL in the poor ear.

Selters and Brackman(l977) reported of equal latencies in both the ears in the nontumour group despite having unilateral sensorineural losses. The few increased latencies which

were observed were attributed to the severe high frequency hearing loss. Hence Selters and Brackman introduced a correction factor for the wave V latency of 0.1m.sec. for each 10 dB hearing loss at 4 KHz above 50dBHL in cochlear hearing loss cases.

Mair et al (1980) reported the maximum Jewett V interaural latency difference (ILD) as 0.35ms. recorded from 15 normally hearing young adults. The mean values ranged from 0.12 ms at 0.5 KHz to 0.07 ms at 4 KHz.

They also noted that ILDs greater than 1 m.s irrespective of frequency occured either in association with cerebellopontive angle tumours or multiple sclerosis. ILDs shorter than the sliding scale from 0.6 ms at 0.5 KHz to 0.4 ms at 4 KHz were not associated with any evidence of retrocochlear pathology

The Interaural difference greater than 0.3 m.sec. (0.4 m.se when the hearing loss was greater than 65 dBHL) was considered a +Ve test result for tumour detection. (Clemis and McGee,1979).

(Clemis and McGee 1979) opine that ILD is a more sensitive measure than absolute latency. They/report of 2 patients with unilateral vestibular schwannomas who had normal absolute latencies but abnormal ILDs.

The correlation of tumour size and the ILD was found to be proportional by Selters and Brackman 1977; Clemis and McGee 1979.

A very small unilateral conductive hearing loss may push the ILD into the abnormal range. When anabnormal ILD is used in tumour screening a conductive component must be carefully ruled out or seriously taken into consideration in test interpretation(Clemis and McGee 1979).

The true-positive and false positive ratas of the ILD measure compared with those of other special tests, as reported by Clemis and Curtis (1977) is 93%. However, its false +Ve rate is worse than for some of the other tests (30%).

Rosenhall et al (1980) reported of prolonged wave V latency in 3 patients with multiple sclerosis and amplitude of this wave decreased in one ear, while the other ear had normal responses.

ILD cannot be used in the diagnosis of bilateral tumours or when the pure tone thresholds in either ear exceed 80 dBHL.

Masking prevents transcranial stimulation of the contralateral ear which might confuse response interpretation, this is particularly important in testing of infants or of patients with masked asymmetry of hearing (Stockard et al 1980; Chiappa et al 1979).

From many studies it is evident that using contralateral masking over a range of zero to 80dB, the ipsilateral brainstem responses are not significantly altered. This is useful in an audiological clinical context. Thornton (1978) cited in Nounto and Fernandez (1978).

Evaluation of ABR findings in patients with cochlear, retrocochlear or brainstem lesions requires knowledge of normal ABR characteristics.

Response amplitude :

Starr and Achor (1975) found that the ratio of V/I amplitude always exceeded 1.0 and stockard et al (1978b) and Rosenharmer et al (1978) found a mean V/I ratio or 2.53 in response to click stimulation in normal ears.

Several authors have reported approximately the same standard deviation 0.3ms for all ABR component latency values (Starr and Achor, 1975; Rosenhamer et al 1978; Rate 1978; Stockard et al 1978).

Normal interwave latencies reported by several authors demonstrated that I-V interval approximates 4.0 m.sc and that the I-III interwave latency is roughly half of this time.

The variation in latencies and amplitudes between studies emphasises that normative values are not comparable across laboratories using different equipments. Thus the norm for the equipment used in the particular clinic should be established.

METHODOLOGY

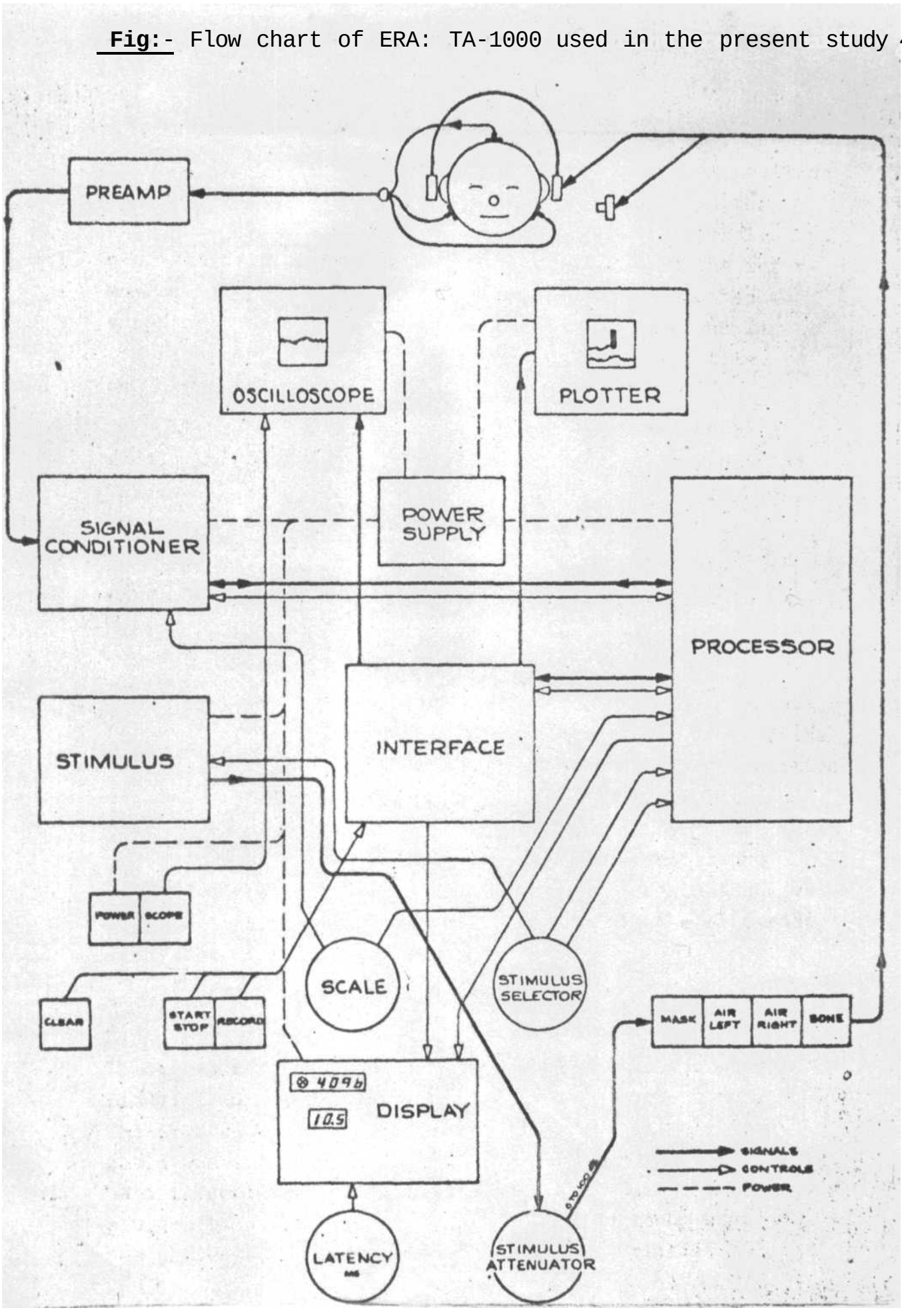
The present study aimed at determining the inter-aural amplitude and latency difference in Brainstem Evoked Response in normal hearing subjects.

Subjects: Ten subjects (5 males and 5 females) in the age range of 17 to 235-years. (The mean age of the subjects was 20 yrs). The subjects were either undergraduate or post-graduate students of the All India Institute of Speech and Hearing. All the subjects were volunteers for the test.

The criteria for the selection of subjects were as follows:-

1. He/She should have a negative history of ear diseases and head injury.
2. He/She should have Air-Conduction or Bone-Conduction thresholds less than or equal to 20 dB at frequencies 250-8000Hz (ANSI 1969) in both ears.
3. He/She should have normal tympanograms (A type) in both ears.
4. He/She should have normal reflex thresholds(90dBHL at 500,1K and 2KHz).

Fig:- Flow chart of ERA: TA-1000 used in the present study 49



Instrumentation:- Subjects were tested using TA-1000. A stimulus generator was used to generate the 2 logan signals 2KHz and 4 KHz (see appendix-for the spectram). The stimulus was amplified, attenuated and delivered to standard audio-metric earphones TDH-39. housed in ear cushions MX41/AR. The stimulus function switch controlled the frequency and the stimulus repetition rate. Polarity of the logon stimulus was alternated. The TA-1000 stimulus logon is characterised by 3 peaks in a 50% - ve, 100% + ve, 50% - ve sequence followed by a 50% positive, 100% - ve, 50% + ve sequence reversing on each successive stimulus. (Appendix 2 for system taming diagram).

The ABR recording apparatus consisted of an array of standard silver chloride electrodes. The skin surface was cleaned with spirit and a little of the electrode gel (Electrogen) was smeared on that/Spot. Then the electrode with the electrode gel was applied to the skin pressing the adhesive pad into firm contact all around.

Electrode placement was as follows:-

Signal, to high forehead.

White:- Reference, mastoid of test ear.

Black:- Guard, mastoid of non-test ear.

When the test ear was changed later in the test procedure, the white and black cords were interchanged at the patient electrode cablereceptacle. The difference voltage vertex to mastoid was led to an preamplifier SLZ 9794 having 30 - 1500 Hz pass band with voltage gain of 1000X, +80dB. The output of the preamplifier was delivered to a signal conditioner which processed and evaluated the output of the preamplifier before passing this electrical information on to the processor. Which is based on a 16 bit memory. From this it is read out, converted to a voltage amplitude and displayed on the oscilloscope and later on the plotter.

The subject's ongoing Electroencephalography was continuously monitored on the oscilloscope.

Day-to-day routine confirmation test was done before starting data collection.

For each ABR, recording responses to 2048 signals were averaged.

Test environment:- All the measurements were made in a sound treated single room situation which was dimly lit. (The audiometric thresholds were established in 2-room situation).

Test procedure:- First of all the AC and BC thresholds of both ears were obtained using modified Hughson and Westlake procedure (Carhart and Jerger 1959) using Beltone 200-C audiometer caliberated to ANSI 1969. Following this, the Impedance audiometry was done to rule out middle ear pathology. (Madsen ZO-73 was used). Later on BSER was obtained.(See appendix 3,for photograph of TA-1000).

Subjects were explained the nature of the test. They were made to lie down comfortably on 'U' foam bed with pillow to reduce neck muscle tension and thereby artefacts and the subject was asked to either close his/her eyes or sleep. With the electrodes fixed in proper position, the TWF/RUN/EEG was set to run, the scale switch to 2048/.2UV and the stimulus switch was set to 10ms and the desired stimulus frequency (either 2 KHz or 4 KHz). The stimulus

attenuator was set to the desired stimulus level either (80dBHL or l00dBHL). By means of push buttons the ear to be tested through Air-Conduction either right or left was selected. Sufficient time was allowed before starting the 'test run' in order to acclimate the patient to the stimulus. The test was not started until the limit light both in the preamplifier and beside the sample counter disappeared.

For each subject the ABR for the following frequencies and intensities were recorded:

1. 2 KHz 100 dBHTL (right)
2. 2 KHz 100 dBHTL (left)
3. 2 KHz 80 dBHTL (right)
4. 2 KHz 80 dBHTL (left)
5. 4 KHz 100 dBHTL (right)
6. 4 KHz 100 dBHTL (left)
7. 4 KHz 80 dBHTL (right)
8. 4 KHz 80 dBHTL (left)

Subjects were tested in a single session lasting for about 2 - 2½ hours. For a few of the subjects the test data were collected on 2 different occasions.

The test data was rejected:

1. When the counter stopped before reaching 2048 samples.
2. When the limit light both in the preamplifier and beaide the counter flickered too often during the testing.

Treatment of the data : Latency determination:- The calibe-rated latency cursor appears on the oscilloscope trace as a function of latency control. The latency is read in 0.1 m sec. increments, from the displayed digital value. Latency measured in this manner is the time the instant the acoustic logon arrives at the tympanic membrane until the vertex electrical response is sensed.

Amplitude measurement: To determine the magnitude of the patients BSER, in microvolts, the marker amplitude 'M'(in 1/2/3/4 divisions), and the amplitude of the desired trace feature "I" was noted, then the scale switch amplitude 'S' -2 UV/div was noted. Thus BSER = TS/M
=microvolts.

The following measures were computed:-

1. The Interaural absolute latency difference for all the waves.
2. The interaural absolute amplitude difference for waves I, III and V.
3. The interpeak latency difference for both ears. I-III, III-V and I-V.
4. The difference between the 2 ears for interpeak latencY.
5. The relative amplitude for both ears. I-III, III-V, I-V.
6. The difference between the 2 ears for relative amplitude.

The most important waves for neurological testing are I,III and V; the waves II, IV, VI and VII show too much of interindividual variability to be of routine clinical use (Rowe 1978; Chiappa et al, 1979).

RESULTS

The aim of the study was to note the Interaural amplitude and latency differences in normal hearing subjects.

The Interaural differences for

1. Absolute latency (for I, II, III, TV and V)
2. Interwave latency (i.e I-III, III-V, and I-V)
3. Absolute amplitude (for I, III and V) and
4. Relative amplitudes (for III/I, V/III, and V/I)

were noted.

The data collected were analysed so as to obtain the means and the standard deviations at 2 frequencies (2KHz and 4KHz) and at 2 intensity levels (80dBHL and lOOdBHL). The 't' test was applied to see if the difference between the right and the left ear was significant at .05 and .01 levels of significance.

The BSER tracings of a normal subject in response to monoaural stimulation is shown in Fig 'A'.

Table 1 shows the absolute latency values for wave V for the right and the left ear for 2 KHz and 4 KHz at 80dBHL and l00dBHL.

The Interaural latency difference values (ILD) for waves I-V is shown in Table '2'.

The ILD for wave V ranged-from 0 to 0.3 msec at 80dBHL for 2KHz
from 0 to .2 m.sec at 100 dBHL for 2 KHz.
from 0 to .2 m.sec at 80 dBHL for 4 KHz. and
from 0 to .2 m.sec at 100 dBHL for 4 KHz.

The ILD for wave I ranged --from 6 to .3m.sec at 80 dBHL for 2 KHz;
from 6 to 71 m.sec at 100 dBHL for 2 KHz;
from 0 to .2 m.sec at 80 dBHL for 4 KHz; and
from 0 to .2 m.sec at 100 dBHL for 4 KHz.

The ILD for wave III ranged—from 0 to .3m.sec at 80 dBHL for 2 KHz;
from 0 to .2m.sec at lOOdBHL for 2 KHz;
from 6 to .2m.sec at 80 dBHL for 4 KHz; and
from 0 to .lm.sec at 100 dBHL for 4 KHz.

Table '1' shows that with increase in intensity the latency values decrease. By 't' test it was found that there

was no significant difference for the absolute latencies (excep for 2 KHz 1000BHL where the difference was significant at .05 level t.2.52) between the right and the left ear at .05 and .01 levels of significance, 't' values are given in table '2'.

The Interpeak latency values (IPL) for I-V for 10 normal hearing subjects are shown in table 3. From table 3 it is clear that with increase in intensity there is decrease in latency.

The Interaural Interpeak Latency values (IIPL) for I-V, III-V and I-III are shown in table 4.

The IIPL values for I-V ranged from — 0 to 0.3 m.sec.

at 80 dBHL for 2 KHz;

0 to 0.2 m.sec. at l00dBHL for 2 KHz;

0 to 0.3 m.sec at 80 dBHL for 4 KHz;

O.to 0+2 m.sec at 100 dBHL for 4 KHz.

No significant difference between the right and left ear for the IPL values was found (except for 4 KHz at 80 dBHL where the difference/was significant at .05 level t=2.37180).

The present study has revealed that at 2KHz(100dBHL), the absolute latency values of right and left ear are significantly different. Also, Interpeak latency values at 4KHz(80dBHL) of right and left ears differ significantly. This is an interesting observation, which needs further investigations.

The means and standard deviation of latency measures of I-V waves to monoaural stimulation i.e for the right and the left ear is shown in tables 5 and 6a respectively. Here also, it can be seen that the absolute latency values decrease with increase in intensity level. The combined latency values (of the right and left ear) of I-V waves for monoaural stimulation is shown in table 6b.

The Interpeak latency values IPL (I-III, III-V and I-V) for monoaural stimulation is shown in table 7.

Measures of amplitude varied considerably between subjects. However, the absolute amplitude values increased with increase in intensity, (see Table 8).

Table '8' shows the absolute amplitude values for wave V for the right and the left ear for 2 KHz and 4 KHz at 80dBHL and loodBHL.

The Interaural absolute amplitude difference (IAAD) for the waves I, III and V is shown in Table 9. There was no significant difference between the right and the left ear at .1 and .05 levels of significance ('t' values are given in table 9).

The IAAD for wave V ranged from—.02 to .16 µ V at 80dBHL for 2 KHz.

.02 to 0.42µ V at l00dBHL at 2 KHz;

0 to .24µ V at 80 dBHL at 4 KHz; and

.02 to 0.34 µ V at 100 dBHL at 4 KHz.

The IAAD for wave III ranged from—

.03 to 0.14 µ V at 80 dBHL for 2 KHz;

.02 to 0.22µ V at 100 dBHL for 2 KHz;

.0 to 0.16µ V at 80 dBHL for 4 KHz;

and .02 to 0.22 µ V at 100 dBHL for 4 KHz.

The IAAD for wave I ranged from—

0 to 0.24 µV at 80 dBHL for 2 KHz;

0 to 0.30µ V at 100 dBHL for 2 KHz;

.05 to 0.16µ V at 80 dBHL for 4 KHz; and

0.02 to 0.34 µ V at 100 dBHL for 4 KHz.

The relative amplitude values for V/I in the right and left ears of 10 normal hearing subjects are shown in Table 10.

The Interaural relative amplitude differences for III/I , V/III and V/I are shown in table 11.

The Interaural relative amplitude difference for V/I ranged from.

0.15 to 3.77 at 80 dBHL for 2 KHz;

0.07 to 2.28 at 100 dBHL for 2 KHz;

0.01 to 2.22 at 80 dBHL for 4 KHz; and

0.04 to 1.09 at 100 dBHL for 4 KHz.

By 't' test it was found that the difference in amplitude (for both the absolute wave V and relative amplitude ratios for V/I) between the right and left ear was not significant. 't' values are shown in the table.

The means and standard deviations of amplitude of the waves I, III and V for monoaural stimulation are shown in table 12. From the table it can be seen that with increase in intensity level the amplitudes increase.

Although the amplitudes of the individual components varied among subjects the ratio of the amplitudes of wave V to Wave I to monoaural stimulation was always greater than 1 at both 80 and 100 dRHL at both 2 KHz and 4 KHz. However this was not true in a few subjects. In subject 2, V/I amplitude ratio was 0.52 V at 4 KHz 100 dBHL(left ear), in subject 3, it was 0.82 V at 4KHz 80 dBHL in the right ear and 0.88 V at 4 KHz 100 dBHL in the left ear. In subject 6, the ratio was--

0.9 V at 2 KHz 80 dBHL in the left eary;

0.85 V at 2 KHz 100 dBHL in the right ear;

0.89 V at 2 KHz 100 dBHL in the left ear;

0.54 V at 4 KHz 80 dBHL in the right ear;

0.56 V at 4 KHz 100 dBHL in the right ear;

and 0.63 V at 4 KHz 100 dBHL in the left ear;

^

In subject 7, the ratio was 0.86 V at 4 KHz 100 dBHL in right ear, and in the subject 10, the ratio was 0.79 V at 2 KHz 100 dBHL in left ear.

0.65 V at 4 KHz 80 dBHL in right ear.

0.64 V at 4 KHz 80 dBHL in left ear.

and 0.85 V at 4 KHz 100 dBHL in left ear.

(See table 10).

The present study shows that in some subjects the (V/1) relative amplitude could be less than 1 V.

Hoeever the mean values of the V/I amplitude ratio exceeded 1. (See table 13).

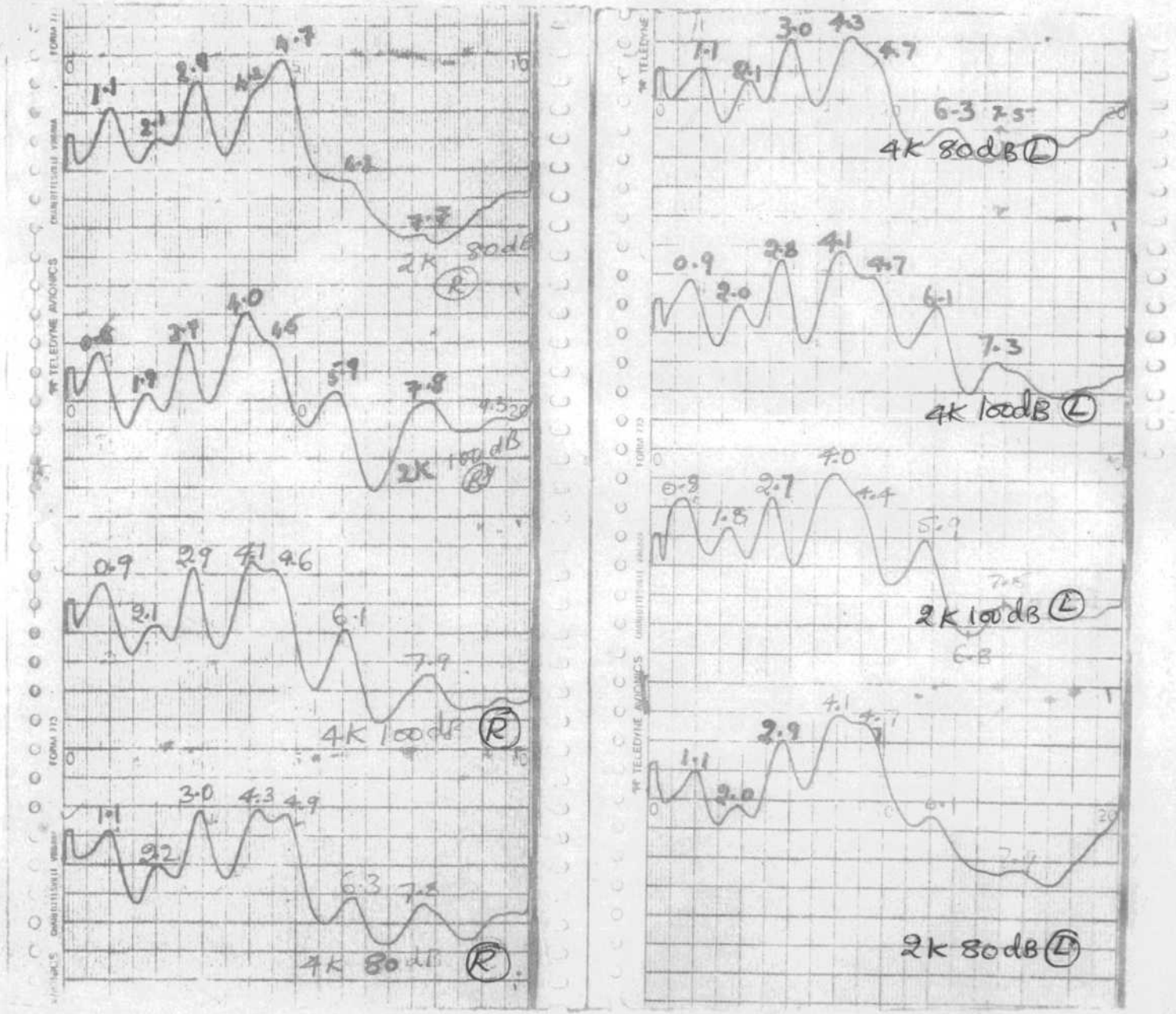


Fig.'A':- BSER tracings of a normal subject in response to monaural stimulation

Subject	Age	2 KHz				4 KHz			
		80 dBHL		100 dBHL		80dBHL		100 dBHL	
		Right	Left	Right	Left	Right	Left	Right	Left
1	19y.	5.2	4.9	4.8	4.6	5.1	4.9	4.9	4.7
2	22y.	5.3	5.2	5.0	5.0	5.2	5.0	5.0	4.9
3	17.5y.	5.1	5.0	4.8	4.7	5.1	5.0	4.9	4.7
4	20y.	4.7	4.7	4.5	4.4	4.9	4.7	4.6	4.7
5	19y.	5.0	4.9	4.7	4.5	4.9	5.0	4.9	4.9
6	23.5y.	4.9	5.0	4.8	4.7	5.2	5.1	4.8	4.8
7	22y.	5.1	4.9	4.7	4.6	5.1	5.2	4.9	4.8
8	18.5y.	4.9	5.0	4.8	4.7	5.2	5.1	4.9	4.8
9	18y.	5.2	5.3	5.0	5.0	5.3	5.3	5.0	4.9
10	20y.	5.1	5.2	5.0	5.1	5.2	5.3	5.1	5.2
Mean		5.05	5.01	4.81	4.73	5.13	5.06	4.9	4.84
Standard Deviation		0.17	0.17	0.15	0.23	0.13	0.18	0.13	0.15

TABLE-1 : The absolute latency values of wave V, for 10 normal subjects for the right and the left ear at 80 dBHL and 100 dBHL for both 2 KHz and 4 KHz.

	2 KHz		4 KHz	
	80 dBHL	100 dBHL	80 dBHL	100 dBHL
I	0.1	.04	.07	.05
S.D	(.12)	(.04)	(.07)	(.05)
	0.1	.12		.1
II	(.07)	(.11)	.07	(.04)
S.D			(.07)	
III	0.08	.07	.06	.07
S.D	(.08)	(.06)	(.08)	(.04)
IV	0.17		.08	.12
S.D	(-14)	.09	(.11)	(.11)
		(.09)		
V	0.11	0.1		.1
S.D	(.08)	(.06)	.13	(.06)
			(.07)	
't' test	0.885	2.52	1.56	1.765
	NS	Significant at 0.1 level	NS	NS

TABLE-2: The mean Interaural absolute latency difference values (ILD) of wave 1-V at 80 dBHL and 100 dBHL for 2 KHz and 4 KHz (N=10) (NS=not significant).

I-V Interpeak latency	2 KHz				4 KHz			
	80 dBHL		100 dB HL		80 dB HL		100 dBHL	
	Right	Left	Right	Left	Right	Left	Right	Left
1	3.8	3.6	3.9	3.7	3.9	3.8	3.9	3.8
2	4.0	3.9	4.0	4.0	3.9	3.6	3.9	3.8
3	3.8	3.9	3.9	3.9	4.0	3.9	4.0	3.8
4	3.6	3.6	3.7	3.6	3.8	3.6	3.7	3.8
5	4.0	3.8	3.9	3.7	3.8	3.9	4.0	4.0
6	3.6	3.7	3.8	3.8	3.9	3.8	3.7	3.9
7	3.7	3.6	3.7	3.6	3.7	3.8	3.8	3.7
8	3.5	3.7	3.9	3.9	4.1	3.9	4.0	3.9
9	3.9	4.2	4.1	4.1	4.3	4.1	4.2	4.0
10	4.0	4.1	4.1	4.3	4.1	4.1	4.1	4.3
Mean	3.78	3.82	3.9	3.86	3.95	3.85	3.93	
Standard Deviation	0.18	0.23	0.14	0.22	0.17	0.17	0.16	0.16

TABLE-3: The Interpeak latency values of I-V for 10 normal hearing subjects for the right and left ear at 80 dBHL and 100 dBHL for 2 KHz and 4 KHz.

Interpeak	2 KHz		4 KHz	
Latency	80 dBHL	100 dBHL	80dBHL	100 dBHL
I-III	.12	0.08	0.16	0.09
S.D	(.11)	(.07)	(.09)	(.05)
III-V	0.1	.09	.11	.07
S.D	(0.09)	(.09)	(.09)	(.06)
I-V	0.16	.08	.14	.13
S.D	(0.13)	(.09)	(.08)	(.06)
't'test	-5.97 NS	1.07 NS	2.3 Significant at 0.1 level	.6347 NS

TABLE-4: The means and S.Ds of Interaural, Interpeak latencies of I-III, III-V and I-V at 80dBHL and l00dBHL for 2 KHz and 4 KHz (N=10) (NS=not significant)

	2KHz		4 KHz	
	80 dBHL	100 dBHL	80 dBHL	100 dBHL
Wave-I	1.27(.15)	.91(.07)	0.97(.10)	.97(.10)
Wave-II	2.25(.20)	1.84(.18)	2.26(.19)	2.03(.17)
Wave-III	3.23(.15)	3(.16)	3.25(.15)	3.09(.13)
Wave-IV	4.45(.21)	4.25(.19)	4.47(.17)	4.31 (.20)
Wave-V	5.05(.17)	4.8K.15)	5.13(.13)	4.90(.13)

TABLE-5: Showing the mean values of latencies I, II, III, IV and V along with their standard deviations at 80 and 100 dBHL at 2 KHz and 4 KHz (N=10). (Figures in the parenthesis indicate standard deviations). Stimulated ear = Right.

	2 KHz		4 KHz	
	80 dBHL	100 dBHL	80 dBHL	l00dBHL
Wave I	1.19(.11)	.87(.08)	1.21(.11)	.94(.08)
Wave II	2.23(.17)	1.84(.17)	2.27(14)	2.01(.15)
Wave III	3.17(.15)	2.97(.13)	3.23(.16)	3.04(.14)
Wave IV	4.38(.16)	4.2(.14)	4.47(.14)	4.31(.17)
Wave V	5.01(.17)	4.73(.23)	5.06(.18)	4.84(.15)

TABLE-6a: Showing the mean values of latencies I, II, III, IV and V along with their S.Ds, at 80 and l00dBHL for 2 KHz and 4 KHz(Stimulated ear = Left ear). (Figures in paranthesis indicate standard deviations).

Latency	2 KHz		4 KHz	
	80 dBHL	100 dB HL	80 dB HL	100 dBHL
I M	1.23	0.89	1.19	0.95
S.D	(0.12)	(0.07)	(0.12)	(0.09)
II M	2.24	1.84	2.265	2.02
S.D.	(.18)	(0.17)	(0.16)	(0.16)
III M	3.2	2.985	3.24	3.665
S.D	(.15)	(0.14)	(.15)	(.13)
IV M	4.42	4.225	4.47	4.31
S.D.	(0.18)	(0.17)	(0.15)	(0.18)
V M	5.03	4.77	5.09	4.87
S.D.	(0.17)	(0.19)	(0.16)	(0.14)

Table 6b:- Showing the mean and standard deviation of the combined latency values (latency values of the right and left ear combined) of waves I to V in 10 normal hearing subjects.

	2 KHz		4 KHz	
(1)	80 dBHL	100 dBHL	80 dBHL	100 dBHL
I-III	1.95(.15)	2.07(.14)	2.05(.17)	2.13(.12)
III-V	1.82(.06)	1.81(.11)	1.88(.11)	1.81(.11)
I-V	3.78(.18)	3.9(.14)	3.95(.17)	3.93(.16)
(Stimulated ear = Right)				
I-III	1.95(.19)	2.09(.12)	2.03(.13)	2.08(.13)
III-V	1.84(.12)	1.76(.16)	1.83(.14)	1.8(.14)
I-V	3.82(.23)	3.86(.22)	3.85(.17)	1.8(.16)
(Stimulated ear = Left)				

TABLE-7:- Showing the Interpeak latency means and their standard deviations.

Amplitude V	2 KHz				4 KHz			
	80 dBHL		100 dBHL		80 dBHL		100 dBHL	
	Right	Left	Right	Left	Right	Left	Right	Left
1	0.62	0.54	0.6	0.70	0.58	0.34	0.58	0.60
2	0.40	0.26	0.2	0.38	0.38	0.37	0.36	0.23
3	0.47	0.31	0.68	0.46	0.29	0.32	0.38	0.32
4.	0.84	0.70	0.58	0.56	0.74	0.6	0.82	0.48
5	0.72	0.70	0.94	0.90	0.54	0.54	0.58	0.68
6	0.48	0.54	0.60	0.50	0.19	0.40	0.36	0.48
7	0.40	0.62	0.78	0.54	0.48	0.44	0.62	0.52
8	0.48	0.58	0.78	0.56	0.44	0.66	0.58	0.56
9	0.42	0.34	0.34	0.46	0.30	0.30	0.54	0.56
10	0.46	0.36	0.80	0.38	0.30	0.22	0.54	0.36
Mean	0.529	0.495	0.63	0.544	0.42	0.419	0.53	0.47
S.D	(.14)	(.16)	(0.22)	(0.15)	(0.16)	(.14)	(.14)	(0.14)

TABLE : 8:- The absolute amplitude values of Wave-V for 10 normal hearing subjects for the right and left ear.

	2KHz		4 KHz	
	80 dBHL	100 dBHL	80 dBHL	100 dBHL
I	.082	.125	.09	.10
S.D	(.09)	(.09)	(.03)	(0.10)
III	0.083	0.086	.05	0.08
S.D.	(.03)	(.05)	(.05)	(0.07)
V	.114	.166		.09
S.D	(.04)	(.11)	(.09)	(0.09)
't' test for V	.86 NS	1.20 NS	.11 NS	1.33 NS

TABLE-9: The means and SDs of Interaural absolute amplitude differences of waves I, III and V at. 80 and 100 dBHL for 2 KHz and 4 KHz (N=10) (NS=Not significant).

Relative Amplitude V/I	2 KHz				4 KHz			
	80 dBHL		100 dBHL		80 dBHL		100 dBHL	
	Right	Left	Right	Left	Right	Left	Right	Left
Sub.l	5.16	2.07	1.87	1.94	3.22	1.00	1.70	1.66
Sub.2	1.66	1.00	1.00	1.15	1.00	1.32	1.50	0.52
Sub.3	2.35	1.55	2.61	1.76	0.82	1.23	1.15	0.88
Sub.4	2.21	1.84	1.11	1.47	1.54	1.66	1.70	1.09
Sub.5	2.76	2.91	3.61	3.75	1.35	1.80	1.26	1.70
Sub.6	1.33	0.90	0.85	0.89	0.54	1.00	0.56	0.63
Sub.7	2.22	2.81	l.11	1.35	1.33	1.69	0.86	1.36
Sub.8	6.00	2.23	2.78	1.40	1.37	2.75	1.45	2.54
Sub.9	5.25	1.41	3.40	1.91	2.14	1.50	2.25	2.15
Sub.10	1.27	1.00	3.07	0.79	0.65	0.64	1.22	0.85
Mean	3.021 (1.76)	1.77 (0.73)	2.141 (1.07)	1.64 (0.83)	1.39 (0.79)	1.45 (0.58)	1.36 (0.47)	1.33 (0.66)

TABLE-10: The relative amplitude values for V/r in the right and left ears of 10 normal hearing subjects.

Relative amplitude	2 KHz		4 KHz	
	80 dBHL	100 dBHL	80 dBHL	100 dBHL
III/I	0.98	0.53	0.49	0.33
	(1.01)	(.66)	(.61)	(9.29)
V/III	0.83	3.49	0.50	0.56
	(.88)	(6.95)	(0.43)	(0.46)
V/I	1.39	0.7	0.64	0.44
	(1.5)	(0.77)	(0.66)	(0.36)
't' test	.73	1.70	0,21	0.04
for V/I	NS	NS	NS	NS

TABLE 11: The means and standard deviations of the Interaural relative amplitude difference for III/I, V/I and V/III (N=10) at 80 dBHL and 100 dBHL for 2 KHz and 4 KHz. (NS=not significant).

	2 KHz		4 KHZ	
(a)	80 dBHL	100 dBHL	80 dBHL	100 dBHL
Wave-I	.226(.11)	.36(.20)	0.34(.10)	.42(.15)
Wave-III	.30(.15)	.27(.16)	.29(.12)	.39(.19)
Wave-V	.53(.14)	0.63(.22)	.42(.16)	.53(.14)
(Stimulated Ear = Right)				
(b)				
Wave-I	.30(.11)	.36(.10)	.29(.06)	.40(.14)
Wave-III	.29(.11)	.27(.18)	.27(.13)	.35(.15)
Wave-V	.49(.16)	.54(.15)	.41(.14)	.47(.14)
(Stimulated ear = Left				

TABLE-12: Showing the means along with S.Ds of the amplitudes; of waves I, III, V for 10 normal hearing subjects.

	2 KHz		4 KHz	
	80 dBHL	100 dBHL	80 dBHL	100 dBHL
III/I	1.81(1.33)	.93(.70)	.68(.41)	.89(.34)
V/III	2.19(1.20)	3.79(4.74)	1.66(.83)	1.85(1.25)
V/I	3.02(1.76)	2.14(1.07)	1.39(.79)	1.37(.47)
	(Stimulated <ear = Right)			
III/I	1.02(.51)	.79(.65)	.924(.45)	#948(.60)
V/III	1.79(.43)	4.61(6.73)	1.72(.611)	1.6(.91)
V/I	1.77(.73)	1.64(.83)	1.46(.58)	1.33(.66)
	(b) (Stimulated ear = Left)			

TABLE-13: Means and standard deviations of BSER amplitude ratios for 10 normal hearing subjects.

DISCUSSION

Selters and Brackman (1977) reported the ILD values for & group of 20 normal listeners and found it to be 0 or O.lm.sec. for 18 subjects and 0.2 m.sec for 2 subjects. Thomsen et al (1978) stated that ABR Interaural latency difference for V wave (IT- or ILD) exceeded 0.3 m.sec in unilateral acoustic neuroma cases. Clemis and Mc Gee (1979) reported an ILD of 0.3m.sec. or greater (0.4m.sec or greater) when the threshold of hearing is 65 d B or more to be considered abnormal. Mair et al (1980) reported the maximum Jewett V ILD recorded from 15 normally hearing young adults as 0.36 m.sec the mean values ranged from .12 m.sec at 0.5 KHz to 0.07 m.sec at 4 KHz. Rosenhamer et al (1980 b) established the ILDs in 20 normal hearing subjects as not exceeding 0.3 m.sec.

In the present study the maximum Jewett V ILD recorded from 10 normally hearing subjects was 0.3 m.sec. The mean values ranged from .11 m.sec. at 2 KHz to 0.13 m.sec. at 4 KHz at 80 dBHL.Normal Interpeak latency values have been reported for several combinations of ABR component waves (Stockard and Rosstter 1977). There is an increasing tendency to focus on the I-III, III-V, and I-V Interpeak latencies.

I-III value estimates transmission time through the Ponto-medullary junction and lower Pons. 111-V values estimate

transmission time from caudal pons to caudal mid brain levels The I-V latency estimates the time needed for impulses to travel the entire system and it is also called central or brainstem transmission time. This measure is very valuable for clinical purposes.

The mean and standard deviation of interwave latency values from several investigation

	N	I - III	III - V	I - V
Chiappa et al (1979)	50	2.1(.15)	1.9(.16)	4.0(.23)
Gilroy & Lynn (1978)	15	2.05(.15)	-	3.83(.13)
Rowe (1978)	2.5	1.97(.16)	1.97(.20)	3.94(.22)
Stockard & Rossitor	125	2.1(.2)	1.9(.2)	4.0(.2)
Rosen hamer etal(1979)		2.26(0.15)	2.00(.20)	4.27(.22)
Bergholtz (1980		2.21(0.25)	1.85(.15)	4.09(.26)
Present study (at 80 dBHL for Right ear stimulation)	10	1.95(.15)	1.82(.06)	3.78(.18)
(For Left ear Stimulation)		1.95(.19)	1.84(.12)	3.82(.23)

Monoaural stimulation is unquestionably more sensitive to neurological abnormality than is binaural stimulation (Chiappa et al 1979; Chiappa et al 1980; Selters and Brackmann 1977; Stockard et al 1977a; 1977b, 1978). as cited in Rowe 1981).

Stockard et al(l978b)advocate that the difference between ears for the interwave latencies as one of the criteria for the detection of ABR abnormalities campatible with neurologic lesions.

An abnormal response from stimulating one ear may be entirely masked by a normal response from the opposite ear if both ears are stimulated simultaneously. In addition it is possible that the IPL values from each ear may be within normal limits, but the longer IPL's from one ear can be shown to be abnormal if they exceed normal limits for symmetry.

In the present study IIPL differences was not significant in normals except at 4 KHz 80 dBHL at .05 level.(t=2.3). This has to be investigated further.

The findings for the interwave latencies are in good agreement with those of Rowe (1978). However the mean scores obtained in this study are slightly lower when compared to the values reported by other authors. Apart from the different equipment used, the reference points number of subjects tested, the frequencies tested etc. The higher intensity level used in this study may be a potential contributor to the lower values for the Interwave latencies reported in the present study.

Comparing the absolute latencies obtained in this study, (see table 6 and 7 in the Results Section) with those of the other studies (see p.35 in Review), the mean scores obtained at 80 dBHL and 100 dBHL are consistently lower - (except the results of Jewett and Williston 1971 who used a click intensity of 70 dBSL). As noted above for the interwave latencies, apart from the different equipment used the reference points etc, the higher intensity level used in this study may be a potential contributor to the lower values seen here. A decrease in stimulus intensity is associated with an increase in component wave latencies (Jewett and Williston, 1971; Jewett et al 1970; Hecox and Galambos 1974; Picton et al 1977? Starr and Achor 1975; Yamada et al 1975). as cited in Fria 1980).

Amplitude of the brainstem responses are considerably variable and the liability of many of the waves especially II and IV is such that a schema for making measurements is very contrived and highly individualistic and probably of no great value (Begley and Sheldrake 1978). Amplitude values are not easily dealt with:

1. First they are not normally distributed, but skewed towards higher values. Rowe (1978).

2. They are much more sensitive to changes in noise level of the recording system, particularly the amount of muscle artefact present.

3. They are very sensitive to minor changes in technique and unless technique is rigorously controlled, they may change on repeated testing for no apparent reason. In view of these problems, at this time absolute amplitudes must be considered poor markers for abnormality.

The variation of normal values for ABR wave component amplitude has been observed to be substantial by a number of investigators (Amadeo and Shagass 1975; Chiappa et al 1979? Starr and Achor 1975) Stockard et al 1978b reported the mean amplitude in response to high intensity clicks to be 0.15 and 0.38 V for waves I and V respectively. In the present study the mean amplitude values to 80 dBHL (2 KHz)stimulus for wave I and V were 0.22 and .53 respectively when the right ear was stimulated and 0.30 and 0.49 when left ear was stimulated and recorded ipsilaterally (see table 8). The discrepancy noted here doesnot need further explanation as the nature of amplitude measurement has already been stated above*

Relative measures are more consistent and are better indices for comparing amplitude phenomenon between subjects

and within the same subject on different occasions. Starr and Achor 1975: Stockard et al 1978b. Starr and Achor (1975) tested 50 normal subjects and found that the ratio of V:I amplitude always exceeded 1.0 in response to click intensities below 65 dB. Chiappa et al (1979) reported of similar ratios for 60 dB click evoked ABR's Stockard et al (1978b) found a mean V:I ratio of 2.53 in 100 normal ears. Rosenhamer 1978 reported a V:I ratio of 1.55 at 80 dBSL and 2.53 at 60 dB SL. The results in the present study are not in complete agreement with the previous reports (See table 10 in results section). In few of the subjects the V/I amplitude ratio was below 1 V.

The standard deviations for the absolute amplitudes were very high. And even in case of Interaural absolute amplitude values, I, III and V the Interaural relative amplitude difference the standard deviations were high and in a few instances it was more than the mean value. This further supports that the amplitude measurements are highly variable. (see table 9, 11 and 13 in results section). However no significant differences was noted between the right and the left ear for both the absolute amplitude values and the relative amplitude values.

SUMMARY AND CONCLUSIONS

Normative data for ABR have been found to vary with regard to the type of equipment used hence there was an urgent need for establishing the normal ILD using TA-1000.

The study was focussed on the following questions

1. What is the range of the Interaural latency and Interaural amplitude differences in normal hearing subjects?
2. What would be the mean values of Interaural latency difference, Interpeak latency, Interaural Interpeak latency, and relative amplitude.

The following measures were computed for each subject:

1) The Interaural absolute latency difference for all the waves.
2) The Interaural absolute amplitude difference for waves I, III and V.
3) The Interwave latency difference for both ears. (I-III, III-V, and I-V)
4) The difference between the 2 ears for interwave latency

5) The relative amplitude for both ears.
(I-III, III-V and I-V)

6) The difference between the 2 ears for relative amplitude.

Before obtaining BSER, the subject's PTA and Impedance measures were taken and later on the BSER was obtained.

For each subject the ABR for the following frequencies and intensities was recorded.

(1) 2 KHz 100 dBHTL(Right)
(2) 2 KHz 100 dBHTL(Left)
(3) 2 KHz 80 dBHTL(Right)
(4) 2 KHz 80 dBHTL(Left)
(5) 4 KHz 100 dBHTL(Right)
(6) 4 KHz 100 dBHTL(Left)
(7) 4 KHz 100 dBHTL(Right)
(8) 4 KHz 100 dBHTL(Left)

A group of 10 normal hearing subjects with age ranging from 17-23 years were tested and the results were analyzed.

CONCLUSIONS:

(1) The ILD Values ranged from 0-0.3m.sec. The mean ILD values for wave V were — 0.llm.sec.at 80 dBHL at 2 KHz.
0.lm.sec at 100 dBHL at 2 KHz.
0.13m.sec at 80 dBHL at 4 KHz.
O.lM.sec at 100 dBHL at 4 KHz.

No significant difference was found for the absolute latency measures between the 2 ears except at 2 KHz 100 dBHL where the difference between the ears was significant at the .05 levels .

(2) The Interaural interpeak latency values ranged from 0 to 0.3 m.sec. No significant difference was found for the Interpeak latencies between the 2 ears except at 4 KHz 80 dBHL, where the difference between the ears was significant at the .05 level.

The mean IIPL values for wave V
were — 0.16 at 80 dBHL at 2 KHz
0.08 at 100 dBHL at 2 KHz
0.14 at 80 dBHL at 4 KHz
0.13 at 100 dBHL at 4 KHz.

(3) The mean absolute latency values and the mean Interpeak latency values at 2 different intensities and frequencies are given in the Results Section (See tables 5, 6a, 6b and 7).

(4) Amplitude values of the BSER are considerably variable. The standard deviations for the absolute amplitudes, the relative amplitude, the interaural absolute amplitude and the Interaural relative amplitude were very high and in some instances more than the mean value, thus supporting

the view that the amplitude of BSER is not a reliable measure.

The V/I relative amplitude which is a relatively reliable measure was below 1 V in few of the subjects.

Recommendations:-

1. The same study can be carried out on a larger population.

2. The 'Ear Effect' for amplitude and latency of BSER for different frequencies and intensities can be studied.

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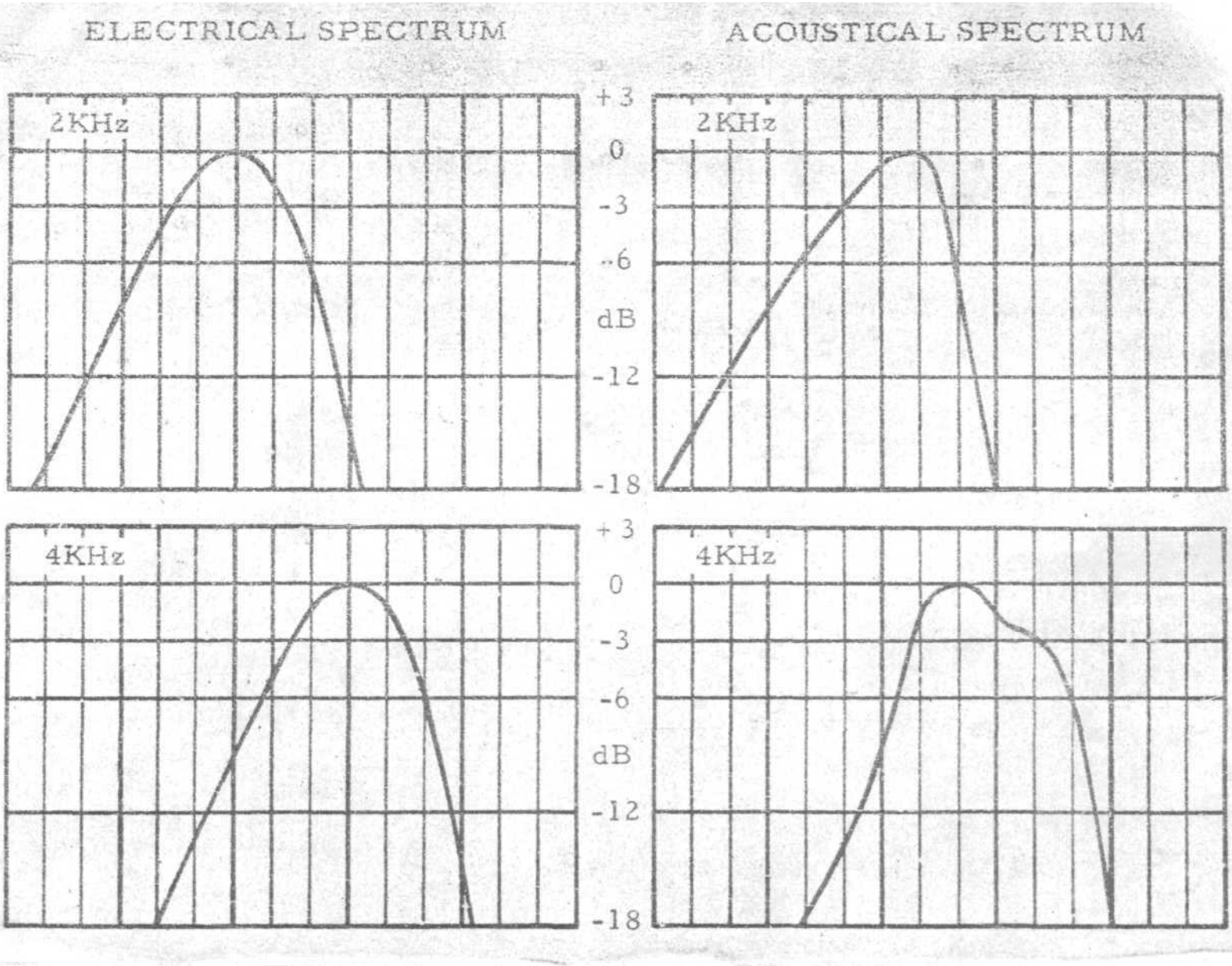
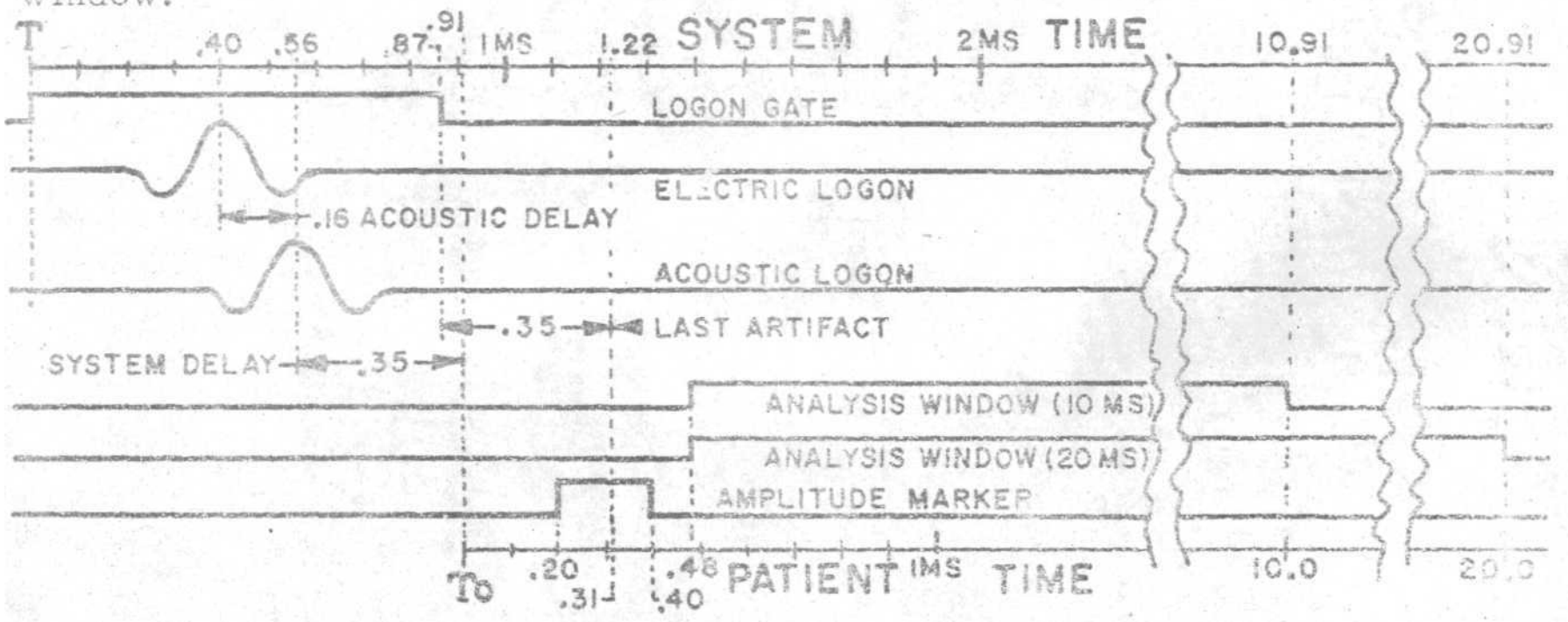


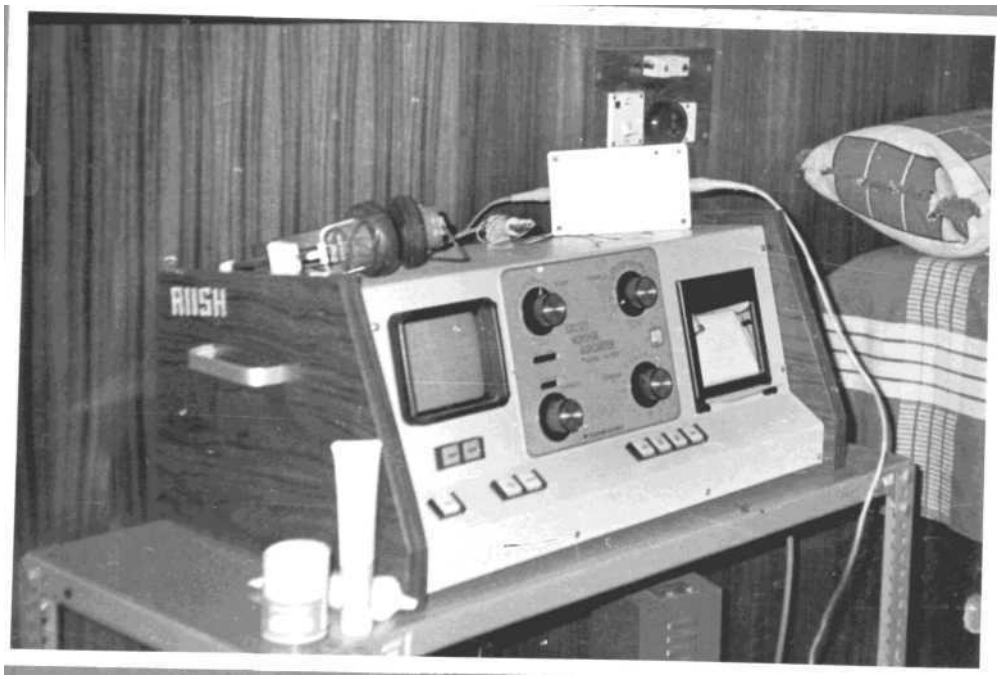
Electric and Acoustic spectrum plots

window.



The system timing diagram, illustrates the events between the system trigger pulse and the analysis window.

Appendix 3



TA - 1000 used in the present study