91

EFFECTS OF FREQUENCY ON LATENCY OF BRAINSTEM RESPONSE

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REGISTER NO. 8601

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ALL INDIA INSTITUTE OF SPEECH AND HEARING: MYSORE - 6

MAY 1987

DEDICATED TO

MY BELOVED FATHER AND MOTHER

CERTIFICATE

This is to certify that the Independent Project entitled: Effects of Frequency on Latency of Brainstem Response: is the bonafide work in partfulfilment for the degree of Master of Science (Speech and Hearing), of the student with Register No. 8601

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CERTIFICATE

This is to certify that this Independent Project entitled "Effects of Frequency on Latency of Brainstem Response" has been prepared under my supervision and guidance.

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DECLARATION

This Independent Project is the result of my own study under the guidance of Dr.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.

Mysore

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INTRODUCTION

INTRODUCTION

The Brain Stem Electric Response Audiometry (BSERA) is an electrophysiologic approach to the study of hearing. In Brain stem Electric Response Audiometry, the electrical activity that originates within the cochlea or the Auditory Nerve is recorded and evaluated. Unlike measures of ongoing electrical activity. Brain Stem represents an evoke or stimulus dependent measures.

Since Caten described the electrical activity of the brain in 1875, Neurophysiologists have slowly accumulated a significant amount of information regarding the neurophysiology, anatomy and bio-acoustics of hearing.

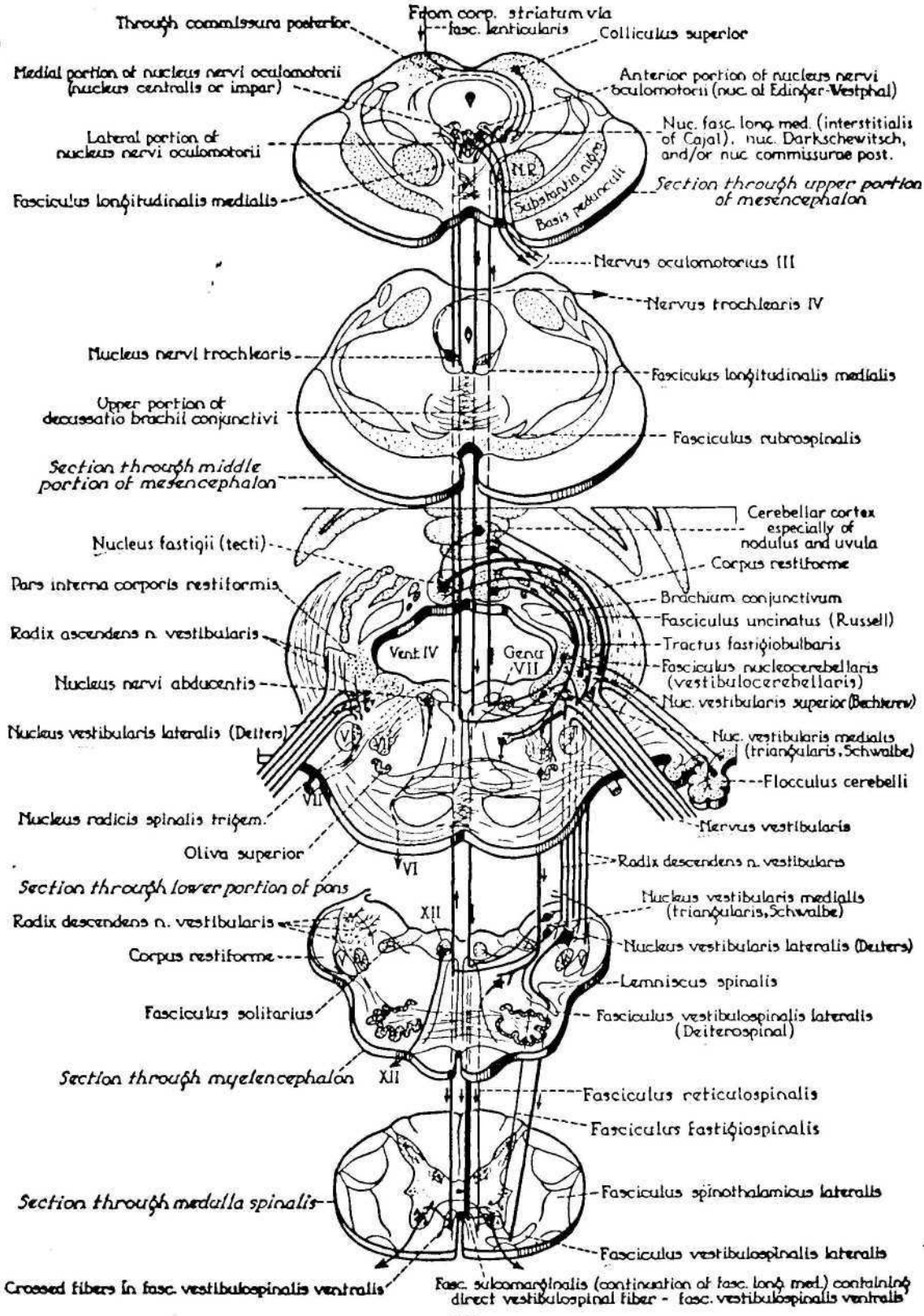
The aim of the Brain Stem Electrical Response Audiometry is to record the potentials which arises in the auditory system as a result of sound stimulation.

There are three classes of electrical potentials which could be analysed in electric response audiometry, which are following:-

i) Compound action potential (AP) of the auditory nerve,
ii) The stimulating potential (SP)
iii) The cochlear potential (CP), also known as cochlear microphonic (Weber, 1966).

FIG. 1

VESTIBULAR SYSTEM



In BSERA far field, specifically generated, electrical impulses thought to reflect neurophysiologic events which takes place in the auditory pathway in response to sound stimuli are recorded within the 10 m.secs. The key to brain responses is synchronization.

Fig.l:

Vesticular system:

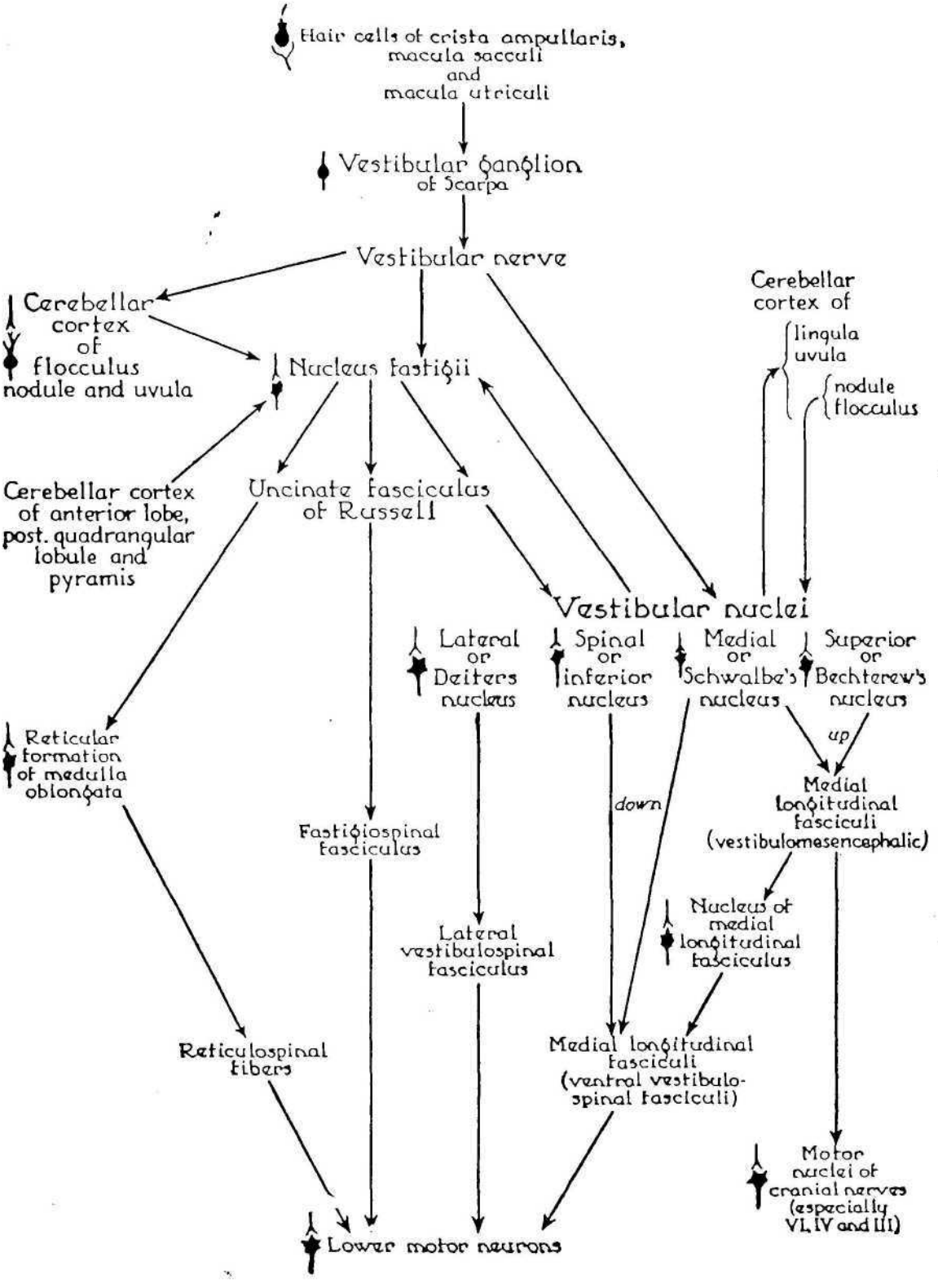
This chart shows that the vestigular nerve terminates in the cortex of the vermis (nodulus and uvula) and of the flocculus of the cerebellum, in nucleus fastigii of the cerebellum (mostly of the same side) and in various portions of the vestibular nuclei proper. Limited regions of the cerebellar cortex also send fibers to nucleus fastigii and to the vestibular nuclei. At least the upper portion of the vestibular nuclei discharges into these cerebellar nuclei and to restricted regions of the cerebellar cortex (see Fig.2). From nucleus fastigii (mostly of the opposite side) arises the uncinate fasciculus of Russell. The direct fibers that do not arch upward to any extent are designated fastigiobullar by some. Most of the fibers from nucleus fastigii curve upward and laterally, and then ventrally and downward into and through the vestibular nuclei, terminating partly in the vestibular nuclei and partly in the reticular formation medial to the vestibular nuclei. A variable number of fibers may continue into the spinal cord. The location and extent of these fastigiospinal fibers are not agreed upon.

From the reticular formation arise reticulospinal tracts, which descend in both the lateral and ventral funiculus. This is an old pathway that has undoubtedly been largely superseded by those arising more directly from the vestibular nuclei.

From the superior vestibular nucleus fibers ascend in the lateral wall of the fourth ventricle and then course ventromedially and ascend in the lateral wing of the medial longitudinal fasciculus of the same side, finally terminating in the region of the nuclei of the fourth and third cranial nerves and in the region of the nucleus of the medial longitudinal fasciculus (interstitial nucleus of Cajal), nucleus of Darkschewitsch and the nucleus of the posterior commissure regions that are probably important in postural reflexes.

FIG. 2.

VESTIBULAR OR EQUILIBRATORY SYSTEM



From the medial vestibular nucleus, fibers course upward in the medial longitudinalfasciculus of the opposite side and downward in the medial longitudinal fasciculus of both sides. Vestibular fibers ascending in the medial longitudinal fasciculus may collectively be designated as vestibulobulbar or vestibulomesencephalic.

The lower end of the medial nucleus, which constitutes the greater part of the spinal or inferior nucleus, sends its fibers largely downward in the medial longitudinal fasciculus (of both sides). Fibers of the medial longitudinal fasciculus which descend into the spinal cord constitute the sulcomarginal fasciculus of Marie. Those of vestibular origin are designated the ventral vestibulospinal fasciculus. The relative position of both the ascending and descending vestibular fiber in the medial longitudinal fasciculus is carefully shown as they have been established, particularly in the cat, which has a well developed vestibular system. The general plan is undoubtedly the same in man.

The lateral nucleus of the vestibular complex is composed of larger cells which give origin to a very prominent direct descending tract, the lateral vestibulospinal fasciculus. This traverses the entire length of the spinal cord.

The absence of direct connections with the cerebral cortex indicates that this system is largely a reflex mechanism, and that the sensations which it arouses are largely, if not entirely, returns from the adjustments set up in various parts of the body, and especially in the eye muscles.

Fig.2:

Vestibular or equilibratory system:

The schema summarises the essential features of the chart shown in figure-1. Again no definite connections to cortical centers are indicated, thus emphasizing the reflex character of the vestibular system. There are possible pathways to the thalamus from the cerebellar cortex through the dentate nucleus and brachium conjunctivum (figure) but, being inconspicuous and of questionable significance, they are not included. No cerebral cortical center is known to exist.

The reciprocal relations of the vestibular nuclei and the cerebellum, particularly through the medium of nucleus fastigii, is brought out rather prominently. Discharging into the fastigial nuclei are not only direct vestibular fibers and fibers from

those regions of the cerebellar cortex that receive vestibular nerve fibers, but also fibers from other cerebellar regions (anterior lobe and adjacent part of the posterior lobe). These nuclei in turn discharge into the vestibuiar nuclei which have more or less direct connections with the motor nuclei of peripheral nerves. The vestibuiar nuclei also discharge back into the cerebellar cortex and into the fastigial nuclei.

While there are probably additional neurons intercalated here and there, particularly between the secondary vestibuiar fibers and the motor nuclei of the cranial nerves, the whole system is a reflex mechanism of relatively few neurons.

Neither the chart nor this schema shows the numerous centers that have been proposed, and more or less theoretically located in various portions of the cerebellum, pons and mid-brain, for linking up this system with specific bodily and ocular movements. When it comes to a pzactical application of such centers in the localization of lesions, they are gene-rally very disappointing, probably because of the complicated character of the mechanism involved.

Since so many fibers from nucleus fastigii terminate in the reticular formation, which in turn discharges many fibers into the spinal cord, it is assumed that this is another vestibuiar connection with the motor cells of the spinal cord.

The fastigiospinal fasciculus might be eliminated, since the most recent investigations indicate that very few fibers from nucleus fastigii actually descend as far as the spinal cord proper.

Attention may be called to the fact that most of the ascending fibers in the upper half of the medial longitudinal fasciculus are of vestibuiar origin and consist of both crossed and direct fibers, similarly, the greater bulk of the descending fibers in the lower half of the medial longi-tudinal fasciculus and its continuation (the sulco-marginal fasciculus of the spinal cord) arises from cells of the vesti-buiar nuclei. These descending fibers are distributed to all segments of the spinal cord and are both crossed and direct.

Because of its relative lack of variability and its immunity to such non-auditory factors as attention state of

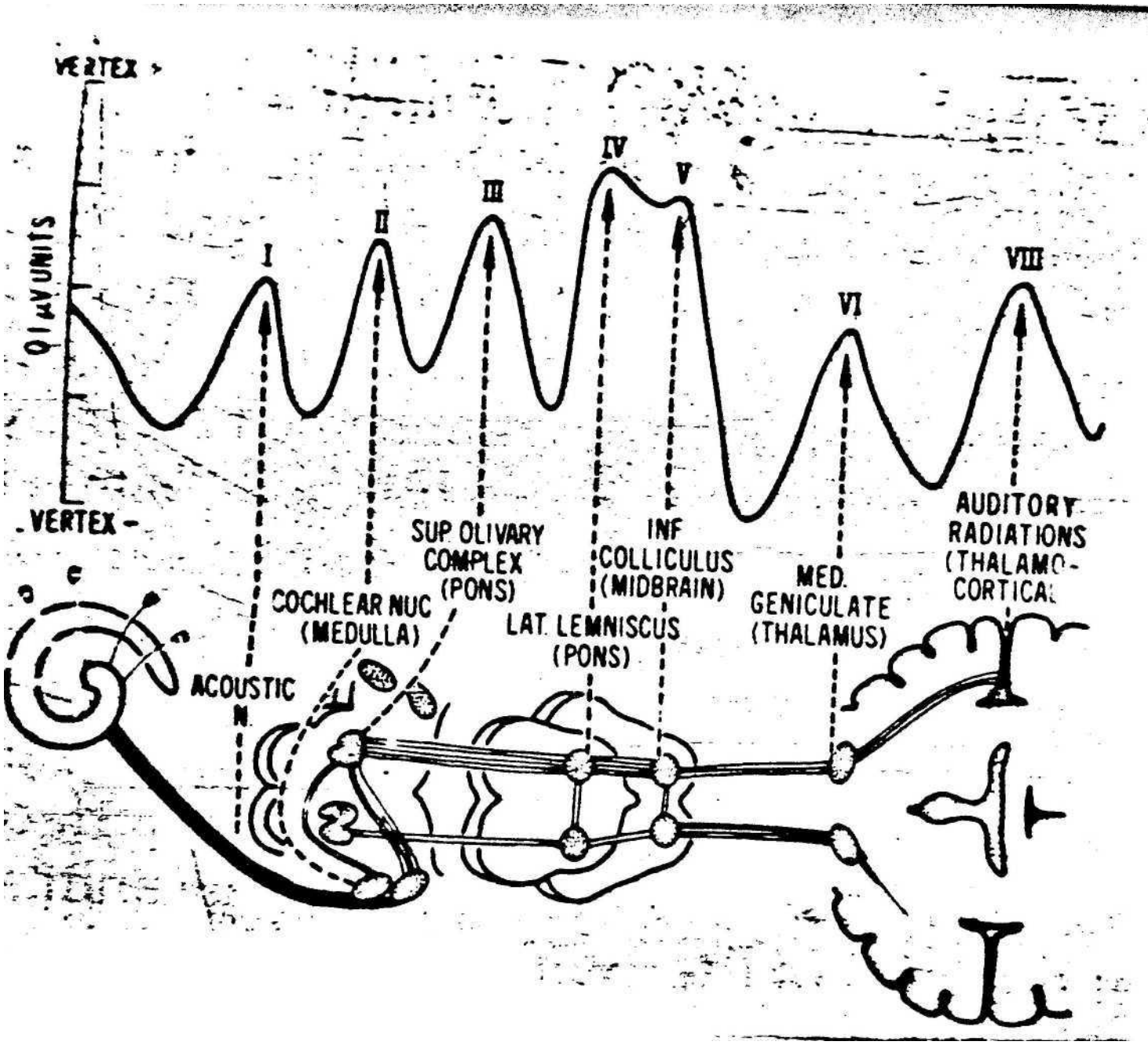
conciousness and sedation, the auditory brainstem response (ABR) which is generally recorded from the vertex has attracted increasing interest as a diagnostic tool i.e., in establishing the hearing threshold in infants and subject uncooperativeness for the routine audiometry and in oto-neurological diagnosis.

The BSERA consists of seven waves which can be recorded using electrodes in response to a series of stimuli. Usually 1000 or 2000 are used and the response is extracted by means of online averaging. The waves are generally agreed to have the following provenance (Beagley and Shetdrake, 1978).

1. Wave—I from the auditory trunk
2. Wave-II from the cochlear nucleus
3. Wave-III from the superior olivary complex
4. Wave-IV from the nucleus of the lateral lemniscus
5. Wave-V from the inferior colliculus
6. Wave-VI from the medial geniculate nucleus
7. Wave-VII from the primary auditory cortex.

The BSERA can be made use of in studying the changes in the cochlear response objectively. It can also be made use of in studying the changes in the medial geniculate body (MGB).

The effects of neurologic dysfunction on atleast three auditory brain stem response (ABR) latency measures have been reported.



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

1. Absolute wave-V latency.
2. Interaural wave-V latency difference (ILD)
3. Interwave latency between waves like:

   i) Waves-I and III
  ii) Waves-III and V
 iii) Waves-V and VII
  iv) Waves-I and V
   v) Waves III and VII

Emphasis on the interaural latency difference (ILD) is a common method in studies, which deal with the effects of cerebellopontine angle lesions (clemis and McGee, T, 1979; House and Brackman, 1975; selters and Brackman, 1977, 1979; Thomson et al, 1978 and Rosenhamer, 1980).

Interwave latencies are the primary response criteria in studies of patients with lesions affecting the entire auditory pathway (Black et al 1979; Ocha et al, 1979; Starr, 1976, 1977; Starr and Achor, 1975; and Rossiter, 1977; Stockward et al, 1976, 1977, Uzil and Benezech, 1978).

The ILD measures (when compared with those of other special tests) demonstrates the best true positive rates (around 93%) Clemis and Curtis, 1977.

When it can be applied the interaural latency difference (DLD) is more sensitive measure than absolute latency (Clemis 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 subjects on different occasions (starr and Achor, 1975; Stockward 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 Archor 1975; Yamada et al 1975; Row 1978; stockward et al, 1978b, 1979; Wolfe et al 1978).

Brainstem responses have frequency components distributed in a frequency range that extend from about lOHz to 2KHz (Eleberling 1975; Ostefhammel 1981). Most workers agree that frequency specific responses may be obtained using tone bursts of 2KHz or higher. (Davis and Hirsch 1975; Paliber 1976; Weber and Folsom 1977; Mair et al 1980; Cobb et al 1978) found to apparent frequency effect on the ABR.

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

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

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 the minimal errors.

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

The factors that can bring about the variations in normal response parameters are:

1. Procedure effect:
   a) Position of the electrodes
   b) The use of the filters i.e. bandwidth
   c) Choice of response reference points for the computation of latency.

d) Difference in stimulus transducer.
e) Effects of masking or the ambient noise levels.

2. Subjects effects:

a) State of the subjects whether the subject is aware, asleep, sedated or anaesthetized.
b) Effects of the temperature
c) Sex differences
d) Effects of change in muscle tone and attention
e) Effects of age.

3. Stimulus parameters:

a) Derived response
b) Intensity stimulus
c) Rate of stimulus presentation
d) Stimulus transduction
e) Polarity effects
f) Binaural interaction
g) Tone–onset response
h) Frequency following response
i) Threshold effects.

This study will help the audiologist, neurologist, microaudiologist, researchers and others for others for their clinical and other purposes.

The present study has been designed to study the effect of frequency on the latency of brainstem response.

The need for the present study:

1. Normative data for BSERA have been found to vary with regard to the type of equipment used hence there is an urgent need for establishing the normal effects of frequency on the latency using TA-1000.

2. This study will be useful to the clinical utility as well as for higher research purpose.

3. From the normative data of this study, can be detect the different abnormality of his vestibular system.

Application of BSERA:

The BSERA has been widely used in most of the audiology clinics. It has gained clinical importance because of the stable responses. Many studies have demonstrated that brain-stem responsea re not affected by sedatives because of this great advantage the hearing sensitivity of noncooperative children can be objectively assessed using BSERA.

In addition to finding Air Conduction Thresholds, Bone-conduction thresholds can also be determind objectively using BSERA.

The objective assessment of Bone-conduction thresholds specially with children with atresia is of utmost importance.

The use of bone conducted signals in electrocochleography 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 somewhat 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).

In other respect ABR technique has emerged as a vital adjunct to the clinical armamemtarian of the Audiologists Otologists and Neurologists, who jointly determine hearing sensitivity, lesion site and central nervous system integrity, pathology and maturation.

BSER applications in audiologic-otologic disorders and site of lesion testing have shown that the responses are well suited for the detection of hearing abnormalities (Shaia and Albright 1980). They became popular in clinical audiology because of reproducibility, ease of administration, low inter and intra subject variability and accuracy in estimating hearing sensitivity.

Recent application of BSER has teen its use in neuro-logical diseases, brainstem lesions cause a selective absence or alteration of one or more of the response components, patients with brain stem circulation, and even brain stem damage (due to various types of tumours, demyelinating diseases, diminished brain stem circulation and even brain death) show either an absence of certain components or prolonged latency and reduced amplitude of response components.

Assessment of hearing of children red investigators to discover that norms applied to adults were not appropriate for various developmental stages in children. This led to a series of systematic studies in pre-mature infants, full-term infants, and pre-adolescaat children, a related application is an attempt to discover electrophysiologic correlates underlying demyelinating diseases such as multiple sclerosis Chaippa, Harrison and Brooks et al, 1980). The majority of these investigators subscribed to the well-known relationship that as the peripheral and CNS mature as (eg. as additional myelinization takes place, and perhaps as axon diameter increases), latency of BSERAs tends to decrease until an adult norm is achieved. In addition, the magnitude of the potential are observed to increase with age.

One of the most frustrating sight during an ERA procedure is to watch an averaged response slowly building only to be suddenly swamped by an artifact. Artifacts may be serious because they can be unwittingly accepted as true evoked responses and there are many cases in which deaf children have been falsely labelled as hearing. So, important is the problem of artifacts that virtually every established worker should have a method of recognizing and rejecting them.

Recognition of abnormal results depends on a knowledge of normal electrophysiological response characteristics such as response morphology, response latency and response amplitude. The children must also be cognizant of the variability of the normal characteristics between and within subjects and the variability due to non-pathologic factors, such as the nature of the stimulus recording procedures and subjects.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Brief review of literature talk about:

i) Brain-Stem Evoke Response

ii) Frequency of BSERA

iii) Intensity of BSERA and

iv) Latency of BSERA.

The discovery of the perceptual fluctuation of electrical potentials in the animals cortex was made in 1875 by Caton who described them as "feable currents of the brain". The discovery of these potentials was quite remarkable in that the amplitude is in the order of microvolts and Caten's discovery preceded the availability of electronic amplifiers for biologic research. The first recordings from the human brain were made in 1924 by Hans Berger (1929). The publication of his work, represented the first use of the team electroencephalogram (EEG) to describe these potentials. Berger established that these potentials. Berger established that these potentials originated in neuronal tissue and that the potentials changed with sensory stimulation (Brazier, 1958).

The presence of electrical potentials in the brain was first noted by Caton (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.

History and Development of BSERA:

It is always instructive to glimpse backward when considering contemporary issues such as electrocochleography (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 bioelectrical potentials in animals, first describe by Galvani, Circa (1971). In 1848, DuBois Reymond published his seminar paper on the discovery of negative action potentials in nerves. This was followed in 1875 by the first published evoked potentials recordings by Caton, following are 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).

Far Field Potentials:

The far field potentials 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 Willisten (1971) and 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 the distant neural generators.

Description of Early Response:

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

The most prominent of the series of 'fast' central nervous system (CNS) responses recorded from electrodes on vertex and mastoid or ear is a vertex positive wave with a latency of 5-9 m.sec, 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 cochleas (Hallowell, 1976).

BSER Generation:

Based on data several species, there is general agreement that the description of the different waves follows as:-

Wave-I:- Based on data from the several species it is seen that the acoustic nerve transmission of action potential from the cochlea to thebrain stem occupies a time course which is compatible with Wave—I latency and so there is agreement that the first positive peak is produced by the acoustic nerve activity (Cat-Archor and starn, 1980; rat-Henry, 1979; human-Sohmer et al 1974; Hashinolo et al, 1981).

Wave-II:- Data from a variety of different experiments consistently indicate that the cochlear nucleus contributes to and in essential for BSERA wave-II (Jewett, 1970? Buchwald, Huang, 1975).

Wave-II; The cochlear nuclei have two major divisions i.e. dorsal and ventral, as many as 13 sub-nuclei have been identified (Lorenle de No,1933). The ventral cochlear nueleus is more than twice as large as dorsal, and the two differ in cell type and organization. The dorsal cochlear nucleus is composed primarily of small granular cells that are laminated, whereas the cells of the ventral nucleus are larger, round in shape and show no layered pattern, intern euren link the two major divisions and most likely the other sub-nuclei.

The number of ganglion cells within the cochlear nuclei has been estimated to range from 80,000 to 90,000 in the cat and monky (Whitefield, 1967) to about 1000,000 in (man Hall, 1964). In addition several neuron types have been found in the cochlear nuclei and depending on the cell type, project to various rostal sites (Osen, 1969). These distinctive cell types contribute to the characteristics bioelectrical response discharge patterns exhibited by the cochlear nuclei (Kiang, 1975).

Second order neurons leave the cochlear nuclei in three acoustic Striae (1) The dorsal straia originates in the dorsal cochlear nucleus and passes through the reticular formation to the opposite side of the brainstem, to join the medial portion of the contralateral liminiscus and inferior colliculen (Osen, 1969; Bredberg, 1981).

Wave-III:- It is thought to arise from the superior olivary complex which is known to be the 1st stage of bilateral innervation.

In view of the direct and indirect links between MSO field potentials and wave-III, the principle substrate for wave-III generation is hypothesized as dendritic postsynaptic potentials of the MSO (Buchwald, 1983).

SOC:- It consists of three major nuclei that gives rise to third order neurons. The superior olive is the first anatomic sits of integration of diotic auditory input and conveys signals from both cochlea to more rostal structure. It may be inferred that sound localizations primarily mediated by cells in the accessory nucleus which are sensitive to inter time differences (Van Noorl, 1969).

The superior olivary complex maintains tonotopic organization from lower levels. The accessory olive is most sensitive to low frequency stimuli whereas the lateral olive responds best to high frequency input (Jsuchitani and Boodreau, 1966; Goldberg and Brown, 1968; Bradal, 1981).

Wave—IV: This wave is generated in the ventral nucleus of the lateral lernniscus and is dependent on crossed and uncrossed projections to this area. Also, this generation is postulated as PSP activity within the lateral leminiscus cell population (Buchwald, 1989).

L.L:- Ascending auditory fibers from the superior olivary complex and the cochlear nuclei course through the lateral limniscal tract to synapse at the inferior calliculus. Cell bodies have been found throughout the tract, but its dorsal and ventral nuclei compose the two major cell divisions. The inferior ventral nucleus of the lateral limniscus receives contralateral projections from the ventral cochlear nucleus and bilateral innervation from the olivary complex (Van Noorl, 1969; Warr, 1969). The dorsal nucleus is supplied with the bilateral input from the lateral and accessary superior oliver and the dorsal cochlear nucleus.

Wave-V:- The wave-V is generated from the inferior colliculus from crossed projections. Its results of lesion studies suggest that the deep ventrolateral portionof the IC is particularly important for wave V generation (Buchwald, 1983).

The wave V latency is short enough to avoid masking by the first sonomotor response that often begins at 10 m.sec. Yet long enough to avoid confusion with cochlear microphonic or the stimulus artifact. The voltage of this wave is very small of the order of 0.1 uV., but as with the middle responses rapid repetition rates are permissible. The chief disadvantages 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 10dB SL (Hallowell, 1976).

Wave-VI: It arises from the medial geniculate body. It is consistently ranked hardest to recognize the BSERA in a normal

population. It is so irregularly present and variable in wave-form that its clinical usefulness has been questioned (Chiappa, Glodstone and Young, 1976).

Since, the wave-VI is a complex neural structure that receives ascending multisensory input and descending corticotugal input.

Wave-VII; It is arises from the auditory radiations of the palmary auditory cortex (Thalanocortical) and this wave is irregularly present.

Wave VII - The basic cytoarchitecture of the cerebral cortex consists of a complex neural network of cells and fibers which comprise six horizontal lanire, while the density and cells type vary between layers, five basic neuronal cells havebeen identi-fied. They include - horizontal cells of Cajal, Stellate cells, paint Djramedial cells of Betz, cells of Martinotti and fusiform cells.

Ascending fibers from the medial geniculate body spread upward through the subtenticular portion of the internal capsule to terminate in the auditory cortex. Early attempts to correlate sensory stimulation to specific areas of the cortex were based on cytoarchitecture, most notably, the work of Broodmann,(1909).

According to Dobie (1980) responsesvariably usually measured is the latency of wave V, for several reasons.

1) Wave V is usually the largest component in BSER.
2) Wave V is the least variable component of the BSER trace, from subject to subject.
3) Under adverse conditions such as low stimulus intensity and high repetition rate, wave V persists while the other waves becomes increasingly indistinct.
4) Latency of any of those wave is far less variable than response amplitude.

Chiappa et al (1979) reported possible variation in the morphology of the IV-V complex for normal adult subjects.

a) Single complex with no separation for waves IV and V.
b) Separate waves with V is greater height than IV.
c) Separate waves with IV of greater height than V.
d) Wave V appearing as an inflectiop6f IV.
e) Wave IV appearing as an inflection of V.
f) Separate waves of the same height.

The preceding direction has shown that sub-cortical auditory pathways from a complex net work of diverse cell types, organizations and interconnections. Yet, there is order and integration within this diversity. Anatomic and electrophysiologic evidence indicates that tonotopic organizations maintained in the auditory cortex. Detailed experimental animal investigations have shown that atleast five auditory area in the cerebral cortex have been associated with frequency 'mapping' in response to electrical or

acoustic stimulation of the periphery Woolsey and Walzi, 1942; Tunturi, 1944, Hind, 1953; Hoolsey, 1961? Meozenich and Brugge, 1973). While the relationships between cortical areas remain enresolved, the concept of the neural redundancy may be illustrated here i.e. the CNS tends to process information in a variety of overlapping ways. By means of its may commissural crossing, the auditory pathways has supplied each cerebral hemisphere with angle input from each cochlea.

Animal studies:

Jewett (1970) studied eighteen anesthesized cats by taking direct recording from the scalp and rostal brain locations. The tongue served as the reference point in all recordings. He observed five positive waves (P1 to P5). P1 recorded from the scalp occurred simultaneously with N1 recorded from the round window, and it was concluded that P1 reflected activity of the eight cranial narve bipolar cells. The remaining waves were suspected to be composit reflections of both slow and fast wave activity of multiple brain stem generations.

Buchwald and Huang (1975) produced histologically confirmed lesions throughout the auditory tract of the cat, and observed the related effects on the surface recorded ABR. Decerebration of the animal at the level of the inferior colliculus did not alter the response i.e. the latency and amplitude of the five component waves was unchanged. Wave V disappeared when the

inferior colliculus was aspirated, but when structures down to but not including the cochlear nucleus were destroyed. Any wave I was observed when the acoustic nerve was isolated.

They also produced lesions through the middleline of the brain stem and observed that waves III and V were dependent on crossed fibers, but wave IV was dependent on both crossed and uncrossed fibers. Lewions within these brain stem halves demonstrated that the integrity of the medial superior olivary nucleus was required for observation of wave III and an intact ventral nucleus of the lateral leminscus was necessary for the observation of wave IV.

Starr and Achor (1978) also took direct recordings from sub-cortical auditory structures of anesthesized cats in a manner similar to that employed by Jewett (1970) and Lev and Sohmer (1972). Starr and Achor (1978) observed a series of potentials lasting for several milliseconds at each recordings site in the brain stem pathway. They concluded that these data suggested that ABR components, recorded with scalp electrodes, reflect the composite activity of as many as six brain stem generations.

Starr and Archor (1978) also examined the effect of discreate lesions on the surface recorded ABRs in the Cat. A lesion in the ventral cochlear nucleus reduced the amplitude, but did not effect the latency of components beyond wave II. Lesions in the inferior colliculus, lateral lem&niscus and dorsal cochlear nucleus had no influence on the scalp recorded ABR.

Allen and Starr (1978) performed a topographic analysis of scalp distribution of ABRs in rhesus monkeys to investigate the possible location and participation of brain stem structures. The sternum served as the reference site and several recordings were taken from active electrodes on various scalp and earlobe locations. Waves I and V appeared to reflect activity from unilateral generators. Waves II and III originated in bilateral generators and wave IV appeared to have its origin in either a midline or bilateral generator.

Human studies:

Lev and Sohmer (1972) speculated that the similarity between the cat and human ABR suggested that human response may reflect similar neural generators. Subsequent studies (sohmer et al, 1974; Starr and Achor, 1978; Starr and Hamilton, 1976; stockward and Rossitor, 1977) examined alterations of the ABR in patients with confirmed eight nerve and brain stem lesions. These studies demonstrated that wave I was typically the only remnant when lesions or when the brain stem was extensively damaged. Alterations of Waves II and III was associated with lesions in the medulla and pors i.e. the cochlear nucleus trapezoid body, and superior olive. Lesions effecting midbrain auditory structures were associated with changes in waves IV and V.

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). Preton et al. (1974) found that the wave I was restricted to the ipsilateral (relative to the stimulated ear) mastoid, and it was very similar to be N1 potential recorded with a transtympanic needle electrode. They concluded that this was reasonable proof 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 superior olivary complex. Wave V appeared to be a for field reflection of lateral leminiscus or inferior colliculus components. Picton et al (1974) concluded that waves I through IV represented activity of the auditory nerve and brainstem auditory nuclei, but the ABR waves recorded from vertex to mastoid reflected the composite contribution of multiple generators.

Goff et al (1977) investigated the ABR innormals young adults undergoing elective non-neurological surgery. Comparions were made between pre and post anesthetic responses, and the only alteration observed was about a 15% decrease in response amplitude. No other barbiturate related to effect on the response were also recorded and these were markedly influenced by anesthesia. Goff et al (1977) concluded that their data stragly indicated a subcortical leminscal origin for the ABR wave components.

A composite impression of the data reviewed above has motivated several investigators to assign a specific correspondence between given ABR components waves and specific neural generators. A diagrammatic representation of this correspondence is shown in the Figure.

Wave I and the eight cranial nerve, wave II and the cochlear nucleus, wave III and the superior olivary complex, wave IV and the lateral leminscus and wave V and the inferior colliculus. Such an association, escape especially for waves II through V, must be considered hypothetically for atleast two reasons.

(i) The brain stem lesion of patients in human studies were often extensive and diffuse, making a non-to-one correspondence between given waves and lie neurologic structures difficult to conceive.

(ii) It has been shown Jewett 1970; Picton et al 1974; Starr and Archor, 1978) that each surface recorded ABR component wave probably reflect the composite activity of several neural generators. As Starr and Hamilton (1978) point out that a click will evoke cochlear nucleus potentials with latencies from two to eight m.secs.

They conclude at this time that wave I is generated by the bio-polar cells of the eight cranial nerve (Sohmer and Feinverssor 1967; Jeuett, 1970; Jewett and Williston, 1971). But waves II, through V may reflect the generalized leminiscal activity of the brain stem auditory system.

Classification of Auditory Brain stem Responses:

The Auditory Brain-stem Responses can be divided into categories on the basis of placement of electrodes, latency, different properties and presumably different anatomical sources.

On the basis of latency i.e. the time elapsed between the stimulus and response, the auditory electrical or evoked responses can be currently divided into 4 categories. Figure No. shows the semantic representation of the four class of auditory evoked potentials of electrical responses. The latency periods that characterized the various measures are the following ways:

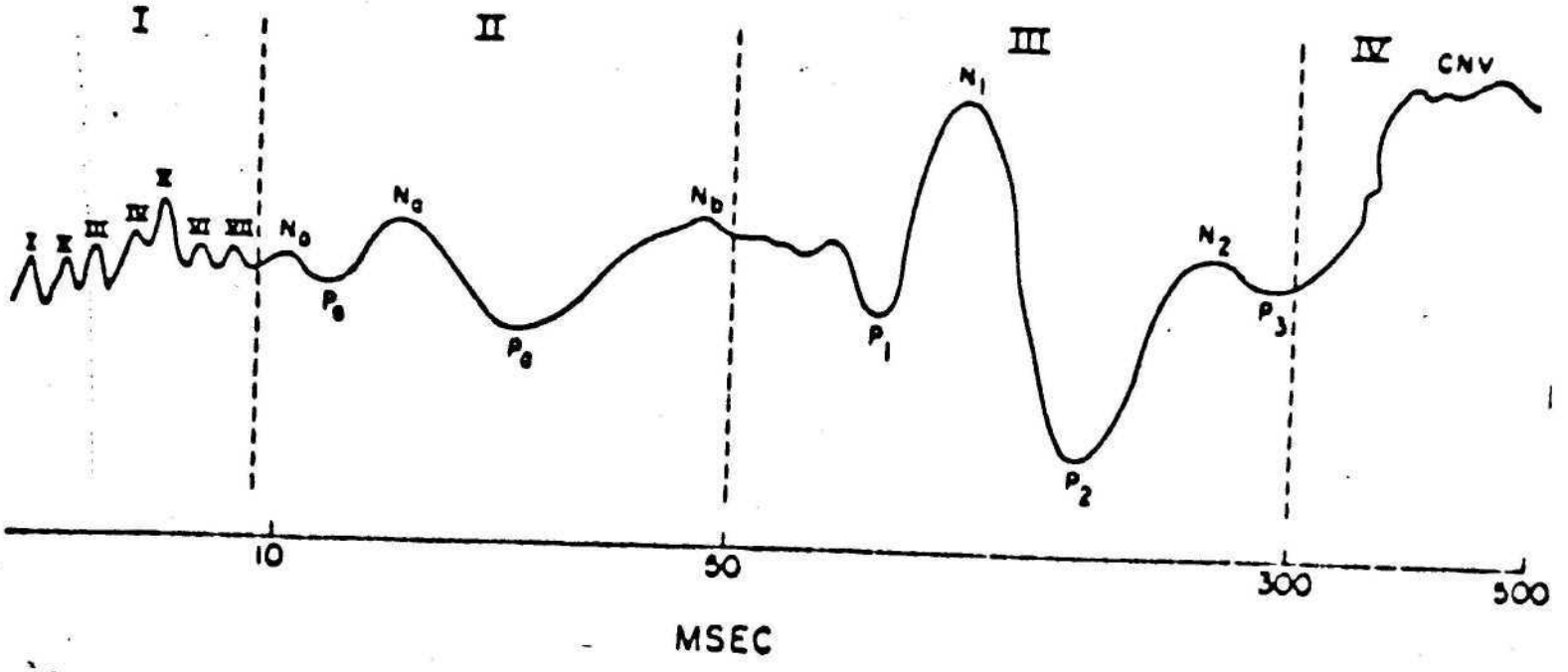
i) Cochlear potentials - 0.5 - 5 m.sec.
ii) Brain stem Responses - 1-10 m.sec.
iii) Middle electroencephalic response - 10 - 15 m.sec.
iv) Late or slow electrocephalic response - 50-500 m.sec

(Rose, 1978).

This division has a practical explanation, since techniques for recording them are different and these responses are felt to represent successive levels of activation in the nervous system(Dobie, 1980).

The early response is comprised of a series of "very fast waves" (100 to 2000Hz) which presumably arise from the brain-stem (Jewett and Williston, 1971; Lev and Sohmer, 1972). The

Fig. 4: Schematic representation of the four classes of auditory evoked potentials.



(Adapted from Skinner, P.H., 1978).

	Response Latency classifi-cation.	Site of origin	Response waveform	Purpose latency m.sec.	Amplitude in uV
1.	BCOG	Auditory nerve	Fast	1 to 5	0.1 - 10
2.	Early	Brain Stem	Fast	4 to 8	0.01- 1
3.	Middle	Brain stem/primary cortical projec-tion.	Fast	8 to 50	1.0 - 3
4.	Late	Primary cortical projection and secondary associa-tion area.	slow	5O to 300	8.0 - 20
3.*	Very late	Prefrontal cortex and secondary association area.	Very slow	300 & beyond	20 - 30

(Newby,1979)

middle response is comprised of a series of "fast waves" (5-100Hz) which presumably arise from the primary cortical projection areas. (Golstein, 1969). The late response is comprised essentially of "slow waves" (2 to 10Hz) which presumably arise from the primary cortical projection and secondary association areas (Appleby, 1964; Scott, 1965). The "very late" response has been described as the expectancy wave which is the last peak in the late response and the contingent negative variation (CNV) which is a long latency negative potential (DC shift). This response presumably arise from the frontal cortex (Walter, 1964a).

Characteristics of Normal Response in BSERA:

The use of the Auditory Brain Stem Responses (ABR) for clinical purposes obviously involves the recognition of abnormal responses from the normal makes diagnosis possible. Such recognition depends on a knowledge of normal auditory brain stem response characteristics* Generally, these are three ABR parameters looked for it. They are the following:

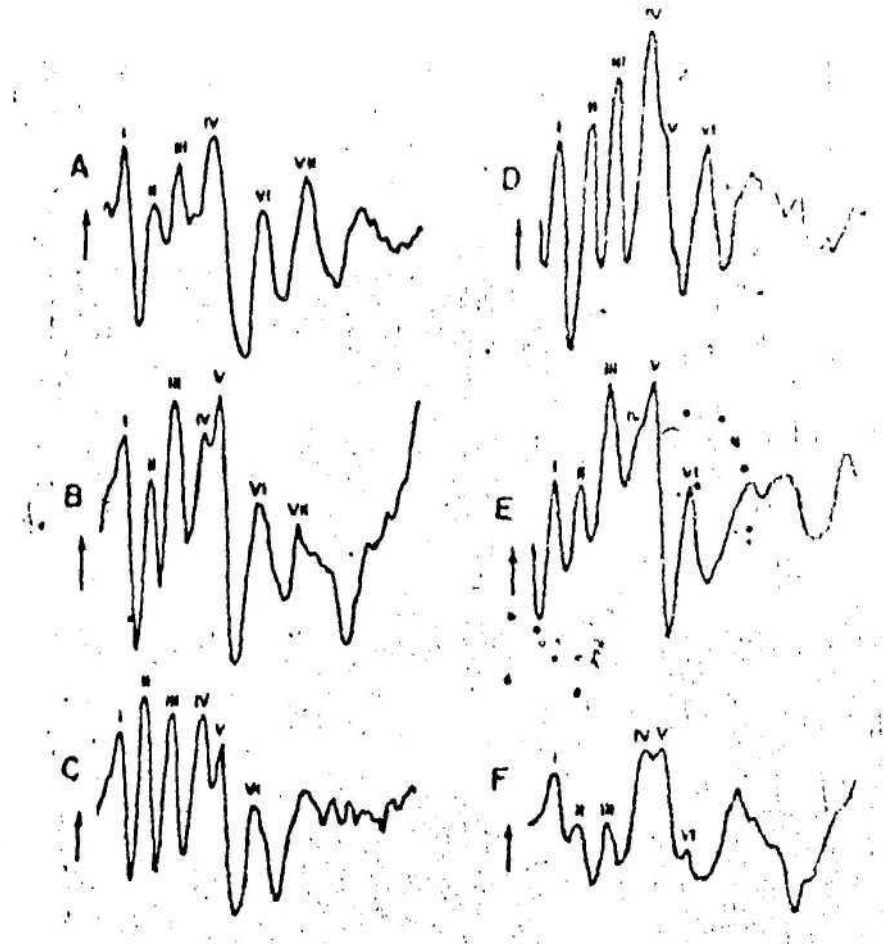
i) Morphology

ii) Response latency, and

iii) Response amplitude.

Particular emphasis is placed on the description of parameters variation due to nonpathologic factors.

Fig.5: Possible Variations in the Morphology of the IV-V complex for normal adult subjects.



(As reported by Chiappa et al (1979)

(i) Morphology:

It refers to visual appearance of wave form. It is a more subjective parameters than either latency or amplitude, because morphology cannot be specified in measurable units such as milliseconds or microvolts.

There are wide individual differences in the morphology of the response (Rowe, 1978, Chiappa et al 1979), that do not appear to be easily explained by any other parameters. In 50% of normal subjects there is a double or bifid peak I and a similar incidence has been reported for a double peak III. These double peaks tends to occur of higher intensities. Chiappa et al (1979) have described several patterns of peak IV-V morphology, Picton et al (1981) have observed similar patterns and gave combined incidence in both studies. In 15% of cases wave IV and V merge into a single peak, in 45% of cases wave IV is similar than wave V, in 30% of cases wave V occurs with lower amplitude than wave IV and in 10% cases waves IV and V approximately equal. In about one third of the cases the waves IV-V pattern in one ear is not the same as that seen in other. Stockard et al (1979) have pointed out that many of these IV-V patterns can be caused by changing the polarity of the stimulus used in evoking the response. Although Chiappa et al (1979) did not report the polarity ef their click stimuli. Picton et al (1981) state that by using clincks of one polarity there are definite individual differences in the response morphology that depends upon the ear, the polarity of the stimulus.

ii) Response Latency:

The latency is the time relationship between any response and the stimulus eliciting that response. For Auditory Brain Stem Response (ABR) this parameters is designated as absolute wave latency or interwave latency.

Absolute latency is the time relationship between stimulus onset and associated response. Interwave latency refers to time difference between two components waves Eg. the I-V inter-wave latency, their values are typically specified in milli-seconds in fig. No.

Clinically the most valuable interwave latencies are the I-II, III-V and I-V intervals (Bergholtz, 1981).

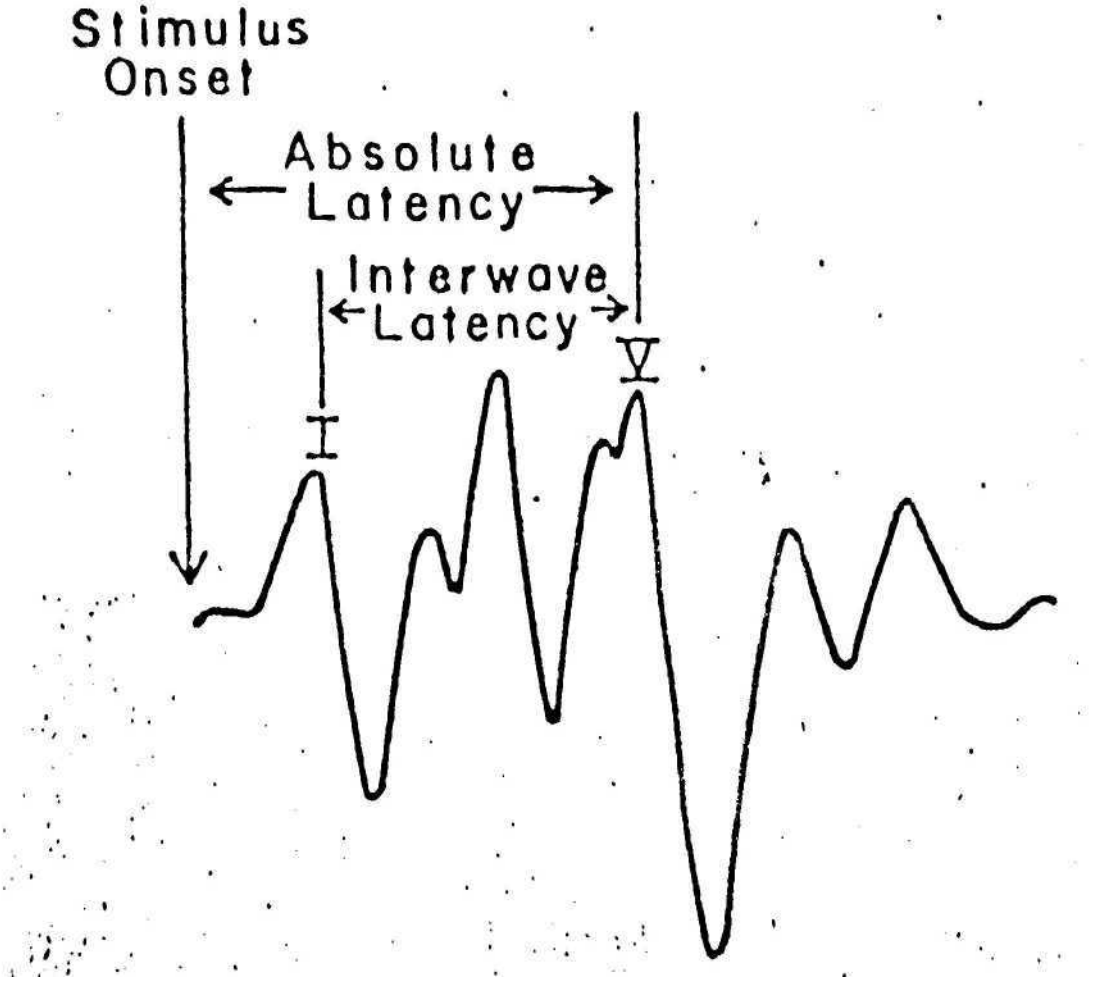
The mean absolute latency values for normal adults reported by different authors are shown in the tables. Those authors used a general technique, vertex ear recording, stimulation with 60 to 70 dB SL unfiltered clicks and latencies measured from onset of the electric clicks except Jewett and Williston (1971) and possibly Lev and Sohmer (1972) who measured latencies from the arrival of the sound to the tympanic membrane. The varia-tion between studies for the different latency values may be attributed partly to different latency zero references and different clicks intensities, but part of these are due to diffe-rent delays in the equipment used.

Measures of the variability of normal absolute latencies can be used for comparison between different reports. The standard deviation of normal latency values reported by Lev and Sohmer (1972) and Amadeo and Shagass (1973) was greater for waves beyond III, but in these early papers the inferently inconsistent IV-V complex was labelled as one wave, and this might account for observed increase in variability. Later reports by (Starr and Achor, 1975? Rosenhamer et al 1978) approximately same standard deviation for all ABR component waves 0.3 ms.

Normal interwave latency values have been reported for several combinations by stockard and Rossiter, (1977), Gilroy and Lynn (1978), Rowe(1978), Beagley and sheldrake (1978) Chiappa et al (1979), Rosenhmer et al (1978) and 1980, Bergholtz (1981). Table No. represents a comparison of published findings for young adult subjects for young adult subjects. As shown the I-V interwave latency approximates 4.0 ms and slightly more than half of this time can be attributed to the I-III interwave latency.

The I-III values estimates transmission time through the ponto-n edollary junction and lower pons, and III-V values estimates transmission time from aaudal pons to caudal midbrain levels. The I-V latency estimates the time needed for impulses to travel the entire system and is sometimes called 'central' or 'brainstem'. transmission time. These estimates are of great values for clinical purposes.

Fig 6. Absolute and Inter-wave Latency Distinction in BER



(Adapted from Fria, T., 1980)

Investigators	N	Click intensity	Absolute latency (m.sec) I	II	III	IV	V	VI
l.Jewett & Willisten(1971)	11	60-75 dB	1.7	-	-	—	4.6-5.1	—
2.Lev & Sohmer (1972)	10	65 "	1.5	2.5	3.5	5.0	5.7	-
3.Amadeo & shegass(1973)	4	60 "	1.6	2.6	3.5	4.3	5.8	7.4
4.Picton et al (1974)	20	60 "	1.5	2.6	3.5	4.3	5.8	7.4
5.Starr & Achor (1975)	6	65 "	1.6	2.8	3.8	4.8	5.5	7.1
6.stockard & Rossiter (1977)		60 "	1.9	3.0	4.1	5.1	5.9	7.6
7.Rosenhamer et al (1978)	20	60 "	1.7	2.9	3.9	5.2	5.9	7.6
8.Rowe (1976)	25	60 "	1.9	2.9	3.9	5.1	5.8	-
9.Rowe(1978)	25	60 "	1.96		4.01	-	6.01	-
lO.Stockard et al (1978)	20	60 "	1.8	2.9	3.9	5.2	5.8	-
ll.Beagley & Sheldrake(1978)	20	60 "	2.4	-	4.6	-	6.4	-
12.Chiappa et al (1979)	50	60 "	1.7	2.8	3.9	5.1	5.7	7.3
13.Rosenhamer et al (1979)	41	60 "	1.96	-	4.03	-	6.03	-
14.Bergholtz(1981)		65 "	1.8	2.9	4.0	5.2	5.9	-
15.J.P.Gupta (1983)	20	80 "	1.20	2.2	3.2	4.3	5.0	
		90 "	0.92	1.9	2.9	4.1	4.8	

Investigation	Intensity	I-III	III-V	I-V
l.Stockard and Rossiter (1977)	60 dB	2.10(0.20)	1.9(0.20)	4.00(0.20)
2.Gitray and Lynn (1978)	15 dB	2.05(0.15)	-	3.83(0.13)
3.Rowe (1978)	25dB	1.97(0.16)	1.97	-

Response Amplitude:

In BSERA, response amplitude refers to the height of the given wave component, and it is usually measured in microvolts (uV) from the peak of the wave to the following trough (assuming that vertex positive wave are displayed as upward deflection). This measurement is called absolute amplitude. The absolute amplitudes of ABR component waves can also be expressed in relation to one another, and these are called relative amplitudes.

The variation of normal values of ABR amplitude have been observed substantially by Amadeo and Shagass (1975); Starr and Achor (1975); Chiappa et al (1979), stockard et al (1978) reported the mean amplitude in response to high intensity clicks to be 0.15 and 0.38 uV for wave I and V respectively. Since there is great variability in absolute amplitude measurement, relative amplitude is suggested by Starr and Achor (1975). in 50 normal subjects, they found that ratio of V:I always exceeded 1.0 in response to click intensities below 65dB. Similar ratios for 60dB clicks evoked ABRs were reported by Stockard et al(1978), Chiappa et al (1979), who found mean V:I ratio 2.53 in 100 normal ears.

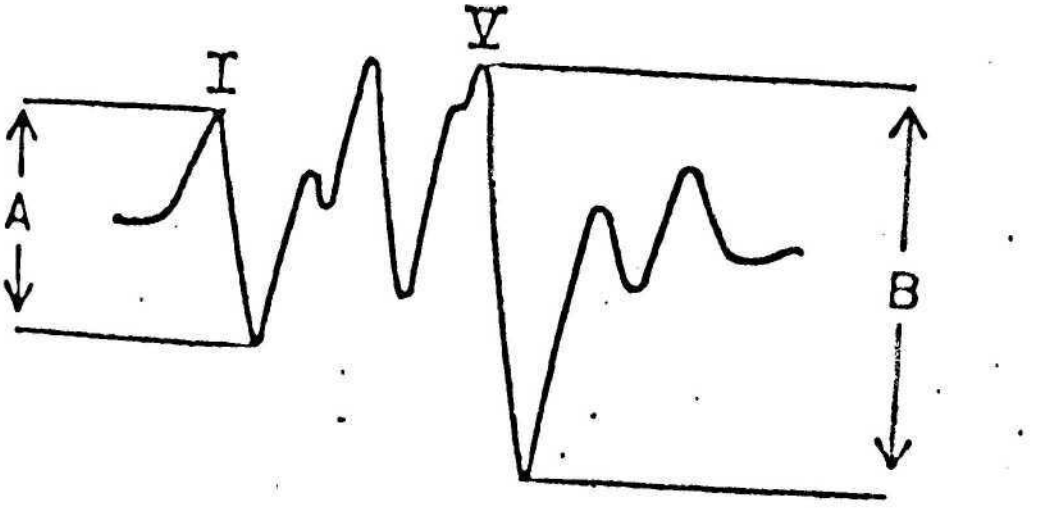
Effects of Intensity on BSERA:

The auditory Brain Stem Evoked Response Audiometry responses, the morphology, the latency and the amplitude changes with changes in intensity of the clicks stimulus.

The latency of all components increases with decreasing of intensity. The peak latency of wave changes from 5.6 m.sec. at 80 dBHL to 8.2 m.sec at 10 dB, (Hecox and Galambos, 1974), Starr and Achor, 1975, Zollner et al 1976; Picton, et al 1977; Beagley and Sheldrake 1978; Coats, 1978; Galambos, and Hecox, 1978; Rasenhamer et al 1980; Picton et al 1981). The standard deviation of the latency measurements increases somewhat with decreasing intensity. At 70 dB the standard deviations for V-latency have been reported between 0.20 and 0.25 whereas at 30dB the standard deviations have increased to about 0.30 m.sec. The latency intensity data can be fitted reasonably well by a linear regression line with an average slope of -38 US/dB and with a base line value of 8.25 m.sec. at O.dB. The normal values for the slope of this line ranges between 20 and 50 US/dB (Pratt and Sohrner, 1977;Galambos and Hecox,1978; Marillaud, 1980) although at high intensity slopes as low as 10 Us/dB and at lower intensities slopes of upto 60 Us/d3 may be seen. The relationship is not really linear and a somewhat better fit can be obtained using a power function such that lag 10 (V-latency in m.sec).

-0.0025 (Clicks intensity in dB) + 0.924. The other peaks of the responses have approximately equal slopes to that of wave-V (Starr and Achor, 1975; Pratt and Sohner, 1977). However, as noted by Stockard et al 1979; wave-I may actually show a slightly larger latency shift with decreasing intensity than

Fig-7: Diagram showing the distinction between absolute and relative amplitude in the context of the brainstem electrical response (BER)



(Adapted from Fria, T., 1980)

wave-V, particularly over the middle intensity range. Thus the I-V inter-peak latency decreases from an average of 4.02 m.sec. at 70dB SL to 3.68 m.sec. at 30 dBSL.

The changes in amplitude of the brainstem response components with intensity have been the subject of study of very few people (Starr and Achor, 1975; Zollner et al 1976; Pratt and Sohmer, 1977; Picton et al 1987). Further more, because many different high pass filter settings are used it is difficult to compare data across laboratories. Using high filter setting of 100Hz to lower, the amplitude 6f wave V measured relative to the succeeding vertex-negative wave decreases from about 0.6uV at 70dB to 0.3 uV at 20dB nHL with the average curve being approximately linear over this region. The amplitude decreases much more slowly above 70dB, when high pass filter setting of greater than 100Hz are used the amplitude of wave V is smaller and may reach a maximum value at lower intensities. The amplitude is far more variable than the latency measurement and individual subjects may show quite consistent steps in the amplitude intensity function that do not show up in the average data over a population of subjects. The earlier components of the brain stem responses show a more rapid decline in amplitude than wave-V. At 30dB nHL, the amplitude of wave-V in response to a 10/sec. Click stimulus, is about 60 percent the amplitude at 70dB, whereas the amplitudes of wave I and III have been reduced to about 30 percent of their respective amplitudes at 70dB. Wave V is

easily recognizable in normal subjects to within 20dB of threshold whereas the earlier waves of the response become difficult to identify below 50dB nHL.

Interwave latencies do not follow the logic of intensity latency function. Rowe (1978) and gtockard et al (1978) observed minimal changes in interwave latency when stimulus intensity was decreased. Stockard et al (1978) reported one subject who showed a 0.07 m.sec. increase in the I-V interwave latency when responses to 70 to 20dBSL. Clicks were compared close examination of this subject wave forms, however, reveals that they measured the I-IV latency at 70dBSL and perhaps the I-V latency at 20dBSL. Hence slight increase in interwave latency for the 20dB SL stimulus is not surprising. In a later paper Stockard et al (1979) reported that wave-I latency Increased more than wave III and V when stimulus intensity was decreased. Consequently interwave latency values involving wave I-III and I-V were shorter at lower stimulus intensities. The average decrease I-III latency was 0.19 m.sec. for I-V was 0.34 m.sec. For one subject the I-V latency decreased 0.73 m.sec. When the responses to 70 and 30dB SL clicks were compared. For some subjects, the transition (decrease) in interwave latencies was most prominent for responses to 40 or 50 dB SL clicks.

The relative amplitude ratio V:I increases with decreasing intensity (Fria, 1980). This intensity related changes in relative amplitude confirmed the original observation of Starr and Achor (1975).

Effect of sex on BSERA:

The latency and the amplitude of the BSERA is significantly related to the sex of the subject. Adult female subjects have significantly shorter latencies for wave III and V. For clicks the difference in V-latency has been reported as between 0.05 and 0.36 (on average 0.22) m.sec (Beagley and Sheldrake, 1978, Kajar 1979, McClelland and McBrea, 1979; Jerger and Hall, 1980; Michalewski et al, 1980; Jackobson et al 1980). The differences in Ill-latency is slightly less, on average about 0.15 m.sec. Wave I is little affected and therefore the I-V inter-peak latency is about 0.21 m.sec. Shorter in female subjects (stockard et al, 1979). The sex related latency differences persist at lower intensities and at faster presentation rates Kjaer, 1979; Michaleswki et al, 1980). Wave I appears to be about 30% larger in females wave III 23% and wave V 30%.

The sex differences noted in the latency measurements do not occur in normal young children. The occasional sex differences noted in neonatal studies (Seilz et al, 1980; Cox et al 1981) are probably related to the increased perinatal risk in male infants and do not persist (Cox et al, 1981). There is some controversy in the literature about when the adult difference begins. McCtelland and McCrea (1979) found no significant sex related latency differences in a group of 9-13 years old children but noted difference related to adolescence and its attendant hormonal

changes. 0'Donovan (1980), however, found significantly different latencies from the age of eight years onwards. Anatomical differences between the sexes might therefore underlie the differences in recording brain stem responses. At present it is tutile to speculate the cause for these differences. The only intelligible explanation seems to be based on spatial diamension of the wave generating system and volume conductor embedding it, then electrophysiological diversity. Shorter pathways would give an earlier latency and might also increase synchronization so as to give a larger amplitude.

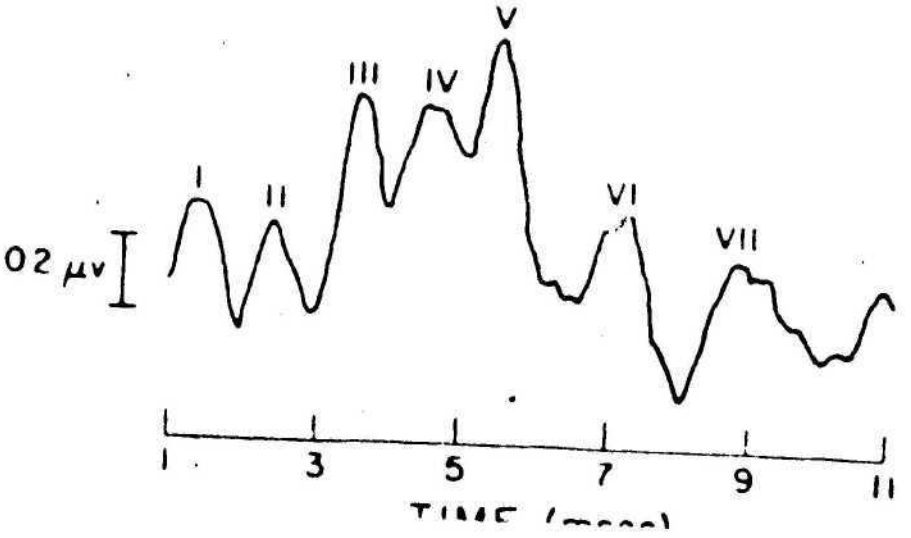
Another factor that is specific to the adult female is the menstrual cycle. Picton et al (1981) have reported that I-V inter peak latency changes slightly, during the menstrual cycle, being on average 3.87 m.sec. between the days 12 and 26 and 3.92 m.sec on the other days. This is probably related to temperature changes during the menstrual cycle. Temperature differences cannot although explain the overall male and female differences since males in general have slightly higher cores temperature than female.

Test-Rest-Reliability of BSERA:

The test reliability of BSERA is excellent. The N and V peak can be used confidently to estimate the hearing status. The latency of this peak is remarkably constant even from subject

to subject and is normally hearing adults, it occurs at 4.9 -

Fig.8: A Typical brainstem electrical response (BER) obtained in a normal young adult.



(Adapted from Skinner, P.H., 1978)

m.sec. Using an 80 dB HL click stimuli (Gibson, 1978). The N V peak, nearly always follows the N I by exactly 4.0 m.sec. Unless the subject has some disorders affecting the brainstem.

For audiometric purposes, the N V can usually be indentified at 10dB SL or less usually click stimuli or tone burst of 2-8KHz. (Davis, 1976). Some subjects do not yield an identifiable N V within 10dB but this never happens at 30dB SL using 4 KHz stimuli. The older subjects over 40 years of age seemed to be most difficult to test for threshold purposes. At lower stimulus frequencies the N V becomes broder and more difficult to identify (Davis and Hirsh, 1977). Antenelli (1976) BSERA threshold between 10-30 dB for 75% of his 39 adult subjects. At 500Hz the N V is very difficult to identify (Davis and Hirsh, 1979). The test retest reliability is good. The BSERA wave form does not show any change on the repeated or prolonged testing. Thornten (1975) tested the same subjects on different occasions and found no significant changes in either the amplitude or latency of the BSERA. The standard deviation (S.D) of the amplitude data were proportionally much larger than thoae obtained from the latency data.

This suggests that despite the averaging procedure, a considerable proportion of the measured response amplitude variance is attributable to the remaining variance of the background noise process (Thornton, 1975). Rosenhamer et al (1978) determined test retest reliability in6 subjects. The time gap in testing was 6

months and be used two sided t-test with equal latency, hypothesis rejection probability set at 5%. The results showed good test retest reliability.

METHODOLOGY

METHODOLOGY

The methodology of the present study is described under the following headings.

1. Selected subjects for study
2. Equipment used for study
3. Test environment during testing
4. Testing procedure
5. Testing results and analysis.

Subjects:

For the present research twenty normal hearing (20dB HL ANSI 1969) subjects with the age range of 18 to 25 years (mean age is 20.5 years), ten males with mean age of 20.3 years and ten females with mean age of 19.8 years were selected. Both the ears i.e. right ear and left ear were tested in all these subjects. The subjects were selected on the following criteria.

1. They should not have had any history of chronic ear discharge tinnitus, giddiness, earache or any other otological complaints.
2. They should not have had any history of epilepsy or any other neurological complaints.
3. They should be able to relax and feel comfortable with electrodes on* within 10-15 minutes after their placement.
4. They should not have any psychological problem or any kind of psychological disorders.

5. Their electrophysiological input should come below 500 microvolts within 10-15 minutes after electrodes placement.

6.The subject should not show any hearing loss i.e. their hearing sensitivity should be within the normal limits i.e. within 20dB HL (ANSI 1969).

Equipment:

The following are the instruments used for the present study purpose:

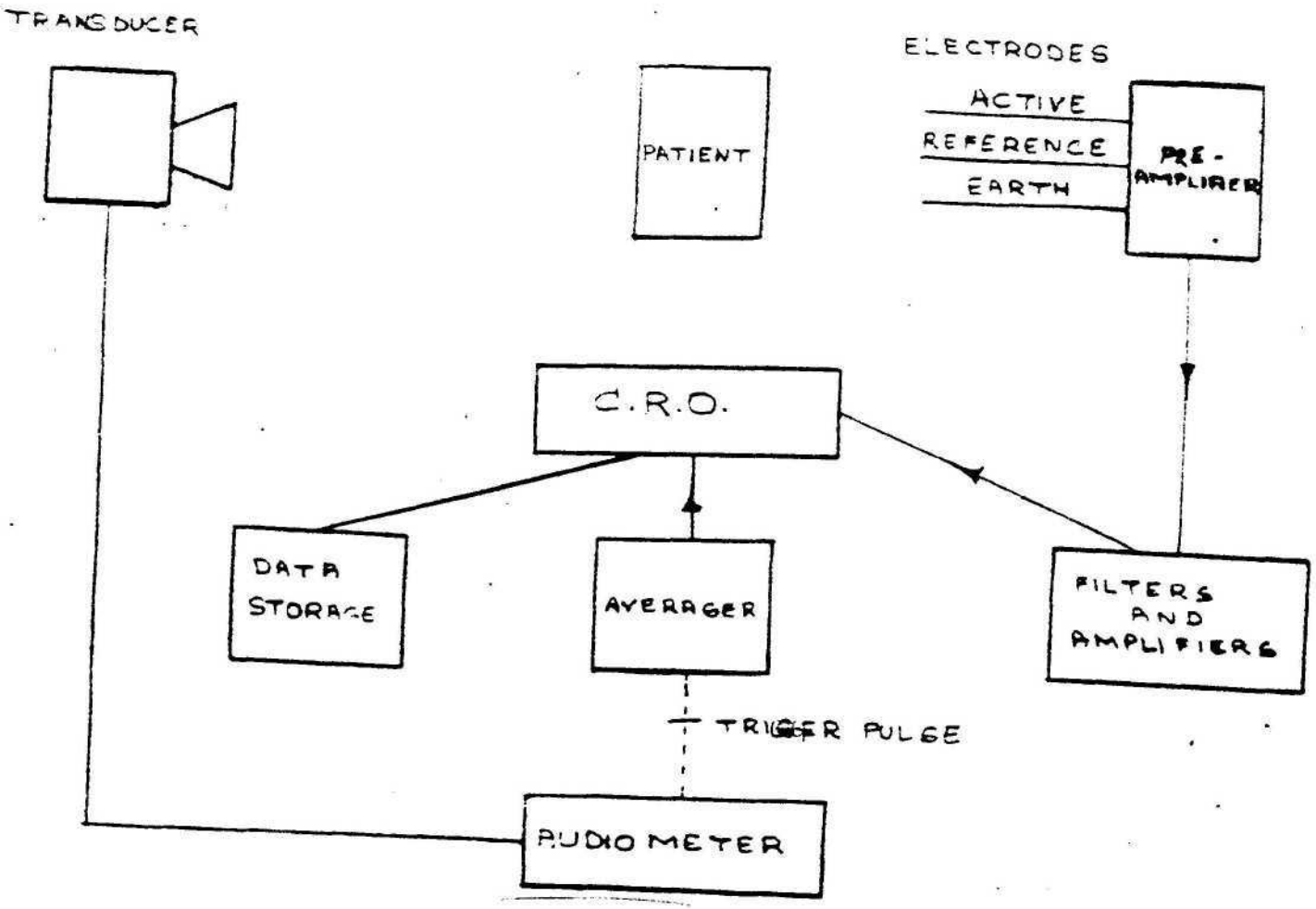
1. GSI-10 Audiometer.
2. Electric Response Audiometry Model TA-1000.

For the selection of the subjects hearing thresholds were obtained for right ear and left ear at all octave frequencies i.e. from 250Hz to 8KHz. Using GSI-10 Audiometer. The output of the audiometer was given to ear phones TDH-39 housed in earcushions MX-41/AR. The audiometer was calibrated for pure-tones and speech noise objective calibration was repeated once in a month till the study was very stable. Subjective calibration was done everyday before the testing.

Brief description of the Electric Response Audiometer Model TA-1000:

The instrument Electric Response Audiometer Model TA-1000 consists of the SLZ 9793 desk top console, the SLZ 9794 pre-amplifier and an accessory group.

Figure-9: Schematic diagram of ERA equipment



(adapted from Gibson, WPR; 1978)

The SLZ 9793 console contains all of the operating controls, indications and readouts for the system. It provides the patients an auditory stimulus and accepts patient's electrical responses from the pre-amplifier. Signal conditioning and digital averaging extract the patients BSERA response from the background noise. Oscillographic display and ink-on-paper recording provide an on going monitor as well as a permanent record of responses.

The SLZ 9794 pre-amplifier is an isolated EEG pre-amplifier with frequency response and gain specifically designed for BSERA. Patient's electrical response is sensed by a set of three electrodes and after amplification, is conducted to the console by an interconnecting cable.

Accessory group used wast

1. A binaural air-conduction headset with cord set.
2. Interconnecting cables, chart paper and pens.
3. Sets of electrodes, electrotype gel and electrode adhesive pad (which was exhausted and substituted by johnson plast).

Controls and their function:

The TA-1000 is operated with only (1) Four knobs and (2) nine push button switches. All knobs are clearly marked to indicate their functions. Push button switches are of two types,

alternate acting i.e. push-ON, push-OFF, and momentary acting i.e. push-to-indicate. All push buttons indicates, by means of internal lamps, the active state of the selected function. Unwanted or illogical function are internally inhibited.

Four Knobs:

The stimulus function switch permits selection of 2KHz, 4KHz or 6KHz acoustic logon stimulus equivalent frequencies, at repetition rate of 5 or 20 stimuli per second and patient response intervals of 10 m.secs or 20 m.secs immediately following the acoustic logon stimulus.

2. The stimulus attenuator establishes the presentation level, permits selection of acoustic logon stimulus from 0 to +100 dB HL.

3. The scale function switch permits selection of system sensitivity and number of averaged response samples. For 1024 samples, 0.5 MV, 1 MV and 5 MV per division sensitivities are available. For 2048 samples 0.2mV, 0.5mV, lmV and 2wV per division sensitivities are available. For 4096 samples, O.1mV, 0.2mV, 0.5mV and lmV per division sensitivities are available.

4. TA-1000 has a calibrated latency cursor, which appears on the oscilloscope trace as a function of latency control. The latency of a particular peak can be obtained by moving the cursor to the desired peak. Readout of latency is in milliseconds.

Push Button Switches:

1. Power switch energizes the system and indicate the system status.
2. Scope switch controls the oscilloscope display.
3. Clear pushbutton clears the micro processor averages memory, resets the sample display counter and corrects the micro-processor operating mode to correspond to the current control status.
4. START/STOP-push button initiates the microprocessor average function. As the number of samples accumulates, the averager can be stopped to evaluate intermediate results and restarted without disturbing the averager action. The averager function is automatically terminated when the selected number of samples has accumulated or when any averager memory channel is full, automatic termination requires a clear, to permit restart.
5. Record push button initiates the platter readout if the averager is not active.
6. AIR LEFT applies the stimulus to the desired earphone.
7. AIR RIGHT applies the stimulus to the desired earphone.
8. Record the latency of the waves of each individual ear after testing.

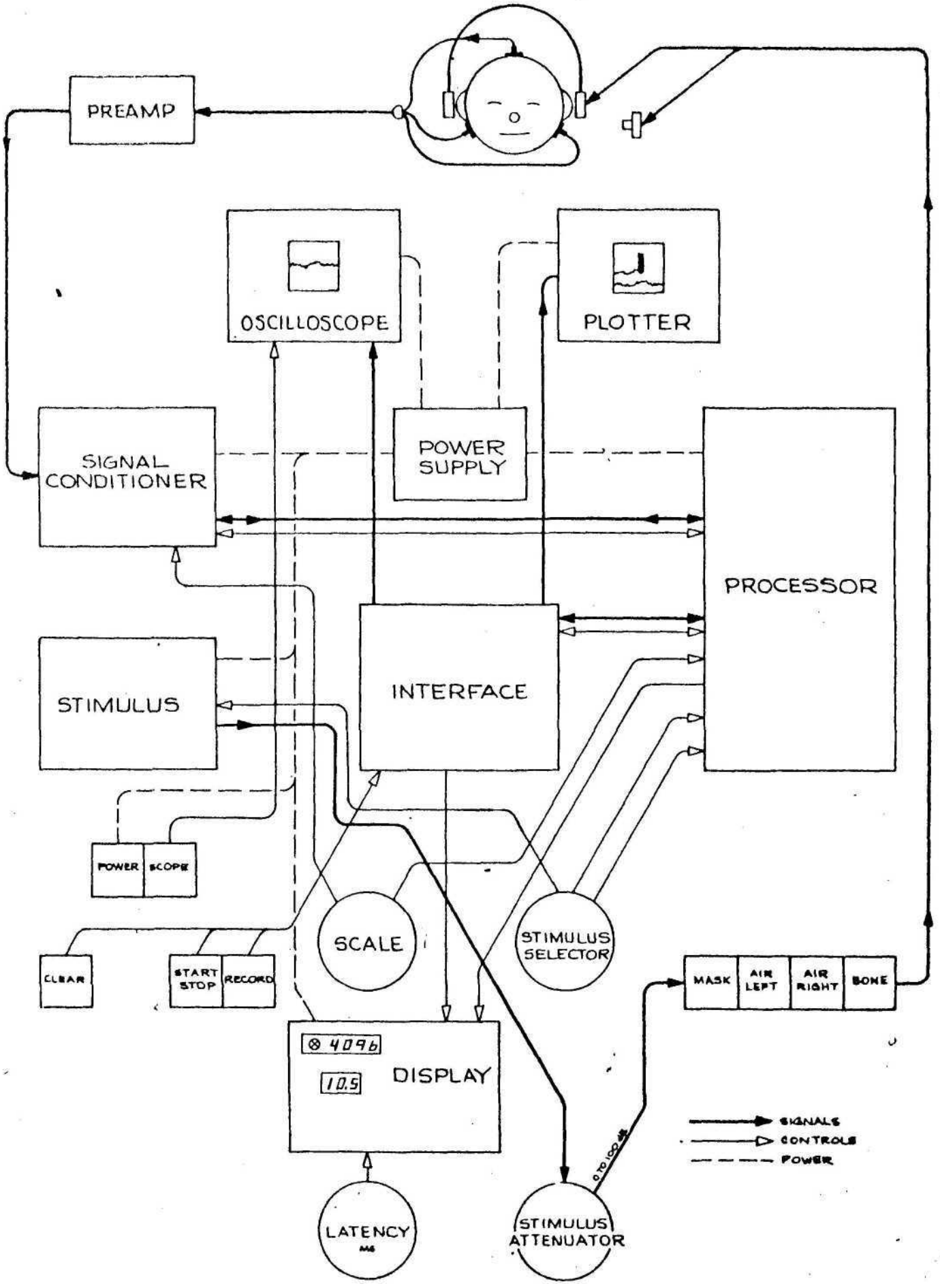


Figure 10: Flow chart of ERA: TA-1000 used in the present study.

Besides these there is:

1) Paper advancer thumb wheel when rotated downward advances the plotter chart paper.
2) The limit indicator, in the samples window will light briefly to indicate the presence of excess input to the system. At the high sensitivities i.e. O.1uV, 0.2uV and 0.5uV/division, this indicator will be relatively active depending on the individual patient. Patient responses occuring when the limit light is on, are rejected from the averaged responses and are neither accumulated nor counted.
3) The PWF/RUN/EEG switch should be in RUN for normal operation. When in the TWF position after a CLEAR, the oscilloscope will display a characteristic test waveform to confirm oscilloscope operation. In the EEG position, after a CLEAR, the oscilloscope will display the ongoing patient EEG activity, the raw signed from which the averaged response is derived.

Test Environment:

The experiment was carried out in sound treated room at the Audiology Department, All India Institute of Speech and Hearing, Mysore.

a) Power source: The main AC current was cannalized to ITL Model SVS-200L stabilizer with input 170-270 volts and output at 230 volts, this was stepped down by Kardio S.No.101 to 110 volts which is the requirement of the Instrument to function properly.

b) Location of the instrument: The instrument was placed inside a larger sound tested room.

(i) Humidity was neither too high or low to the point where either the subject or clinician were uncomfortable.

(ii) It was away from noisy drafty or excessive vibration area.

(iii) Away from high brightness areas, curtains were drawn to control direct sunlight in the room.

(iv) It was away from electrically noisy areas i.e. large motors, copying machine etc.

Procedure:

Prior to every test the stabilizer output was checked to ensure a constant voltage of 200 volts. The Chart papers in the plotter was checked for its proper position. The tubular pen holder was uncaped.

The subject was to lie in relaxed, recumbent position on a medical examination table option was given for pillow to avoid head, neck tension and to make muscle artifact negligible. Subject was briefed with the information that three electrodes would be placed and then an earphone from which be cooled hear click like sound in the right ear. He was told to be in a relaxed state and be could go to sleep.

Electrodes were checked with a gentle tag on both ends. They were cleaned with cotton soaked in rectified spirit

(electrodes are of solid sterling silver). Thus, there was no danger of wearing of any plating.

Cotton soaked in rectified spirit was brisky rubbed on the skin area where the electrodes were to be placed, till pinkish colour indicative of increased vascularity appeared. This was then wiped with dry cotton.

Sufficient quantity of Beckman electrodes electrolyte (electrolyte gel) was placed on the electrodes to till the recess in the electrode to the 'slightly rounded' condition and to get applied to the skin. Electrode was placed on the previously cleaned area, pressing slightly. The excess of paste which oozed out from the electrode holes and sides was cleaned with dry cotton. Then Johnson adhesive of 2x2 cms approximately was used to hold the electrode into firm contact all round.

The electrodes placement was as follows:

i) Red electrode +ve signal placed on high forehead.

ii) White electrode -ve signal called on reference electrode placed on the right or left mastoid of the test ear.

iii) Black electrode neutral signal called as ground electrode, placed on the mastoid of the nontest ear.

The electrodes end of the preamplifier patient electrode cable was attached to the bed surface near the head and held in position with the adhesive plaster. Each electrode was plugged

into the correspondingly coloured receptacle on the patient electrode cable from the preamplifier.

Preamplifier was positioned in a convenient location and was plugged with the 3 pin patient electrodes cable plug into the corresponding preamplifier receptacle (They have blue colour code).

Preamplifier and the BRA were interconnected by means of the cable and receptacles which are colour coated (Yellow).

Headphones were placed and the headset was positioned in such a way that it was comfortable to the patient. Power and scope buttons were pressed. The preamplifier high input-light was checked. If the red light was on continuously, the various factors such as improper electrodes attachments, excess muscular activity on the part of the patient (if he was uncomfortable), possible neck muscle strain and swallowing were checked to climinate the preamplifier high input light.

The present study was carried out to find the effect of frequency on latency of brainstem responses. 10 males and 10 females were usedfor the study. The data were collected at 2K, 4K, 6KHz stimuli and at three intensity levels viz. 80, 60 and 40dB HL. For each subject both the ears were tested.

Rejected samples:

The samples were rejected when:

i) An automatic stop occurred before 2048 samples.

ii) When rapid averaging of the amplitude was observed, a four division marker was observed at the left side which as test progresses and trace reaches full oscilloscope amplitude, a two division marker and finally one division was observed. It one division was observed before 500 samples or not observed w e n when 2048 samples were achieved.

Also, during the process of experiment following things were noted down:-

1) Change in the ongoing RUN due to some attention seeking stimuli.
2) Glowing of the preamplifier light indicating that the subject is not completely relaxed.
3) Stopping of the samples before the completion of the pre-determined number of samples.
4) Motor movements of the subjects and the subsequent effect on the waveform.
5) In one subject, the sensitivity had to be changed to 0.5mV to get the required waveform for one ear to another ear.

When adequate samples and divisions were observed, the final recording was done by pressing the record button (the oscilloscope trace, representative of the patient's BSERA for test parameter was observed and recorded on the plotter by a tubular pen).

I to VII peak latency readings were noted down with the help of latency cursor.

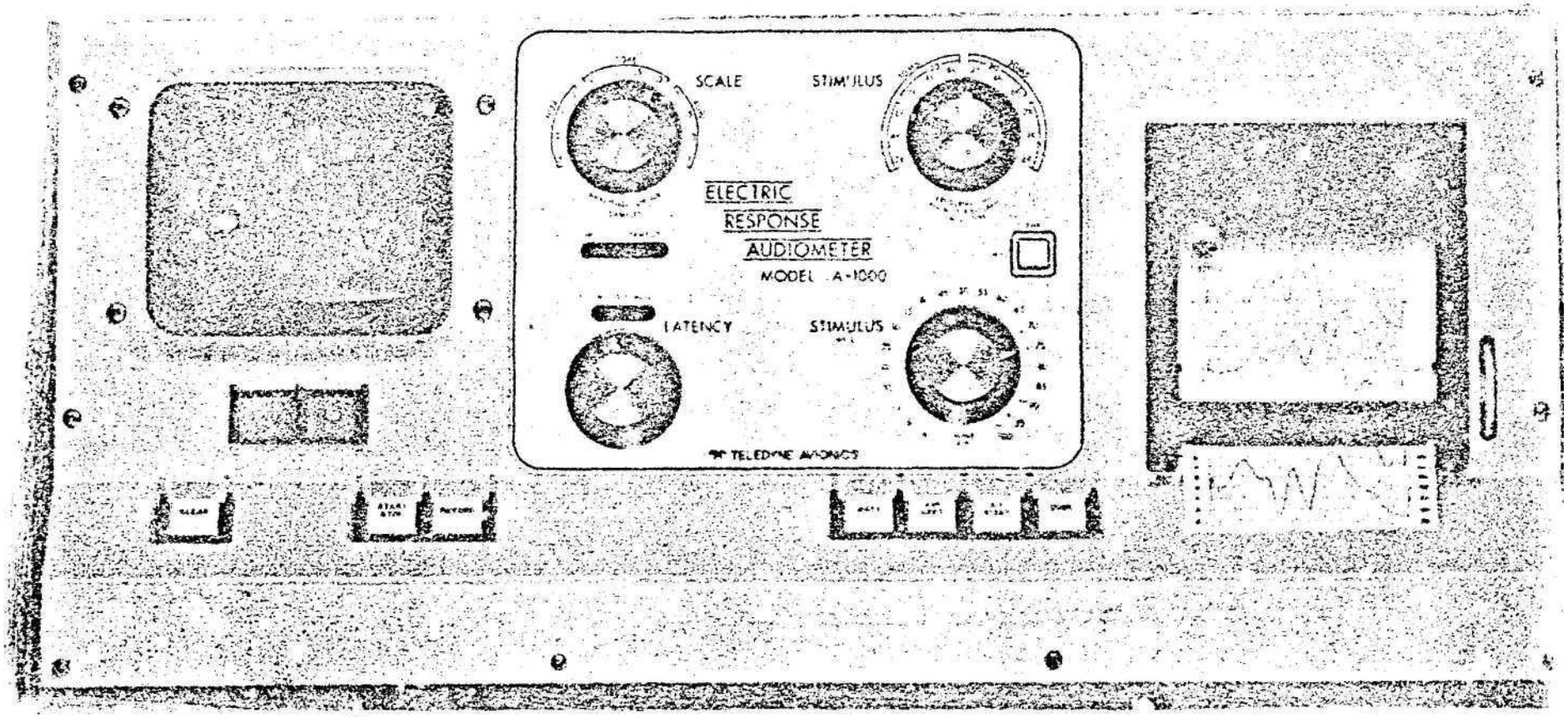


Fig II- Electric Response Audiometer. Model-TA1000
(used in this present study)

By pressing the CLEAR button changing the intensity to 80dB HL, after adequate sampling and averaging, next recording was done. Similarly, averaged brain stem responses were recorded at 60dBHL and 40dBHL in both the ears.

All the subjects were tested in the above manner. In this study 40 ears were tested and 280 recordings were done and all the 100% samples were accepted as the samples.

Besides these, the morphology and other stimulus parameters were not consistent. Instrument was calibrated time to time and again everything was checked the only problem seemed to be power fluctuation, the Keltron stabilizer did not seem to be strong enough to absorb the fluctuation, as whenever there was fluctuation, it was seen on the oscilloscope representation of the response. A high power stabilizer was then utilized to give a steady flow and it was ensured that a constant flow of 230 volts was coming, and stepped down to 110 volts for the TA-1000 BSERA. Then the responses were constant.

RESULTS AND DISCUSSIONS

RESULTS AND DISCUSSIONS

Table-1:

Table-l(a) shows the latency values with means and standard deviations for Peak-I for right ear at 80 dB for frequencies 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

Table-2;

Table-2(a) shows the latency values with means and standard deviations for Peak-II for right ear at 80dB for frequencies 2K,4K and 6KHz. Analysis shows significant difference between the mean latency between 2K and 4K at .01 and .05 levels. Other frequencies are not significant.

Similarly Table-2(b) shows the latency values for left ear. Here, analysis shows no significant difference.

Table-3:

Table—3(a) shows the latency values with means and standard deviations for peak III for right ear at 80 dB for frequencies at 2K, 4K and 6KHz. Analysis shows no significant differences between the means.

Similarly table 3(b) shows the absolute latency values for left ear. Here also no significant differs found between the frequencies.

Table-4:

Table-4(a) shows the absolute latency values with means and standard deviation for Peak IV for right ear, at 2K, 4K and 6KHz. Analysis shows significant difference between 2K and 4K at .01 and .05 level. The other frequencies are not found significant.

Table 4(b) shows the latency value for left ear. Here analysis shows no significant difference between the means.

Table-5:

Table-5(a) shows the absolute latency values with mean and standard deviations for Peak V for right ear at 80 dB for frequencies at 2K, 4K or 6KHz. Analysis shows significant difference between the mean at frequencies between 2K and 4K and frequencies between 4K and 6K at .01 and .05 level. No significant difference observed between 2K and6K.

In table 5(b) shows the latency values for left ear. Here in this table analysis shows no significant difference.

Table-6:

Table-6(a) shows the absolute latency values with means and standard deviations for Peak VI for right ear at 80 dB for frequencies 2K, 4K and6KHz. Analysis shows significant difference between the means at frequenciesbetween 2K and 6K and frequencies between 4K and 6K at .01 and .05 levels. No significant difference between 2K and 4KHz.

Table-6(b) shows latency values for left ear. Here significant difference shows between mean latency at 2K and 4K at .01 and .05 levels.

Table-7:

In table-7(a) shows absolute latency values with means and standard deviations for peak VII for right ear at 80 dB for frequencies 2K, 4K and 6KHz. Analysis showed no significant difference.

Similarly table 7(b) shows absolute latency values with for left ear. Here, analysis showed no significant difference.

Table-8:

In table—8(a) shows absolute latency values with mean and standard deviations for peak I for right ear at 60dB for frequencies 2K, 4K and 6KHz. Analysis showed no significant difference between the mean.

Table 8(b) shows latency values for left ear analysis showed no significant difference between the means.

Table-9:

Table-9(a) shows the absolute latency values with means and standard deviation for peak II at 60dB for frequencies 2K, 4K and 6KHz. Analysis shewed no significant difference between the means.

Table-9(b) shows the absolute latency values for left ear. Here analysis showed no significant difference between the means.

Table-10:

Table-10(a) shows the absolute latency values with means and standard deviation for peak III at 60dB for frequencies at 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

Similarly table 10(b) shows the absolute latency values for left ear. Here analysis showed no significant difference between the means.

Table-ll:

Table-ll(a) shows the latency values with means and standard deviations for peak-IV for right ear at 60dB for frequencies at 2K, 4K and 6K. Analysis showed no significant difference between the means.

Similarly, table-ll(b) shows the latency values for left ear. Here, analysis shows no significant difference between the means.

Table-12:

Table-12(a) shows absolute latency values with means and standard deviations for peak V for right ear at 60dB for

frequencies at 2K, 4K and 6KHz. Analysis showed no significant difference between the mean latency between 2K and 6K at .01 and .05 levels. Other frequencies have not shown significant difference.

Table-12(b) showed latency values for left ear. Analysis showed significant difference between the mean latency of 4K and 6K at .01 and .05 levels. Others frequencies have not shown significant difference.

Table-13;

Table-13(a) shows the absolute latency values with means and standard deviations for Peak VI for right ear at 60dB for frequencies at 2K, 4K and 6KHz. Analysis showed no significant difference between the mean latencies of 2K and 4K and 4K and 6K at .01 and .05 levels. The other frequency 2K and 6K have not shown significant difference.

Table-13(b) shows the latency values for left ear. Here analysis showed no significant difference between the means.

Table-14:

Table-14(a) shows the absolute latency values with means and standard deviations for Peak VII for right ear at 60dB for frequencies 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

Table-14(b) shows the absolute latency values for left ear. Here analysis showed no significant difference between the means.

Table-15:

Table-15(a) shows the absolute latency values for Peak I right ear at 40dB for frequency at 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

Similarly table 15(b) shows the absolute latency values for left ear. Here analysis showed no significant difference between the means.

Table-16:

Table-16(a) shows the absolute latency values for Peak II for right ear at 40dB for frequencies at 2K, 4K and 6KHz. Analysis showed significant difference between the mean latency at 2K and 4K and between 2K and 6K at .01 and .05 levels. The other frequency 4K and 6K have not shown significant difference.

Similarly, table-16(b) shows the latency values for left ear. Here, analysis shows no significant difference between the means.

Table-17:

Table-17 (a) shows the absolute latency values for peak III for right ear at 40dB for frequency at 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

In table-17(b) shows the latency values for left ear. Here analysis showed no significant difference between the means.

Table-18:

Table-18(a) shows the absolute latency values for peak IV for right ear at 40dB for frequency at 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

Similarly, table-18(b) shows the absolute latency values for left ear. Here, analysis showed no significant difference between the means.

Table-19:

Table-19(a) shows the absolute latency values for peak V for right ear at 40dB for frequency at 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

Similarly, table-19(b) shows the absolute latency values for left ear. Here analysis shows no significant difference between the means.

Table-20:

Table-20(a) shows the absolute latency values for peak VI for right ear at 40dB for frequency at 2K, 4K and 6KHz. Analysis showed significant difference between the mean latency of 2K and

6k at .01 and .05 levels. Other frequencies 2K and 4K and frequency 4K and 6K have not shown significant difference.

Similarly, table-20(b) showed the absolute latency values for left ear. Here, analysis showed no significant difference between the means.

Table-21:

Table-21(a) shows the absolute latency values for Peak VII for right ear at 40dB for frequency at 2K, 4K and 6KHz. Analysis showed no significant difference between the means.

Similarly, table-21(b) showed the absolute latency values for left ear. Here, analysis showed no significant difference between the means.

Discussion:

From the present study the results shows that there is no significance difference between the means of the latencies. In other words it shows that there is no effects of frequency on latency of auditory brain stem, response, i.e. the effects of frequency having the negligible response on latency. So with a large sample the same study should be carried out in future.

TABLE-IA

I Peak at 80dB right ear.

	2K	4K	2K	6K	4K	6K
1.	1;4	1.6	1.4	1.6	1.6	1.6
2.	1.4	1.4	1.4	1.2	1.4	1.2
3.	1.3	1.3	1.3	1.3	1.3	1.3
4.	1.2	1.1	1.2	1.2	1,1	1.2
5.	1.3	1.3	1.3	1.3	1.3	1.3
6.	1.4	1.3	1.4	1.3	1.3	1.3
7.	1.2	1.3	1.2	1.2	1.3	1.2
8.	1.4	1.3	1.4	1.4	1.3	1.4
9.	1.2	1.3	1.2	1.3	1.3	1.3
10.	1.2	1.2	1.2	1.2	1.2	1.2
11.	1.4	1.3	1.4	1.3	1.3	1.3
12.	1.5	1.4	1.5	1.5	1.4	1.5
13.	1.5	1.3	1.5	1.3	1.3	1.3
14.	1.4	1.3	1.4	1.4	1.3	1.4
15.	1.2	1.3	1.2	1.9	1.3	1.9
16.	1.2	1.2	1.2	1.4	1.2	1.4
17.	1.7	1.2	1.7	1.3	1.2	1.3
18.	1.4	1.2	1.4	1.1	1.2	l.i
19.	1.7	1.6	1.7	1.8	1.6	1.8
20.	1.7	1.3	1.7	1.6	1.3	1.7
Mean	1.385	1.310	1.320	1.285	1.310	1.261
SD	0.2412	0.1179	0.2412	0.2206	0.1179	0.2206

Table-IB

I Peak at 80dB left ear

	2K	4K	2K	6K	4K	6K
1.	1.6	1.6	1.6	1.5	1.6	1.5
2.	1.5	1.7	1.5	1.7	1.7	1.7
3.	1.4	1.4	1.4	1.5	1.4	1.5
4.	1.3	1.3	1.3	1.4	1.3	1.4
5.	1.5	1.4	1.5	1.5	1.4	1.5
6.	1.5	1.4	1.5	1.6	1.4	1.6
7.	1.4	1.5	1.4	1.6	1.5	1.6
8.	1.5	1.5	1.5	1.6	1.5	1.6
9.	1.5	1.4	1.5	1.5	1.4	1.5
10.	1.8	1.9	1.8	1.7	1.9	1.7
11.	1.5	1.5	1.5	1.5	1.5	1.5
12.	1.5	1.6	1.5	1.6	1.6	1.6
13.	1.5	1.4	1.5	1.6	1.4	1.6
14.	1.8	1.7	1.8	1.8	1.7	1.8
15.	1.5	1.5	1.5	1.6	1.5	1.6
16.	1.5	1.4	1.5	1.3	1.4	1.3
17.	1.6	1.4	1.6	1.4	1.4	1.4
18.	1.6	1.5	1.6	1.4	1.5	1.4
19.	1.6	1.7	1.6	1.7	1.7	1.7
20.	1.5	1.4	1.5	1.5	1.4	1.5
Mean	1.530	1.510	1.530	1.550	1.510	1.550
SD	0.1145	0.1447	0.1145	0.1204	0.1447	0.1304

TABLE-2A

II Peak at 80 dB Right Ear

	2K	4K	2K	6K	4K	6K
1.	2.0	2.0	2.0	2.1	2.0	2.1
2.	2.6	2.6	2.6	2.2	2.6	2.2
3.	2.4	2.4	2.4	2.3	2.4	2.3
4.	2.3	2.3	2.3	2.4	2.3	2.4
5.	2.2	2.3	2.2	2.3	2.3	2.3
6.	2.2	2.2	2.2	2.3	2.2	2.3
7.	2.4	2.4	2.4	2.6	2.4	2.6
8.	2.4	2.3	2.4	2.3	2.3	2.3
9.	2.3	2.2	2.3	2.4	2.2	2.4
10.	2.4	2.4	2.4	2.3	2.4	2.3
11.	2.2	2.1	2.2	2.1	2.1	2.1
12.	2.6	2.4	2.6	2.6	2.4	2.6
13.	2.8	2.2	2.8	2.3	2.2	2.3
14.	2.3	2.4	2.3	2.2	2.4	2.2
15.	2.7	2.5	2.7	2.6	2.5	2.7
16.	2.1	2.0	2.1	2.0	2.0	2.0
17.	2.4	2.3	2.4	2.2	2.3	2.2
18.	2.2	2.0	2.2	2.1	2.0	2.1
19.	2.6	2.6	2.6	2.9	2.6	2.9
20.	2.6	2.4	2.6	2.5	2.4	2.5
Mean	2.520	2.300	2.385	2.335	2.300	2.385
SD	0.2469	0.1893	0.2469	0.2100	0.1893	0.2100

Table-IIB

II Peak at 80 dB Left ear

	2K	4K	2K	6K	4K	6K
1.	2.5	2.4	2.5	2.5	2.4	2.5
2.	2.7	2.6	2.7	2.7	2.6	2.7
3.	2.7	2.5	2.7	2.4	2.5	2.4
4.	2.5	2.6	2.5	2.5	2.6	2.5
5.	2.4	2.6	2.4	2.6	2.6	2.6
6.	2.3	2.3	2.3	2.5	2.3	2.5
7.	2.6	2.6	2.6	2.4	2.6	2.4
8.	2.5	2.5	2.5	2.4	2.5	2.4
9.	2.5	2.4	2.5	2.4	2.4	2.4
10.	2.7	2.6	2.7	2.5	2.6	2.5
11.	2.6	2.4	2.6	2.5	2.4	2.5
12.	2.9	2.8	2.9	2.8	2.8	2.8
13.	2.7	2.4	2.7	2.5	2.4	2.5
14.	2.6	2.9	2.6	2.7	2.9	2.7
15.	2.6	2.5	2.6	2.6	2.5	2.6
16.	2.6	2.6	2.6	2.5	2.6	2.6
17.	2.7	2.8	2.7	2.6	2.8	2.6
18.	2.4	2.7	2.4	2.8	2.7	2.8
19.	2.6	2.7	2.6	2.8	2.7	2.8
20.	2.5	2.4	2.5	2.3	2.4	2.3
Mean	2.580	2.565	2.580	2.550	2.565	2.550
SD	0.1327	0.2263	0.1327	0.1432	0.2263	0.1432

TABLE-3A

III peak at 80dB right ear

	2K	4K	3K	6K	4K	6K
1.	3.4	3.5	3.4	3.6	3.5	3.6
2.	3.5	3.6	3.5	3.6	3.6	3.6
3.	3.3	3.5	3.3	3.7	3.5	3.7
4.	3.1	3.2	3.1	3.1	3.2	3.1
5.	3.1	3.1	3.1	3.2	3.1	3.2
6.	3.0	3.1	3.0	3.2	3.1	3.2
7.	3.2	3.3	3.2	3.4	3.3	3.4
8	3.1	3.1	3.1	3.2	3.1	3.2
9.	3.2	3.1	3.2	3.1	3.1	3.1
10.	3.4	3.4	3.4	3.4	3.4	3.4
11.	3.3	3.2	3.3	3.3	3.2	3.3
12.	3.5	3.4	3.5	3.6	3.4	3.6
13.	3.6	3.2	3.6	3.9	3.2	3.9
14.	3.3	3.3	3.3	3.3	3.3	3.3
15.	3.6	3.5	3.6	3.6	3.5	3.6
16.	3.1	3.1	3.1	3.1	3.1	3.1
17.	3.2	3.3	3.2	3.4	3.3	3.4
18.	3.2	3.1	3.2	3.2	3.1	3.2
19.	3.4	3.5	3.4	3.5	3.5	3.5
20.	3.6	3.4	3.6	3.3	3.4	3.3
Mean	3.305	3.295	3.305	3.385	3.295	3.385
SD	0.3873	0.1949	0.3873	0.2358	0.1949	0.2358

Table-3B

III Peak at 80 dB Left ear

	2K	4K	2K	6K	4K	6K
1.	3.4	3.3	3.4	3.5	3.3	3.5
2.	3.6	3.8	3.6	3.7	3.8	3.7
3.	3.4	3.7	3.4	3.8	3.7	3.8
4.	3.5	3.5	3.5	3.5	3.5	3.5
5.	3.6	3.4	3.6	3.4	3.4	3.4
6.	3.4	3.7	3.4	3.7	3.7	3.7
7.	3.4	3.3	3.4	3.3	3.3	3.3
8.	3.8	3.9	3.8	3.9	3.9	3.9
9.	3.5	3.4	3.5	3.5	3.4	3.5
10.	3.4	3.4	3.4	3.5	3.4	3.5
11.	3.7	3.4	3.7	3.8	3.4	3.8
12.	3.6	3.6	3.6	3.6	3.6	3.6
13.	3.7	3.7	3.7	3.6	3.7	3.6
14.	3.4	3*4	3.4	3.3	3.4	3.3
15.	3.8	3.3	3.8	3.3	3.8	3.3
16.	3.4	3.3	3.4	3.3	3.3	3.3
17.	3.4	3.5	3.4	3.6	3.5	3.6
18.	3.4	3.3	3.4	3.6	3.3	3.6
19.	3.5	3.4	3.5	3.7	3.4	3.7
20.	3.4	3.5	3.4	3.3	3.5	3.3
Mean	3.515	3.515	3.515	3.545	3.515	3.545
SD	0.1315	0.1851	0.1315	0.1843	0.1851	0.1843

TABLE-4A

IV Peak at 80dB Right ear

	2K	4K	2K	6K	4K	6K
1.	4.4	4.5	4.4	4.7	4.5	4.7
2.	4.7	4.3	4.7	4.6	4.3	4.6
3.	4.6	4.9	4.6	4.6	4.9	4.6
4.	4.2	4.2	4.2	4.1	4.1	4.1
5.	4.2	4.1	4.2	4.2	4.1	4.2
6.	4.1	4.1	4.1	4.1	4.1	4.1
7.	4.4	4.6	4.4	4.6	4.6	4.6
8.	4.6	4.5	4.6	4.1	4.5	4.1
9.	4.2	4.2	4.2	4.3	4.2	4.3
10.	4.5	4.7	4.5	4.8	4.7	4.8
11.	4.1	4.4	4.1	4.2	4.4	4.2
12.	4.5	4.6	4.5	4.8	4.6	4.8
13.	4.5	4.4	4.5	4.3	4.4	4.4
14.	4.3	4.3	4.3	4.6	4.3	4.6
15.	4.6	4.8	4.6	4.3	4.8	4.3
16.	4.3	4.2	4.3	4.4	4.2	4.4
17.	4.3	4.3	4.3	4.8	4.3	4.8
18.	4.5	4.3	4.5	4.3	4.3	4.3
19.	4.2	4.3	4.2	4.8	4.3	4.8
20.	4.2	4.6	4.2	4.3	4.6	4.3
Mean SD	4.370 0.1780	4.535 0.2626	4.370 0.1780	4.445 0.2329	4.535 0.2626	4.455 0.2323

Table-4B

IV Peak at 80dB left ear

	2K	4K	2K	6K	4K	6K
1.	4.4	4.3	4.4	4.7	4.3	4.7
2.	4.6	4.4	4.6	4.5	4.4	4.5
3.	4.5	4.4	4.5	4.6	4.4	4.6
4.	4.5	4.7	4.5	4.7	4.7	4.7
5.	4.4	4.4	4.4	4.5	4.4	4.5
6.	4.4	4.5	+.4	4.5	4.5	4.5
7.	4.6	4.5	4.6	4.2	4.5	4.2
8.	4.8	4.9	4.8	4.9	4.9	4.9
9.	4.4	4.5	4.4	4.5	4.5	4.5
10.	4.5	4.2	4.5	4.8	4.2	4.8
11.	4.7	4.2	4.7	4.4	4.2	4.4
12.	4.6	4.7	4.6	4.8	4.7	4.8
13.	4.9	4.9	4.9	4.3	4.9	4.3
14.	4.6	4.6	4.6	4.8	4.6	4.8
15.	4.7	4.6	4.7	4.8	4.6	4.6
16.	4.9	4.5	4.9	4.6	4.5	4.6
17.	4.3	4.3	4.3	4.3	4.3	4.3
18.	4.7	4.6	4.7	4.5	4.6	4.5
19.	4.2	4.3	4.2	4.3	4.3	4.3
20.	4.5	4.4	4.5	4.5	4.4	4.5
Mean	4.560	4.495	4.560	4.550	4.495	4.550
SD	0.1828	0.1959	0.1828	0.1884	0.1959	0.1884

Table-5A

V Peak at 80 dB Right Bar

	2K	4K	2K	6K	4K	6K
1.	5.2	5.2	5.2	5.2	5.2	5.2
2.	5.4	5.3	5.4	5.6	5.3	5.6
3.	5.4	5.3	5.4	5.5	5.3	5.5
4.	5.2	5.2	5.2	5.4	5.2	5.4
5.	5.1	5.0	5.1	5.1	5.0	5.1
6.	5.8	5.8	5.8	5.4	5.8	5.4
7.	5.0	5.1	5.0	5.2	5.1	5.2
8.	5.7	5.8	5.7	5.7	5.8	5.7
9.	5.1	5.1	5.1	5.0	5.1	5.0
10.	5.2	5.3	5.2	5.5	5.3	5.5
11.	5.1	5.0	5.1	5.2	5.0	5.2
12.	5.3	5.1	5.3	5.4	5.1	5.3
13.	5.5	5.2	5.5	5.2	5.2	5.2
15.	5.2	5.3	5.2	5.1	5.3	5.1
16.	5.0	5.1	5.0	5.3	5.1	5.3
17.	5.0	5.1	5.0	5.2	5.1	5.2
18.	5.1	5.2	5.1	5.1	5.2	5.1
19.	5.2	5.3	5.2	5.5	5.3	5.5
20.	5.1	5.2	5.1	5.2	5.2	5.2
Mean	5.240	5.775	5.240	5.305	5.775	5.305
SD	0.2083	0.1734	0.2083	0.1701	0.1734	0.1701

Table-5B

V Peak at 80 dB Left ear

	2K	4K	2K	6K	4K	6K
1.	5.3	5.5	5.3	5.4	5.5	5.4
2.	5.4	5.4	5.4	5.5	5.4	5.5
3.	5.4	5.4	5.4	5.4	5.4	5.4
4.	5.7	5.6	5.7	5.4	5.6	5.4
5.	5.4	5.3	5.4	5.6	5.3	5.6
6.	5.8	5.9	5.8	5.7	5.9	5.7
7.	5.7	5.6	5.7	5.8	5.6	5.8
8.	5.8	5.9	5.8	5.9	5.9	5.9
9.	5.7	5.7	5.7	5.6	5.7	5.6
10.	5.4	5.5	5.4	5.4	5.5	5.4
11.	5.2	5.2	5.2	5.2	5.2	5.2
12.	5.4	5.6	5.4	5.7	5.6	5.7
13.	5.9	5.9	5.9	5.6	5.9	5.6
14.	5.4	5.4	5.4	5.4	5.4	5.4
15.	5.2	5.2	5.2	5.3	5.2	5.3
16.	5.1	5.2	5.1	5.2	5.2	5.2
17.	5.1	5.2	5.1	5.3	5.2	5.3
18.	5.2	5.3	5.2	5.3	5.3	5.3
19.	5.3	5.5	5.3	5.6	5.5	5.6
20.	5.4	5.3	5.4	5.4	5.3	5.4
Mean	5.440	5.480	5.440	5.485	5.480	5.485
SD	0.2375	0.2322	0.2375	0.2233	0.2322	0.2233

Table-6A

VI Peak at 80dB right ear

	2K	4K	2K	6K	4K	6K
1.	6.3	6.6	6.3	6.7	6.6	6.7
2.	6.9	6.4	6.9	6.6	6.4	6.6
3.	6.3	6.3	6.3	6.4	6.3	6.4
4.	6.3	6.9	6.3	6.7	6.9	6.7
5.	6.4	6.6	6.4	6.3	6.6	6.3
6.	6.8	6.5	6.8	6.3	6.5	6.3
7.	6.4	6.4	6.4	6.7	6.4	6.7
8.	6.3	6.8	6.3	6.7	6.8	6.7
9.	6.3	6.5	6.3	6.4	6.5	6.4
10.	6.3	6.9	6.3	6.9	6.9	6.9
11.	6.8	6.9	6.8	6.6	6.9	6.6
12.	6.8	6.7	6.8	6.9	6.7	6.9
13.	6.5	6.7	6.5	6.9	6.7	6.9
14.	6.7	6.4	6.7	6.4	6.4	6.4
15.	6.5	6.5	6.5	6.3	6.5	6.3
16.	6.3	6.6	6.3	6.4	6.6	6.4
17.	6.3	6.4	6.3	6.4	6.4	6.4
18.	6.5	6.3	6.5	6.4	6.3	6.4
19.	6.8	6.9	6.8	6.5	6.9	6.5
20.	6.8	6.9	6.8	6.9	6.9	6.9
Mean	6.615	6.610	6.615	6.355	6.610	6.355
SD	0.2434	0.2432	0.2435	0.3022	0.2432	0.3022

Table-6B

VI peak at 80 dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	6.4	6.4	6.4	6.6	6.4	6.6
2.	6.6	6.5	6.6	6.8	6.5	6.8
3.	6.5	6.4	6.5	6.8	6.4	6.8
4.	6.6	6.7	6.6	6.4	6.7	6.4
5.	6.5	6.7	6.5	6.6	6.7	6.6
6.	6.5	6.7	6.5	6.4	6.7	6.4
7.	6.7	6.4	6.7	6.3	6.4	6.3
8.	6.6	6.4	6.6	6.3	6.4	6.3
9.	6.5	6.7	6.5	6.6	6.7	6.6
10.	6.8	6.9	6.8	6.8	6.9	6.8
11.	6.9	6.9	6.9	6.6	6.9	6.6
12.	6.9	6.9	6.9	6.9	6.9	6.9
13.	6.6	6.8	6.6	6.7	6.8	6.7
14.	6.8	6.6	6.8	6.3	6.6	6.3
15.	6.3	6.3	6.3	6.4	6.3	6.4
16.	6.6	6.7	6.6	6.7	6.7	6.7
17.	6.7	6.3	6.7	6.4	6.3	6.4
18.	6.5	6.4	6.5	6.7	6.4	6.7
19.	6.7	6.9	6.7	6.7	6.9	6.7
20.	6.5	6.6	6.5	6.6	6.6	6.6
Mean	6.605	6.610	6.605	6.590	6.610	6.590
SD	0.1547	0.1921	0.1547	0.1836	0.1921	0.1836

Table-7A

VII Peak at 80dB Right Ear

	2K	4K	2K	6K	4K	6K
1.	7.3	7.9	7.3	7.6	7.9	7.6
2.	7.3	7.4	7.3	7.5	7.4	7.5
3.	7.2	7.3	7.2	7.8	7.3	7.8
4.	7.6	7.9	7.6	7.9	7.9	7.9
5.	7.9	7.9	7.9	7.9	7.9	7.9
6.	7.9	7.8	7.9	7.6	7.8	7.6
7.	7.2	7.9	7.2	7.9	7.9	7.9
8.	7.2	7.2	7.2	7.9	7.2	7.9
9.	7.9	7.9	7.9	7.3	7.9	7.3
10.	7.2	7.9	7.2	7.9	7.9	7.9
11.	7.9	7.9	7.9	7.9	7.9	7.9
12.	7.9	7.5	7.9	7.9	7.5	7.9
13.	7.2	7.7	7.2	7.3	7.7	7.3
14.	7.5	7.4	7.5	7.8	7.4	7.8
15.	7.3	7.2	7.3	7.2	7.2	7.2
16.	7.9	7.3	7.9	7.9	7.3	7.9
17.	7.9	7.9	7.9	7.6	7.9	7.6
18.	7.9	7.9	7.9	7.9	7.9	7.9
19.	7.5	7.9	7.5	7.3	7.9	7.3
20.	7.9	7.9	7.9	7.9	7.9	7.9
Mean	7.580	7.685	7.580	7.700	7.685	7.700
SD	0.3155	0.3041	0.3155	0.2459	0.3041	0.2459

Table-7B

VII Peak at 80 dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	7.5	7.7	7.5	7.4	7.7	7.4
2.	7.4	7.5	7.4	7.5	7.5	7.5
3.	7-8	7.7	7.8	7.6	7.7	7.6
4.	7.7	7.9	7.7	7.9	7.9	7.9
5.	7.9	7.8	7.9	7.5	7.8	7.5
6.	7.9	7.9	7.9	7.6	7.9	7.6
7.	7.9	7.7	7.9	7.6	7.7	7.6
8.	7.3	7.6	7.3	7.9	7.6	7.9
9.	7.4	7.9	7.4	7.9	7.9	7.9
10.	7.6	7.9	7.0	7.9	7.9	7.9
11.	7.9	7.7	7.9	7.5	7.7	7.5
12.	7.8	7.8	7.8	7.9	7.8	7.9
13.	7.8	7.5	7.8	7.6	7.5	7.6
14.	7.4	7.5	7.4	7.6	7.5	7.6
15.	7.6	7.4	7.6	7.3	7.4	7.3
16.	7.7	7.9	7.7	7.9	7.9	7.9
17.	7.9	7.9	7.7	7.8	7.9	7.8
18.	7.8	7.6	7.8	7.7	7.6	7.7
19.	7.6	7.9	7.6	7.5	7.9	7.9
20.	7.7	3.5	7.7	7.6	7.5	7.6
Mean	7.67	7.715	7.670	7.66	7.715	7.66
SD	0.1849	0.1679	0.1849	0.1833	0.1679	0.1833

Table-8A

I Peak at 60dB right ear

	2K	4K	2K	6K	4K	6K
1.	1.3	1.5	1.3	1.7	1.5	1.7
2.	1.4	1.4	1.4	1.5	1.4	1.5
3.	1.3	1.3	1.3	1.3	1.3	1.3
4.	1.3	1.4	1.3	1.7	1.4	1.7
5.	1.9	1.8	1.9	1.8	1.8	1.8
6.	1.4	1.3	1.4	1.3	1.3	1.3
7.	1.4	1.8	1.4	1.4	1.8	1.4
8.	1.4	1.8	1.4	1.4	1.8	1.4
9.	1.6	1.3	1.6	1.3	1.3	1.3
10.	1.7	1.4	1.7	1.8	1.4	1.8
11.	1.5	1.7	1.5	1.8	1.7	1.8
12.	1.8	1.9	1.8	1.8	1.9	1.8
13.	1.6	1.4	1.6	1.6	1.4	1.6
14.	1.8	1.3	1.8	1.8	1.3	1.8
15.	1.9	1.9	1.9	1.6	1.9	1.6
16.	1.5	1.5	1.5	1.4	1.5	1.4
17.	1.7	1.7	1.7	1.8	1.7	1.8
18.	1.4	1.6	1.4	1.3	1.6	1.3
19.	1.7	1.4	1.7	1.4	1.4	1.4
20.	1.5	1.7	1.5	1.9	1.7	1.9
Mean	1.555	1.555	1.555	1.450	1.555	1.450
SD	0.1948	0.1948	0.1948	0.2578	0.1948	0.2578

Table-8B

I Peak at 60dB Left ear

	2K	4K	2K	6K	4K	6K
1.	1.5	1.5	1.5	1.7	1.5	1.7
2.	1.4	1.4	1.4	1.3	1.4	1.3
3.	1.3	1.7	1.3	1.4	1.7	1.4
4.	1.5	1.9	1.5	1.3	1.9	1.3
5.	1.3	1.5	1.3	1.5	1.5	1.5
6.	1.6	1.4	1.4	1.4	1.4	1.4
7.	1.7	1.8	1.7	1.7	1.8	1.7
8.	1.4	1.4	1.4	1.5	1.4	1.5
9.	1.7	1.5	1.7	1.6	1.5	1.6
10.	1.5	1.8	1.5	1.7	1.8	1.7
11.	1.5	1.5	1.5	1.6	1.5	1.6
12.	177	1.4	1.7	1.6	1.7	1.7
13.	1.7	1.7	1.7	1.9	1.7	1.9
14.	1.9	1.7	1.9	1.4	1.7	1.4
15.	1.8	1.6	1.8	1.9	1.6	1.9
16.	1.7	1.7	1.7	1.9	1.7	1.9
17.	1.6	1.7	1.6	1.7	1.7	1.7
18.	1.8	1.5	1.8	1.5	1.5	1.5
19.	1.6	1.9	1.6	1.9	1.9	1.9
20.	1.5	1.6	1.5	1.4	1.6	1.4
Mean	1.585	1.61	1.585	1.595	1.625	1.6
SD	0.174	0.165	0.163	0.201	0.158	0.2026

Table-9A

II Peak at 60dB right ear

	2K	4K	2K	6K	4K	6K
1.	2.6	2.5	2.6	2.3	2.5	2.3
2.	2.4	2.7	2.4	2.6	2.7	2.6
3.	2.3	2.3	2.3	2.5	2.3	2.5
4.	2.6	2.4	2.6	2.6	2.4	2.6
5.	2.5	2.5	2.5	2.5	2.5	2.5
6.	2.5	2.6	2.5	2.4	2.6	2.4
7.	2.6	2.9	2.6	2.9	2.9	2.9
8.	2.4	2.3	2.4	2.3	2.3	2.3
9.	2.6	2.4	2.6	2.3	2.4	2.3
10.	2.5	2.7	2.5	2.8	2.7	2.8
11.	2.7	2.6	2.7	2.4	2.6	2.4
12.	2.4	2.9	2.4	2.5	2.9	2.5
13.	2.3	2.4	2.3	2.3	2.4	2.3
14.	2.6	2.9	2.6	2.3	2.9	2.3
15.	2.9	2.6	2.9	2.6	2.6	2.6
16.	2.6	2.3	2.6	2.3	2.3	2.3
17.	2.7	2.4	2.7	2.9	2.4	2.9
18.	2.6	2.8	2.6	2.6	2.8	2.6
19,	2.6	2.5	2.6	2.4	2.5	2.4
20.	2.7	2.4	2.7	2.5	2.4	2.5
Mean	2.555	2.555	2.555	2.500	2.555	2.500
SD	0.1431	0.1431	0.1431	0.1466	0.1431	0.1466

Table-9B

II Peak at 60dB Left Bar

	2K	4K	2k	6K	4K	6K
1.	2.4	2.8	2.4	2.9	2.8	2.9
2.	2.6	2.8	2.6	2.5	2.8	2.5
3.	2.6	2.9	2.6	2.4	2.9	2.4
4.	2.6	2.8	2.6	2.3	2.8	2.3
5.	2.3	2.3	2.3	2.5	2.3	2.5
6.	2.8	2.4	2.8	2.6	2.4	2.6
7.	2.4	2.8	2.4	2.7	2.8	2.7
8.	2.3	2.6	2.3	2.4	2.6	2.4
9.	2.5	2.5	2.5	2.6	2.5	2.6
10.	2.9	2.7	2.9	2.8	2.7	2.8
11.	2.4	2.4	2.4	2.8	2.4	2.8
12.	2.9	2.9	2.9	2.4	2.9	2.4
13.	2.7	2.4	2.7	2.8	2.4	2.8
14.	2.9	2.5	2.9	2.7	2.5	2.7
15.	2.8	2.6	2.8	2.6	2.6	2.6
16.	2.8	2.8	2.8	2.4	2.8	2.4
17.	2.6	2.5	2.6	2.6	2.5	2.6
18.	2.3	2.5	2.3	2.4	2.5	2.4
19.	2.8	2.5	2.8	2.3	2.5	2.3
20.	2.5	2.6	2.5	2.7	2.6	2.7
Mean	2.605	2.615	2.605	2.57	2.615	2.57
SD	0.2114	0.18	0.2114	0.180	0.1843	0.180

Table-10A

III Peak at 60dB Right ear

	2k	4K	2K	6K	4K	6K
1.	3.7	3.6	3.7	3.6	3.6	3.6
2.	3.8	3.6	3.8	3.7	3.6	3.7
3.	3.5	3.8	3.5	3.6	3.8	3.6
4.	3.3	3.2	3.3	3.4	3.2	3.4
5.	3.5	3.3	3.5	3.3	3.3	3.3
6.	3.5	3.5	3.5	3.5	3.5	3.5
7.	3.7	3.8	3.7	3.6	3.8	3.6
8.	3.5	3.6	3.5	3.7	3.6	3.7
9.	3.5	3.4	3.5	3.5	3.4	3.5
10.	3.6	3.9	3.6	3.7	3.9	3.7
11.	3.8	3.8	3.8	3.8	3.8	3.8
12.	3.8	3.5	3.8	3.6	3.5	3.6
13.	3.5	3.4	3.5	3.4	3.4	3.4
14.	3.8	3.7	3.8	3.7	3.7	3.7
15.	3.6	3.8	3.6	3.7	3.8	3.7
16.	3.6	3.4	3.6	3.4	3.4	3.4
17.	3.7	3.7	3.7	3.7	3.7	3.7
18.	3.7	3.6	3.7	3.8	3.6	3.8
19.	3.8	3.8	3.8	3.7	3.8	3.7
20.	3.6	3.5	3.6	3.7	3.5	3.7
Mean	3.625	3.585	3.625	3.605	3.585	3.605
SD	0.1373	0.1888	0.1373	0.1395	0.1888	0.1395

Table-10B

III Peak at 60dB Left ear

	2K	4K	2K	6K	4K	6K
1.	3.5	3.9	3.5	3.8	3.9	3.8
2.	3.4	3.8	3.4	3.6	3.8	3.6
3.	3.6	3.9	3.6	3.3	3.9	3.3
4.	3.4	3.5	3.4	3.3	3.5	3.3
5.	3.5	3.5	3.5	3.4	3.5	3.4
6.	3.4	3.9	3.4	3.6	3.9	3.6
7.	3.3	3.9	3.3	3.8	3.9	3.8
8.	3.9	3.3	3.9	3.4	3.3	3.4
9.	3.7	3.5	3.7	3.6	3.5	3.5
10.	3.8	3.9	3.8	3.8	3.9	3.8
11.	3.7	3.6	3.7	3.9	3.6	3.9
12.	3.8	3.8	3.8	3.6	3.8	3.6
13.	3.4	3.5	3.4	3.6	3.5	3.6
14.	3.6	3.7	3.6	3.4	3.7	3.4
15.	3.7	3.6	3.7	3.6	3.6	3.6
16.	3.6	3.5	3.6	3.7	3.5	3.7
17.	3.7	3.6	3.7	3.6	3.6	3.6
18.	3.9	3.7	3.9	3.8	3.7	3.8
19.	3.8	3.4	3.8	3.5	3.4	3.5
20.	3.5	3.6	3.5	3.4	3.6	3.4
Mean	3.61	3.655	3.61	3.58	3.655	3.58
SD	0.180	0.1877	0.180	0.17	0.1877	0.17

Table-llA

IV Peak at 60dB right ear

	2K	4K	2K	8K	4K	6K
1.	4.9	4.6	4.9	4.6	4.6	4.6
2.	4.1	4.2	4.1	4.2	4.2	4.2
3.	4.2	4.9	4.2	4.1	4.9	4.1
4.	4.3	4.1	4.3	4.2	4.1	4.2
5.	4.1	4.4	4.1	4.1	4.4	4.4
6.	4.1	4.2	4.1	4.3	4.2	4.9
7.	4.4	4.6	4.4	4.9	4.6	4.9
8.	4.3	4.3	4.3	4.5	4.3	4.5
9,	4.6	4.6	4.6	4.5	4.6	4.5
10.	4.6	4.9	4.6	4.2	4.9	4.2
11.	4.9	4.5	4.9	4.6	4.5	4.6
12.	4.5	4.6	4.5	4.5	4.6	4.5
13.	4.1	4.1	4.1	4.6	4.6	4.6
14.	4.4	4.8	4.4	4.9	4.8	4.9
15.	4.5	4.9	4.5	4.1	4.9	4.1
16.	4.2	4.8	4.2	4.3	4.8	4.3
17.	4.6	4.8	4.6	4.7	4.8	4.7
18.	4.4	4.3	4.4	4.9	4.3	4.9
19.	4.9	4.6	4.9	4.7	4.6	4.7
20.	4.2	4.4	4.2	4.4	4.4	4.4
Mean	4.415	4.560	4.415	4.465	4.560	4.465
SD	0.2752	0.2632	0.2752	0.2651	0.2632	0.2651

Table-llB

IV Peak at 60dB left ear

	2K	4K	2K	6K	4K	6K
1.	4.9	4.8	4.9	4.7	4.8	4.7
2.	4.6	4.6	4.6	4.6	4.6	4.6
3.	4.6	4.9	4.6	4.7	4.9	4.7
4.	4.4	4.4	4.4	4.3	4.4	4.3
5.	4.4	4.4	4.4	4.5	4.5	4.5
6.	4.4	4.4	4.4	4.5	4.4	4.5
7.	4.2	4.9	4.2	4.9	4.9	4.9
8.	4.3	4.3	4.3	4.2	4.3	4.2
9.	4.9	4.4	4.9	4.8	4.4	4.8
10.	4.8	4.5	4.8	4.9	4.5	4.9
11.	4.5	4.5	4.5	4.3	4.5	4.3
12.	4.9	4.9	4.9	4.2	4.9	4.2
13.	4.4	4.6	4.4	4.6	4.6	4.6
14.	4.8	4.6	4.8	4.3	4.6	4.3
15.	4.3	4.8	4.3	4.9	4.8	4.9
16.	4.6	4.6	4.6	4.8	4.6	4.8
17.	4.6	4.5	4.6	4.5	4.5	4.5
18.	4.6	4.8	4.6	4.3	4.8	4.3
19.	4.7	4.3	4.7	4.3	4.3	4.3
20.	4.3	4.4	4.3	5.3	4.4	4.3
Mean	4.547	4.56	4.547	4.53	4.56	4.53
SD	0.222	0.211	0.222	0.247	0.211	0.247

Table-12A

V Peak at 60 dB right Ear

	2K	4K	2K	6K	4K	6K
1.	5.8	5.7	5.8	5.5	5.7	5.5
2.	5.9	5.6	5.9	5.5	5.6	5.5
3.	5.6	5.9	5.6	5.9	5.9	5.9
4.	5.2	5.1	5.2	5.4	5.1	5.4
5.	5.2	5.2	5.2	5.4	5.2	5.4
6.	5.1	5.8	5.1	5.6	5.8	5.6
7.	5.5	5.6	5.5	5.6	5.6	5.6
8.	5.2	5.2	5.2	5.3	5.2	5.3
9.	5.3	5.2	5.3	5.2	5.2	5.2
10.	5.7	5.5	5.7	5.5	5.5	5.5
11.	5.5	5.7	5.5	5.2	5.7	5.2
13.	5.6	5.2	5.6	5.5	5.2	5.5
13.	5.4	5.2	5.4	5.6	5.2	5.6
14.	5.6	5.6	5.6	5.6	5.6	5.6
15.	5.8	5.6	5.8	5.6	5.6	5.6
16.	5.3	5.2	5.3	5.4	5.2	5.4
17.	5.4	5.3	5.4	5.5	5.4	5.5
18.	5.6	5.5	5.6	5.7	5.5	5.7
19.	5.6	5.8	5.6	5.7	5.3	5.7
20.	5.3	5.4	5.3	5.2	5.4	5.2
Mean	5.480	5.465	5.480	5.495	5.465	5.495
SD	0.2228	0.2329	0.2228	0.2324	0.2329	0.2324

Table-12B

V Peak at 60dB Left ear

	2K	4K	2K	6K	4K	6K
1.	5.5	5.6	5.5	5.4	5.6	5.4
2.	5.8	5.4	5.8	5.6	5.8	5.6
3.	5.9	5.3	5.9	5.6	5.3	5.6
4.	5.4	5.7	5.4	5.7	5.7	5.7
3.	5.4	5.2	5.4	5.3	5.2	5.3
6.	5.3	5.6	5.3	5.4	5.6	5.4
7.	5.7	5.6	5.7	5.5	5.6	5.5
8.	5.2	5.4	5.2	5.5	5.4	5.5
9.	5.5	5.3	5.5	5.4	5.3	5.4
10.	5.7	5.6	5.7	5.8	5.6	5.8
11.	5.6	5.6	5.6	5.4	5.6	5.4
12.	5.7	5.7	5.7	5.9	5.7	5.9
13.	5.4	5.3	5.4	5.4	5.3	5.4
14.	5.5	5.8	5.5	5.4	5.8	5.4
15.	5.4	5.9	5.4	5.6	5.9	5.6
16.	5.3	5.6	5.3	5.8	5.6	5.8
17.	5.4	5.2	5.4	5.3	5.2	5.3
18.	5.9	5.4	5.9	5.4	5.4	5.4
19.	5.5	5.9	5.5	5.9	5.9	5.9
20.	5.4	5.5	5.4	5.3	5.5	5.3
Mean	5.525	5.527	5.525	5.53	5.527	5.53
SD	0.199	0.203	0.199	0.197	0.203	0.197

Table-13A

VI peak at 60dB right ear

	2K	4K	2K	6K	4K	6K
1.	6.2	6.5	6.2	6.4	6.5	6.4
2.	6.8	6.3	6.8	6.4	6.3	6.4
3.	6.8	6.9	6.8	6.9	6.9	6.3
4.	6.9	6.6	6.9	6.6	6.6	6.6
5.	6.8	6.3	6.8	6.6	6.3	6.6
6.	6.6	6.3	6.6	6.6	6.6	6.6
7.	6.5	6.2	6.5	6.6	6.2	6.6
8.	6.4	6.3	6.4	6.7	6.3	6.7
9.	6.7	6.3	6.7	6.7	6.3	6.7
10.	6.2	6.5	6.2	6.4	6.5	6.4
11.	6.8	6.6	6.8	6.8	6.6	6.8
12.	6.6	6.2	6.6	6.6	6.2	6.6
13.	6.8	6.2	6.8	6.2	6.2	6.2
14.	6.8	6.8	6.8	6.9	6.8	6.9
15.	6.4	6.5	6.4	6.8	6.5	6.8
16.	6.5	6.5	6.5	6.8	6.5	6.8
17.	6.8	6.2	6.6	6.8	6.2	6.8
18.	6.9	6.9	6.9	6.9	6.9	6.9
19.	6.8	6.8	6.8	6.6	6.8	6.6
20.	6.4	6.3	6.4	6.2	6.3	6.2
Mean	6.715	6.460	6.715	6.615	6.460	6.615
SD	0.2305	0.2290	0.2305	0.2434	0.2290	0.2434

Table-13B

VI Peak at 60dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	6.5	6.6	6.5	6.4	6.6	6.4
2.	6.9	6.4	6.9	6.9	6.4	6.9
3.	6.9	6.9	6.9	6.9	6.9	6.9
4.	6.6	6.9	6.6	6.5	6.9	6.5
5.	6.7	6.9	6.7	6.9	6.9	6.9
6.	6.8	6.9	6.8	6.9	6.9	6.9
7.	6.9	6.8	6.9	6.7	6.8	6.7
8.	6.7	6.5	6.7	6.9	6.5	6.9
9.	6.8	6.9	6.8	6.7	6.9	6.7
10.	6.6	6.7	6.6	6.8	6.7	6.8
11.	6.9	6.6	6.9	6.5	6.6	6.5
12.	6.5	6.8	6.5	6.6	6.8	6.6
13.	6.3	6.6	6.3	6.5	6.6	6.5
14.	6.7	6.6	6.7	6.5	6.6	6.5
15.	6.8	6.6	6.8	6.8	6.6	6.8
16.	6.4	6.4	6.4	6.6	6.4	6.6
17.	6.6	6.4	6.6	6.9	6.4	6.9
18.	6.6	6.6	6.6	6.4	6.6	6.4
19.	6.8	6.7	6.8	6.6	6.7	6.6
20.	6.5	6.4	6.5	6.4	6.4	6.4
Mean	6.675	6.656	6.675	6.67	6.656	6.67
SD	0.1773	0.135	0.1773	0.192	0.135	0.192

Table-14A

VII Peak at 60dB right ear

	2K	4K	2K	6K	4K	6K
1.	7.4	7.3	7.4	7.5	7.3	7.5
2.	7.8	7.7	7.8	7.5	7.7	7.8
3.	7.5	7.8	7.5	7.3	7.8	7.3
4.	7.3	7.8	7.4	7.9	7.8	7.9
5.	7.9	7.9	7.9	7.9	7.9	7.9
6.	7.8	7.9	7.8	7.8	7.9	7.8
7.	7.9	7.5	7.9	7.6	7.5	7.6
8.	7.1	7.8	7.1	7.7	7.8	7.7
9.	7.8	7.9	7.8	7.2	7.9	7.2
10.	7.4	7.9	7.4	7.9	7.9	7.9
11.	7.3	7.9	7.3	7.5	7.9	7.5
12.	7.9	7.2	7.9	7.7	7.2	7.7
13.	7.3	7.9	7.3	7.2	7.9	7.2
14.	7.3	7.7	7.3	7.1	7.7	7.1
15.	7.2	7.2	7.2	7.9	7.2	7.9
16.	7.8	7.9	7.8	7.9	7.9	7.9
17.	7.3	7.1	7.3	7.4	7.1	7.4
18.	7.9	7.9	7.9	7.9	7.9	7.9
19.	7.9	7.3	7.9	7.7	7.3	7.7
20.	7.3	7.4	7.3	7.5	7.4	7.5
Mean	7.540	7.650	7.540	7.605	7.650	7.605
SD	0.2807	0.2837	0.2807	0.2568	0.2837	0.2568

Table-14B

VII Peak at 60dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	7.8	7.6	7.8	7.7	7.6	7.7
2.	7.7	7.8	7.7	7.6	7.8	7.6
3.	7.5	7.6	7.5	7.6	7.6	7.6
4.	7.3	7.8	7.3	7.6	7.8	7.6
5.	7.3	7.6	7.3	7.6	7.6	7.6
6.	7.4	7.4	7.4	7.6	7.4	7.6
7.	7.9	7.9	7.9	7.9	7.9	7.9
8.	7.4	7.6	7.4	7.4	7.6	7.4
9.	7.5	7.7	7.5	7.6	7.7	7.6
10.	7.7	7.7	7.7	7.7	7.7	7.7
11.	7.6	7.6	7.6	7.4	7.6	7.4
12.	7.6	7.9	7.6	7.8	7.9	7.8
13.	7.7	7.4	7.7	7.5	7.4	7.5
14.	7.4	7.9	7.4	7.3	7.9	7.3
15.	7.4	7.2	7.4	7.5	7.2	7.5
16.	7.4	7.6	7.6	7.5	7.6	7.5
17.	7.6	7.6	7.6	7.7	7.6	7.7
18.	7.6	7.5	7.6	7.4	7.5	7.4
19.	7.7	7.7	7.7	7.9	7.7	7.9
20.	7.5	7.4	7.5	7.6	7.4	7.6
Mean	7.4622	7.42	7.4622	7.498	7.42	7.498
SD	0.933	1.11378	0.93	0.8066	1.113	0.8066

Table-15A

I Peak at 40dB right ear

	2K	4K	2K	$K	4K	6K
1.	1.6	1.4	1.6	1.7	1.4	1.7
2.	1.6	1.9	1.6	1.9	1.9	1.9
3.	1.1	1.4	1.1	1.2	1.4	1.2
4.	1.2	1.4	1.2	1.2	1.4	1.2
5.	1.2	1.6	1.2	1.6	1.6	1.6
6.	1.7	1.5	1.7	1.3	1.5	1.3
7.	1.6	1.6	1.6	1.6	1.6	1.6
8.	1.8	1.2	1.8	1.5	1.2	1.5
9.	1.8	1.3	1.8	1.5	1.3	1.5
10.	1.3	1.3	1.3	1.9	1.3	1.9
11.	1.3	1.6	1.3	1.7	1.6	1.7
12.	1.4	1.5	1.4	1.9	1.5	1.9
13.	1.8	1.8	1.8	1.8	1.8	1.9
14.	1.8	1.9	1.8	1.6	1.9	1.6
15.	1.6	1.3	1.6	1.6	1.3	1.6
16.	1.4	1.8	1.4	1.5	1.8	1.5
17.	1.7	1.5	1.7	1.9	1.5	1.7
18.	1.7	1.4	1.7	1.2	1.4	1.2
19.	1.3	1.7	1.3	1.8	1.7	1.8
20.	1.4	1.3	1.4	1.5	1.3	1.4
Mean	1.515	1.520	1.515	1.600	1.520	1.600
SD	0.2230	0.2071	0.2230	0.2366	0.2071	0.2366

Table-15B

I Peak at 40dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	1.6	1.4	1.6	1.4	1.4	1.4
2.	1.4	1.4	1.4	1.4	1.4	1.4
3.	1.4	1.3	1.4	1.4	1.3	1.4
4.	1.3	1.4	1.3	1.4	1.4	1.4
5.	1.3	1.3	1.3	1.4	1.3	1.4
5.	1.5	1.4	1.5	1.4	1.4	1.4
7.	1.3	1.6	1.3	1.4	1.6	1.4
8.	1.8	1.4	1.8	1.5	1.4	1.5
9.	1.7	1.8	1.7	1.4	1.8	1.4
10.	1.4	1.7	1.4	1.6	1.7	1.6
11.	1.4	1.7	1.4	1.7	1.7	1.7
12.	1.4	1.5	1.4	1.6	1.5	1.6
13.	1.9	1.5	1.9	1.8	1.5	1.8
14.	1.5	1.8	1.5	1.9	1.8	1.9
15.	1.9	1.4	1.9	1.3	1.4	1.3
16.	1.5	1.7	1.5	1.5	1.7	1.5
17.	1.5	1.4	1.5	1.7	1.4	1.7
18.	1.9	1.9	1.9	1.9	1.9	1.9
19.	1.7	1.3	1.7	1.7	1.3	1.7
20.	1.5	1.6	1.5	1.4	1.6	1.4
Mean	1.545	1.5316	1.545	1.5246	1.5316	1.5244
SD	0.203	0.189	0.203	0.1833	0.189	0.7833

Table-16A

II Peak at 40dB right ear

	2K	4K	2K	6K	4K	6K
1.	2.7	2.2	2.7	2.3	2.2	2.3
2.	2.4	2.9	2.*	2.9	2.9	2.9
3.	2.1	2.9	2.1	2.2	2.9	2.2
4.	2.1	2.8	2.1	2.3	2.8	2.3
5.	2.9	2.3	2.9	2.5	2.3	2.5
6.	2.6	2.4	2.6	2.1	2.4	2.1
7.	2.6	2.6	2.6	2.6	2.6	2.6
8.	2.4	2.7	2.4	2.7	2.7	2.7
9.	2.7	2.3	2.7	2.7	2.3	2.7
10.	2.2	2.2	2.2	2.7	2.2	2.7
11.	2.3	2.6	2.3	2.6	2.6	2.6
12.	2.5	2.3	2.5	2.9	2.3	2.9
13.	2.9	2.9	2.9	2.6	2.9	2.6
14.	2.7	2.9	2.7	2.6	2.9	2.6
15.	2.6	2.9	2.6	2.6	2.9	2.6
16.	2.3	2.4	2.3	2.8	2.4	2.8
17.	2.5	2.9	2.5	2.9	2.9	2.9
18.	2.7	2.1	2.7	2.6	2.1	2.6
19.	2.2	2.4	2.2	2.8	2.4	2.8
20.	2.5	2.3	2.5	2.4	2.3	2.4
Mean	2.390	2.550	2.390	2.590	2.550	2.590
SD	0.2468	0.2393	0.2468	0.2215	0.2393	0.2215

Table-16B

II Peak at 40dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	2.8	2.4	2.8	2.4	2.4	2.4
2.	2.4	2.8	2.4	2.4	2.8	2.4
3.	2.4	2.9	2.4	2.3	2.9	2.3
4.	2.2	2.5	2.2	2.3	2.5	2.3
5.	2.3	2.5	2.3	2.4	2.5	2.4
6.	2.4	2.6	2.4	2.8	2.6	2.8
7.	2.4	2.7	2.4	2.4	2.7	2.4
8.	2.9	2.9	2.9	2.3	2.9	2.3
9.	2.8	2.7	2.8	2.4	2.7	2.4
10.	2.9	2.4	2.9	2.8	2.4	2.8
11.	2.3	2.9	2.3	2.3	2.9	2.3
12.	2.3	2.7	2.3	2.6	2.7	2.6
13.	2.9	2.4	2.9	2.5	2.4	2.5
14.	2.9	2.9	2.9	2.9	2.9	2.9
15.	2.3	2.6	2.3	2.4	2.6	2.4
16.	2.7	2.4	2.7	2.4	2.4	2.4
17.	2.6	2.3	2.6	2.4	2.3	2.4
10.	2.6	2.3	2.6	2.9	2.3	2.9
19.	2.4	2.3	2.4	2.3	2.3	2.3
20.	2.4	2.5	2.4	2.5	2.5	2.5
Mean	2.545	2.565	2.545	2.5338	2.565	2.5338
SD	0.245	0.229	0.245	0.222	0.229	0.222

Table-17A

III Peak at 40dB right ear.

	2K	4K	2K	6K	4K	6K
1.	3.2	3.3	3.2	3.3	3.3	3.3
2.	3.3	3.6	3.3	3.6	3.6	3.6
3.	3.1	3.3	3.1	3.8	3.3	3.8
4.	3.4	3.9	3.4	3.9	3.9	3.9
5.	3.9	3.2	3.9	3.5	3.2	3.5
6.	3.3	3.2	3.3	3.2	3.2	3.2
7.	3.3	3.7	3.3	3.7	3.7	3.7
8.	3.6	3.6	3.6	3.7	3.6	3.7
9.	3.2	3.3	3.2	3.3	3.3	3.3
10.	3.7	3.9	3.7	3.5	3.9	3.5
11.	3.7	3.6	3.7	3.4	3.6	3.4
12.	3.7	3.6	3.7	3.9	3.6	3.9
13.	3.6	3.6	3.6	3.6	3.6	3.6
14.	3.6	3.7	3.6	3.7	3.7	3.7
16.	3.6	3.6	3.6	3.6	3.6	3.6
16.	3.3	3.1	3.3	3.3	3.1	3.3
17.	3.7	3.6	3.7	3.6	3.6	3.6
18.	3.6	3.1	3.6	3.4	3.1	3.4
19.	3.6	3.3	3.6	3.3	3.3	3.3
20.	3.5	3.2	3.5	3.3	3.2	3.3
Mean	3.445	3.470	3.445	3.530	3.470	3.530
SD	0.2178	0.2459	0.2178	0.2076	0.2459	0.2076

Table-17B

III Peak at 40 dB Left Ear

	3K	4K	2K	6K	4K	6K
1.	3.7	3.4	3.7	3.6	3.4	3.6
2.	3.4	3.5	3.4	3.6	3.5	3.6
3.	3.6	3.3	3.6	3.9	3.3	3.9
4.	3.4	3.5	3.4	3.4	3.5	3.4
5.	3.9	3.4	3.9	3.4	3.4	3.4
6.	3.3	3.5	3.3	3.5	3.5	3.5
7.	3.4	3.8	3.4	3.4	3.8	3.4
8.	3.8	3.9	3.8	3.7	3.9	3.7
9.	3.6	3.5	3.6	3.5	3.5	3.5
10.	3.6	3.3	3.6	3.6	3.3	3.6
11.	3.5	3.8	3.5	3.7	3.8	3.7
12.	3.4	3.4	3.4	3.3	3.4	3.3
13.	3.7	3.3	3.7	3.3	3.3	3.3
14.	3.9	3.9	3.9	3.8	3.9	3.8
15.	3.4	3.6	3.4	3.3	3.6	3.3
16.	3.8	3.3	3.8	3.3	3.3	3.3
17.	3.9	3.4	3,9	3.4	3.4	3.4
18.	3.7	3.8	3.7	3.6	3.8	3.6
19.	3.4	3.3	3.4	3.4	3.3	3.4
20.	3.3	3.4	3.3	3.5	3.4	3.5
Mean	3.585	3.586	3.585	3.534	3.546	3.534
3D	0.2033	0.2062	0.2033	0.195	0.2062	0.195

TABLE-18A

IV peak at 40dB Right Ear

	2K	4K	2K	6K	4K	6K
1.	4.7	4.6	4.7	4.6	4.6	4.6
2.	4.3	4.9	4.3	4.3	4.9	4.3
3.	4.9	4.6	4.9	4.9	4.6	4.9
4.	4.2	4.3	4.2	4.3	4.3	4.3
3.	4.1	4.3	4.1	4.5	4.3	4.5
6.	4.2	4.5	4.2	4.2	4.5	4.2
7.	4.1	4.7	4.1	4.5	4.7	4.5
8.	4.2	4.6	4.2	4.9	4.6	4.9
9.	4.2	4.4	4.2	4.1	4.4	4.1
10.	4.8	4.9	4.8	4.7	4.9	4.7
11.	4.6	4.8	4.6	4.6	4.8	4.6
12.	4.9	4.9	4.9	4.9	4.9	4.9
13.	4.7	4.7	4.7	4.3	4.7	4.3
14.	4.3	4.7	4.3	4.2	4.7	4.2
15.	4.6	4.8	4.6	4.6	4.8	4.6
16.	4.6	4.2	4.6	4.1	4.2	4.1
17.	4.7	4.5	4.7	4.5	4.5	4.5
18.	4.9	4.7	4.9	4.5	4.7	4.5
19.	4.8	4.9	4.8	4.8	4.9	4.8
20.	4.5	4.3	4.5	4.4	4.3	4.4
Mean	4.515	4.615	4.515	4.495	4.615	4.495
SD	0.2645	0.2401	0.2401	0.2521	0.2401	0.2521

Table-18B

IV Peak at 40 dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	4.7	4.6	4.7	4.4	4.6	4.4
2.	4.4	4.8	4.4	4.4	4.8	4.4
3.	4.8	4.5	4.8	4.5	4.5	4.5
4.	4.4	4.6	4.4	4.4	4.6	4.4
5.	4.9	4.4	4.9	4.9	4.4	4.9
6.	4.5	4.4	4.5	4.6	4.4	4.6
7.	4.3	4.4	4.3	4.5	4.4	4.5
8.	4.7	4.4	4.7	4.4	4.4	4.4
9.	4.9	4.5	4.9	4.6	4.5	4.6
10.	4.4	4.9	4.4	4.4	4.9	4.4
11.	4.6	4.9	4.6	4.8	4.9	4.8
12.	4.4	4.4	4.4	4.7	4.4	4.7
13.	4.8	4.8	4.8	4.7	4.8	4.7
14.	4.5	4.6	4.5	4.7	4.6	4.7
15.	4.8	4.6	4.8	4.6	4.6	4.6
16.	4.5	4.6	4.5	4.6	4.6	4.6
17.	4.7	4.6	4.7	4.3	4.6	4.3
18.	4.9	4.7	4.9	4.4	4.7	4.4
19.	4.5	4.8	4.5	4.4	4.8	4.4
20.	4.4	4.5	4.4	4.6	4.5	4.6
Mean	4.605	4.583	4.605	4.575	4.583	4.575
SD	0.198	0.177	0.198	0.1808	0.177	0.1808

Table-19A

V Peak at 40 dB Right ear

	2K	4K	2K	6K	4K	6K
1.	5.5	5.7	5.5	5.5	5.7	5.5
2.	5.4	5.8	5.4	5.5	5.8	5.5
3.	5.4	5.3	5.4	5.6	5.3	5.6
4.	5.9	5.8	5.9	5.9	5.8	5.9
5.	5.6	5.7	5.6	5.7	5.7	5.7
6.	5.8	5.5	5.8	5.7	5.5	5.7
7.	5.6	5.4	5.6	5.5	5.4	5.5
8.	5.9	5.4	5.9	5.9	5.4	5.9
9.	5.8	5.9	5.8	5.9	5.9	5.9
10.	5.4	5.9	5.4	5.4	5.9	5.4
11.	5.4	5.9	5.4	5.9	5.9	5.9
12.	5.9	5.6	5.9	5.5	5.6	5.5
13.	5.3	5.9	5.3	5.7	5.9	5.7
14.	5.4	5.5	5.4	5.6	5.5	5.6
15.	5.7	5.6	5.7	5.9	5.6	5.9
16.	5.6	5.9	5.6	5.5	5.9	5.5
17.	5.4	5.5	5.4	5.5	5.5	5.5
18.	5.5	5.8	5.5	5.7	5.8	5.7
19.	5.3	5.2	5.3	5.4	5.2	5.4
20.	5.4	5.5	5.4	5.6	5.5	5.6
Mean	5.540	5.640	5.540	5.645	5.640	5.645
SD	0.2017	0.2154	0.2017	0.2153	0.2154	0.2153

Table-19B

V Peak at 40dB Left Ear

	2K	4K	2K	5K	4K	6K
1.	5.5	5.5	5.5	5.8	5.5	5.8
2.	5.6	5.4	5.6	5.5	5.4	5.5
3.	5.8	5.8	5.8	5.6	5.8	5.6
4.	5.4	5.4	5.4	5.5	5.4	5.5
5.	5.4	5.4	5.4	5.4	5.4	5.4
6.	5.6	5.4	5.6	5.5	5.4	5.5
7.	5.6	5.6	5.6	5.8	5.6	5.8
8.	5.5	5.6	5.5	5.9	5.6	5.9
9.	5.8	5.4	5.8	5.7	5.4	5.7
10.	5.4	5.6	5.4	5.6	5.6	5.6
11.	5.3	5.6	5.3	5.5	5.6	5.5
12.	5.5	5.3	5.5	5.4	5.3	5.4
13.	5.4	5.9	5.4	5.3	5.9	5.3
14.	5.9	5.6	5.9	5.4	5.6	5.4
15.	5.4	5.7	5.4	5.7	5.7	5.7
16.	5.6	5.3	5.6	5.5	5.3	5.5
17.	5.6	5.8	5.6	5.5	5.8	5.5
18.	5.7	5.7	5.7	5.4	5.7	5.4
19.	5.6	5.4	5.6	5.4	5.4	5.4
20.	5.4	5.3	5.4	5.4	5.3	5.4
Mean	5.55	5.5425	5.55	5.5416	5.542	5.541
SD	0.1605	0.2482	0.1605	0.267	0.248	0.267

Table-20A

VI peak at 40dB right ear

	2K	4K	2K	6K	4K	6K
1.	6.8	6.5	6.8	6.6	6.5	6.5
2.	6.8	6.9	6.8	6.6	6.9	6.6
3.	6.7	6.6	6.7	6.8	6.6	6.8
4.	6.6	6.4	6.6	6.9	6.4	6.3
5.	6.7	6.7	6.7	6.4	6.7	6.4
6.	6.9	6.8	6.9	6.9	6.8	6.9
7.	6.5	6.3	6.5	6.7	6.3	6.7
8.	6.4	6.3	6.4	6.7	6.3	6.7
9.	6.4	6.5	6.4	6.5	6.5	6.5
10.	6.5	6.7	6.5	6.5	6.7	6.5
11.	6.5	6.4	6.5	6.5	6.4	6.5
12.	6.8	6.7	6.8	6.8	6.7	6.8
13.	6.3	5.6	6.3	6.4	6.6	6.4
14.	6.4	6.3	6.4	6.3	6.3	6.3
15.	6.9	6.8	6.9	6.8	6.8	6.8
16.	6.4	6.6	6.4	6.3	6.6	6.3
17.	6.4	6.6	6.4	6.7	6.6	6.7
18.	6.8	6.5	6.8	6.5	6.5	6.5
19.	6.9	6.6	6.9	6.8	6.6	6.8
20.	6.5	6.6	6.5	6.5	6.6	6.6
Mean	6.610	6.570	6.610	6.575	6.570	6.575
SD	0.1918	0.1661	0.1918	0.1665	0.1661	0.1665

Table-20B

VI Peak at 40dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	6.7	6.5	6.7	6.6	6.5	6.6
2.	6.6	6.6	6.5	6.6	6.6	6.6
3.	6.5	6.6	6.5	6.4	6.6	6.4
4.	6.4	6.4	6.4	6.5	6.4	6.5
5.	6.7	6.9	6.7	6.9	6.9	6.9
6.	5.4	6.7	6.4	6.5	6.7	6.5
7.	6.8	6.7	6.8	6.7	6.7	6.7
8.	6.4	6.2	6.4	6.4	6.2	6.4
9.	6.7	6.4	6.7	6.6	6.4	6.6
10.	6.4	6.9	6.4	6.5	6.9	6.5
11.	6.5	6.6	6.5	6.6	6.6	6.6
12.	6.7	6.6	6.7	6.4	6.6	6.4
13.	6.4	6.4	6.4	6.5	6.4	6.5
14.	6.4	6.8	6.4	6.4	6.8	6.4
15.	6.4	6.5	6.4	6.5	6.5	6.5
16.	6.7	6.5	6.7	6.4	6.5	6.4
17.	6.5	6.5	6.5	6.6	6.5	6.6
18.	6.5	6.7	6.5	6.7	6.7	6.7
19.	6.8	6.8	6.8	6.9	6.8	6.9
20.	6.5	6.6	6.5	6.4	6.6	6.4
Mean	6.545	6.5343	6.545	6.567	6.5743	6.567
SD	0.1468	0.1568	0.1468	0.1547	0.1568	0.1547

Table-21A

VII Peak at 40 dB right ear

	2K	4K	2K	6K	4K	6K
1.	7.4	7.5	7.4	7.6	7.5	7.6
2.	7.4	7.3	7.4	7.3	7.3	7.3
3.	7.8	7.8	7.8	7.6	7.8	7.6
4.	7.7	7.6	7.7	7.5	7.6	7.5
5.	7.8	7.4	7.8	7.9	7.8	3.9
6.	7.4	9.8	7.4	7.6	7.8	7.6
7.	7.5	7.8	7.5	7.8	7.8	7.8
8.	7.4	7.8	7.4	7.9	7.8	7.9
9.	7.5	7.4	7.5	7.4	7.4	7.4
10.	7.7	7.7	7.7	7.7	7.7	7.7
11.	7.9	7.9	7.9	7.9	7.9	7.9
12.	7.7	7.9	7.7	7.8	7.9	7.8
13.	7.5	7.7	7.5	7.6	7.7	7.6
14.	7.9	7.6	7.9	7.5	7.6	7.5
15.	7.9	7.4	7.9	7.5	7.4	7.5
16.	7.6	7.7	7.6	7.5	7.7	7.5
17.	7.5	7.8	7.5	7.8	7.8	7.8
18.	7.5	7.8	7.5	7.4	7.8	7.4
19.	7.9	7.7	7.9	7.8	7.7	7.8
20.	7.5	7.4	7.5	7.3	7.4	7.3
Mean	7.625	7.650	7.625	7.620	7.650	7.620
SD	0.1777	0.1817	0.1777	0.1913	0.1817	0.1913

Table-21B

VII Peak at 40dB Left Ear

	2K	4K	2K	6K	4K	6K
1.	7.6	7.8	7.6	7.5	7.8	7.5
2.	7.8	9.4	7.8	7.7	7.4	7.7
3.	7.6	7.9	7.6	7.8	7.9	7.8
4.	7.9	7.5	7.9	7.6	7.5	7.6
5.	7.5	7.7	7.5	7.6	7.7	7.6
6.	7.5	7.5	7.5	7.6	7.5	7.6
7.	7.9	7.9	7.9	7.7	7.9	7.7
8.	7.4	7.8	7.4	7.8	7.8	7.8
9.	7.6	7.8	7.6	7.9	7.8	7.9
10.	7.5	7.5	7.5	7.4	7.5	7.4
11.	7.7	7.6	7.7	7.9	7.6	7.9
12.	7.5	7.7	7.5	7.4	7.7	7.4
13.	7.4	7.7	7.4	7.4	7.7	7.4
14.	7.5	7.4	7.5	7.5	7.4	7.5
15.	7.4	7.8	7.4	7.8	7.8	7.8
16.	7.8	7.4	7.8	7.5	7.4	7.5
17.	7.4	7.6	7.4	7.8	7.6	7.8
18.	7.6	7.5	7.6	7.4	7.5	7.4
19.	7.8	7.7	7.8	7.6	7.7	7.6
20.	7.5	7.4	7.5	7.5	7.4	7.5
Mean	7.595	7.6125	7.595	7.615	7.615	7.616
SD	0.166	0.168	0.166	0.2308	0.168	0.2308

TABLE-22

Correlation table at 80dBHL

	Right ear			Left ear		
Peaks	2K-4K	2K-6K	4K-6K	2K-4K	2K-6K	4K-6K
I	NS	NS	NS	NS	NS	NS
II	S	NS	NS	NS	NS	NS
III	NS	NS	NS	NS	NS	NS
IV	S	NS	NS	NS	NS	NS
V	S	NS	S	NS	NS	NS
VI	NS	S	S	S	NS	NS
VII	NS	NS	NS	NS	NS	NS

NS - Not significant

S - Significant

TABLE-23

Correlation table at 60 dB HL

	Right ear			Left ear		
Peaks	2K-4K	2K-6K	4K-6K	2K-4K	2K-6K	4K-6K
I	NS	NS	NS	NS	NS	NS
II	NS	NS	NS	NS	NS	NS
III	NS	NS	NS	NS	NS	NS
IV	NS	NS	NS	NS	NS	NS
V	NS	NS	S	NS	NS	S
VI	S	NS	S	NS	NS	NS
VII	NS	NS	NS	NS	NS	NS

NS - not significant

S - significant.

TABLE-24

Correlation table at 40dB HL

	Right ear			Left ear		
Peaks	2K-4K	SK-6K	4K-6K	2K-4K	2K-6K	4K-6K
I	NS	NS	NS	NS	NS	NS
II	S	S	NS	NS	NS	NS
III	NS	NS	NS	NS	NS	NS
IV	NS	NS	NS	NS	NS	NS
V	NS	NS	NS	NS	NS	NS
VI	NS	S	NS	NS	NS	NS
VII	NS	NS	NS	NS	NS	NS

NS - Not significant

S - Significant

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

The present study was undertaken with the aim to investigate to effects of frequency on latency of Brain Stem Evoked Response Audiometry. Interest was focussed on the latency-how the effects occur with respect to frequency.

The study also include the absolute latency values of I to VII peaks.

The study was carried out in a sound treated room at Audiology Department of All India Institute of Speech and Hearing, Mysore. Ten(lO) males and ten(10) females normal hearing subjects were tested for the study purpose. ERA model TA-1000 was used. The data were collected at 2K, 4K and 6KHz stimuli and at three intensity levels viz. 80, 60 and 40 dBHL. For each subjects both the ears were tested.

Conclusion:

Tables a, b, and c show that in majority of the conditions significance of difference has not been observed i.e. the frequency of the stimulus has negligible effect on the latency of responses.

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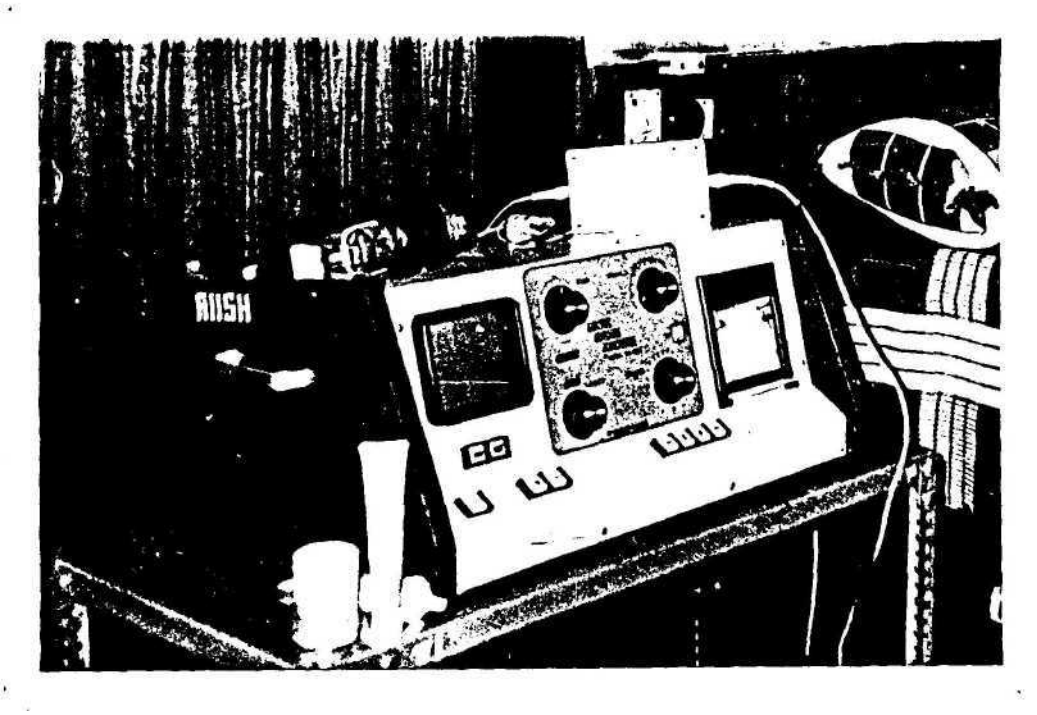
APPENDIX II



TA - 1000 Electric Response Audiometry System used in the present study.