"EEG, ARTIFACTS AND BSERA"

REG. No. 8408

An Independent Project work submitted as part Fulfillment for M.Sc (Speech and Hearing) to University of Musore, Mysore, 1985.

1985

IN LOVING MEMORY OF

MY

GRANDMOTHER

CERTIFICATE

This is to certify that the Independent Project entitled **"EEG, ARTIFACTS AND BSERA"** is the bonafide work done in part fulfillment for FIRST year M.Sc (Speech and Hearing) of the student with Register Number 8408.

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CERTIFICATE

This is to certify that the independent project entitled **"EEG, ARTIFACTS AND BSERA"** has been prepared under my Supervision and Guidance.

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DECLARATION

This Independent Project is my own work done under the guidance of Dr. M.N. Vyasamurthy, Lecturer in Audiology All India Institute of Speech and Hearing, Mysore 6, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore Register No.8408

Dated :

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INTRODUCTION

Auditory brain-stem response technique has emerged as a vital adjunct to the clinical armamentaria* of the Audiologists Otologists and Neurologists, who jointly determine hearing sensitivity, lesion site and Central Nervous System integrity, Pathology and Maturation.

Study of the spontaneous activity of the brain has a long history and a well established place in clinical medicine, and so does brain electrical activity, which is brought about by an experimenter/clinician (and hence "evoked").

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 been its use in neurological diseases. Brain-stem lesions cause a selective absence or alteration of one or more of the response components; patients with 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 led 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 premature infants,full-term infants, and preadolescent children. A related application is an attempt to discover electrophysiologic correlates underlying demyelinating diseases such as multiple sclerosis (Chiappa, Harrisen, and Brooks, et. al., 1980). The majority of these investigators subscribe to the well-known relationship that as the peripheral and CNS mature) (e.g. as additional myelinizatlon takes place, and perhaps as axon diameter increases), latency of BSERs tend to decrease until an adult norm is achieved. In addition, the magnitude of the potentials are observed to increase with age.

One of the most frustrating sights 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 bean 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 clinician must also be cognizant of the variability of normal characteristics between and within subjects) and the variability due to nonpathologic factors, such as the nature of the stimulus; recording procedures and subjects.

Factors that can bring about variations in normal response parameters are:

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

2. Subject effects
    a. State of the subject (awake,asleep,sedated or anaesthetized)
    b. Effect of the temperature
    c. Sex differences
    d. Effect of change in muscle tone and attention)
    e. Effect of age

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

At present, there are no studies about detecting the artifacts from BSER waveform. This study is intended to enable the clinician to differentiate the true BSER waveform from the one which is being swamped by artifacts.

To detect the true BSER, it is essential that the Audiologists should be aware of the artifacts thoroughly, i.e. a thorough knowledge of the artifacts is a pre-requisite for the audiologist to arrive at correct interpretation of 3SER. To have a thorough knowledge of the artifacts, one should have sufficient data of averaged ongoing activity of the brain (i.e. without any auditory stimulus).

This study will help the audiologists to detect artifacts and thus will help in interpreting the results correctly.

STATEMENT OF THE PROBLEM

The present study was undertaken to find out the artifacts which interfere with the brainstem evoked response and thus create problems in interpreting the results.

Relationship between ongoing background electrical activity and the brainstem evoked response was also studied.

This study is designed to answer some of the questions regarding the artifacts in BSER.

1. Does there exist any relationship between Averaged waveform (without stimulus) for 2043 samples (20 times/sec,

6 times/sec) and the BSER waveform?

2. Does there exist any relationship between Averaged waveform (without stimulus) for 1024 samples (20 times/sec, 5 times/sec) and the BSER waveform?

3. Does there exist any relationship between ongoing background electrical activity and the BSER in normal hearing subjects?

This study also gives information about, what percentage of normal hearing subjects (males and females) exhibited VI and VII peaks, as this information will be useful in identifying Multiple sclerosis. In multiple sclerosis VI and VII peaks are reported to be absent.

***

REVIEW OF LITERATURE

Brief review of literature about . - E.E.G, BSERA and its artifacts.

> "Our entire experienced world of consciousness is, as ScoPenhauer justly stated, a brain phenomenon, but the brain itself is a brain phenomenon."
>
> (H. Kuhlenbeck in - The Brain Paradox)

"The purpose of this section is to glimpse backward when considering contemporary issues such as auditory brain stem evoked responses. In order to put the past into proper perspective, several lines of historical evidence must be examined. It started with the discovery of bioelectric potentials in animals, first described by Galvani, Circa 1791. In 1848, duBois-Reymond published his seminal papers on the discovery of negative action potentials in nerves. This was followed in (1875) by the first published evoked potential recordings by Caton. Following this, Berger (1929) first recorded brain electric potentials from the human scalp, which came to be known as the electroencephalogram, or EEG." (Moore, 19S3).

APPRAISAL OF ELECTRIC PHENOMENON

The propogated disturbance travelling through nerve fibres and the transmission of that impulse through synapses and cell bodies are accompanied by changes in electric potentials. These electrical changes have been of the foremost significance in the investigation of the nerve conduction; substantial advances in the understanding of nervous function are based on the study of action currents, spikes and potentials (Kohlenbeck, 1982).

Hans Berger (1929) (cited by DuBovy, 1978) discovered a wave with an average duration of 90ms and a smaller wave with a duration of 35ms. He called the larger wave, the alpha wave and found that the wave underwent large variations in patients who suffered from epilepsy, multiple sclerosis and other diseases of the CNS. Alpha waves (8 to 11 cycle) remain constant in frequency and have their highest amplitudes in the alert but relatively unoccupied brain.

Beta waves are associated with activity or states of tension. They have a frequency of 12 to 18 Hz. Another rhythm evident is the theta, its frequency ranges from 4 to 7 Hz. It emanates from the temporal and adjacent parietal regions of the brain, midway between the front and rear of the head. Theta dominates among two to five year old children, from six up, the theta diminishes (DuBovy, 1978).

The slow delta waves seen in epileptic seizures were also seen in normal infants upto age one and in normal sleeping subjects. At the opposite end of the EEG spectrum, gamma waves are found to emanate from the back of the head.

They occur at random times and have been associated with vision. Murhythm, found only in a small percentage of subjects can be picked up from the central regions of either side of the head. Mu waves disappeared when the subject thought about moving limbs on the opposite side of the body (DuBovy, 1978).

The analysis of the BEG has proved to be of particular clinical value in diagnosis and classification of epilepsies and allied convulsive disorders, especially in detecting suspected cases. In case of brain tumours and other intracranial lesions, localized irregular slow waves may be recorded. Local areas of depressed electric activity can occur in case of haemorrhage, hematoma, or abscess (Kohlenbeck, 1982).

Relationship of the Evoked Response to background EEG activity

The evoked response to acoustic stimuli was recorded from the waking brain by P.A. Davis and from the sleeping brain by H. Davis et. al., in (1939)cited by Reneau and Hnatio (1975).

Goldstein et a. (1965) reported that male subjects with a high incidence of alpha rhythm in their background activity tended to provide a greater proportion of ERG responses than did subjects with a low incidence of alpha rhythm, when responses were measured by inspection.

"Appleby examining the average evoked response of infants and Price et al, examining the average evoked response in subjects between 10 and 83 years of age, found that the amplitude of the evoked response was reduced with the amplitude of the ongoing EEG activity and was increased when the amplitude of the ongoing EEG activity was increased. Response amplitude was unrelated to the frequency of the ongoing EEG activity. In contrast Davis and his colleagues were unable to discern a relationship between amplitude and the subjects EEG background activity. They found no evidence of competition between evoked vertex response and ongoing alpha activity." (Reneaa and Hnato 1975).

"Vaughan pointed that evoked responses are usually recorded from locations on the scalp where the amplitude is maximal. In these locations, knowledge of the level of the ongoing EEG activity becomes relatively less important. However, if the evoked response is not recorded from a location where responses is maximal, knowledge of the level of the ongoing EEG activity takes on greater importance. Vaughan has provided an example where the amplitude of the ongoing EEG is 25 MV and the amplitude of the evoked response is 10 MV. Such a recording site would provide a signal to noise ratio of 4:1. If the recording site is moved to a location where the signal has decayed to one-fourth its maximal amplitude the signal to noise ratio will be l:1. Vaughan recommends using a (I) reference developed by Schimmel to determine how many samples must be included in an average response. This technique is helpful in making an estimate of the structure and size of the EEG background activity and for making an estimate of the interaction between the evoked response and the EEG background activity."(Renean and Hnatio, 1975).

Brain stem evoked responses: According to Buchwald (1983)

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

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

3. BSER waves reflect functionally separable substrate system.

BRAINSTEM AUDITORY NUCLEI

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

1. Cochlear
2. Superior olivary complex
3. Nuclei of the lateral leminiscus
4. Inferior colliculus; and
5. Medical geniculate body.

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

BSER GENERATION

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

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

Hashimoto, Ishiyami and Yoshimoto, 1981).

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

3. In view of the direct and indirect links between MS0 field potentials and Wave III, the principal substrate for wave III generation is hypothesized as dendritic post-synaptic potentials of the M80 (Buchwald, 1983).

4. Wave IV generation is postulated as PSP activity within the lateral leminiscus cell population (Buchwald, 1983).

5. Wave V - Result of lesion studies suggest that the deep Ventrolateral portion of the IC is particularly important for wave V generation (Buchwald, 1983).

5. Wave VI arises from medial geniculate body. It is consistently ranked hardest to recognize the BSER in a normal population, it is so irregularly present and variable in waveform that its clinical usefulness has been questioned. (Chiappa, Gladstone and Young, 1979).

Wave VII arises from auditory radiations (Thalamocortical) and is also irregularly present.

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

1. Wave V is usually the largest component in BSER.

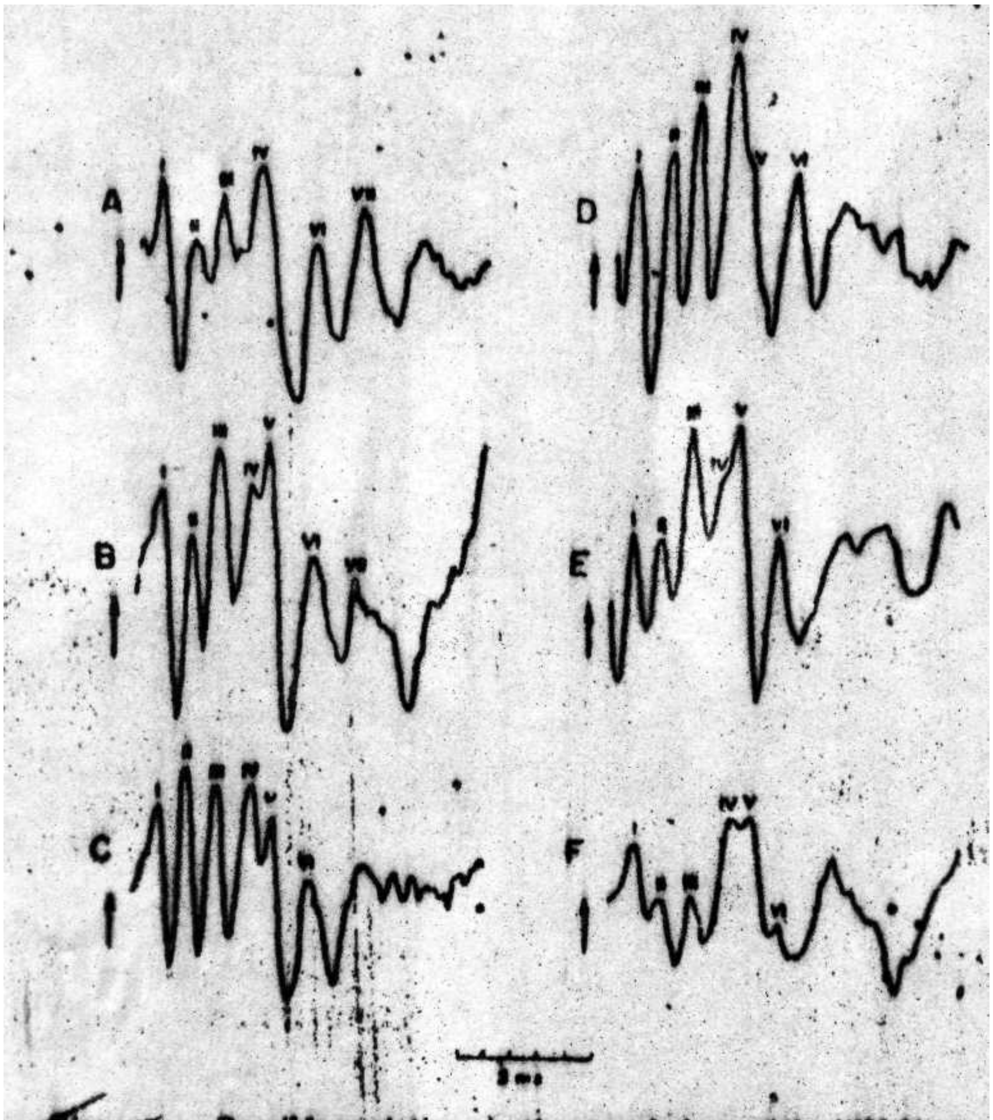


Figure II. Possible variations in the morphology of the "IV-V complex" for normal adult subjects, as reported by Chiappa et al. (1979). The variants (A-F) are based on the separation and relative height of waves IV and V of the ABR. The variants include: (A) a single complex with no separation of waves IV and V; (B) separate waves with V of greater height than IV; (C) separate waves with IV of greater height than V; (D) wave V appearing as an inflection on IV; (E) wave IV appearing as an inflection on V; (F) separate waves of the same height. (From Chiappa et al. 1979.)

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 become increasingly indistinct.

4. Latency of any of these waves is far less variable than response amplitude.

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

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

ARTIFACTS

One of the most frustrating sights during an ERA procedure is to watch an average response slowly building only to be suddenly swamped by an artifact (Satyan, 1984).

Panter and Khovles (1984) report the most frequent disturbances in the determination of BSER are single or multiple large muscle potentials, the result of the patients movements, contraction of the neck muscles, masticating, coughing or swallowing. All these muscle potentials are in the frequency range of BSER (60 to 3 KHz). They are fully amplified in the signal paths. The consequences of these heavy disturbances are an apparent reduction in the amplitudes of the individual waves upto the full obliteration of ABR at low stimulus intensities, or a change in the ABR configuration with simulation of waves in the ABR which do not really exist. All of these effects greatly complicate the identification of the BSER and diminishes its reliability.

Individual subjects differ widely in the morphology of BSER traces. Wave II and wave III may be large or small, wave IV may be larger or smaller than wave V or two may even blend together imperceptibly. At this stage of our knowledge, it is extremely risky to make inferences concerning pathological conditions on the basis of waveform (Dobie 1980).

Vurkek, White and Fong et al (1981) say: Steps must be taken to see that electrical artifacts do not obtrude and obscure the brainstem potentials. The earphone is a very effective generator of radiated electrostatic and electro-magnetic energy. Since the earspeaker is located relatively close to the recording site, the energy it radiates is readily coupled to the recording electrodes to create an electrical artifact. The artifacts waveform will approximate that of the earspeakers input.

Poor electrode contact gives rise to high amplitude noise pick up, this can be verified by observing the unaveraged response trace on the oscilloscope. Electrical instability caused by battery potentials generated across the electrode skin interface can create interference which usually manifests as increased movement artifact and occasionally large baseline swings even when the patient is still (Coats, 1983).

Amplitude values are highly susceptible to noise level and muscle artifact, they are difficult to replicate and can be influenced by miner changes in recording technique (Musiek et al 1984).

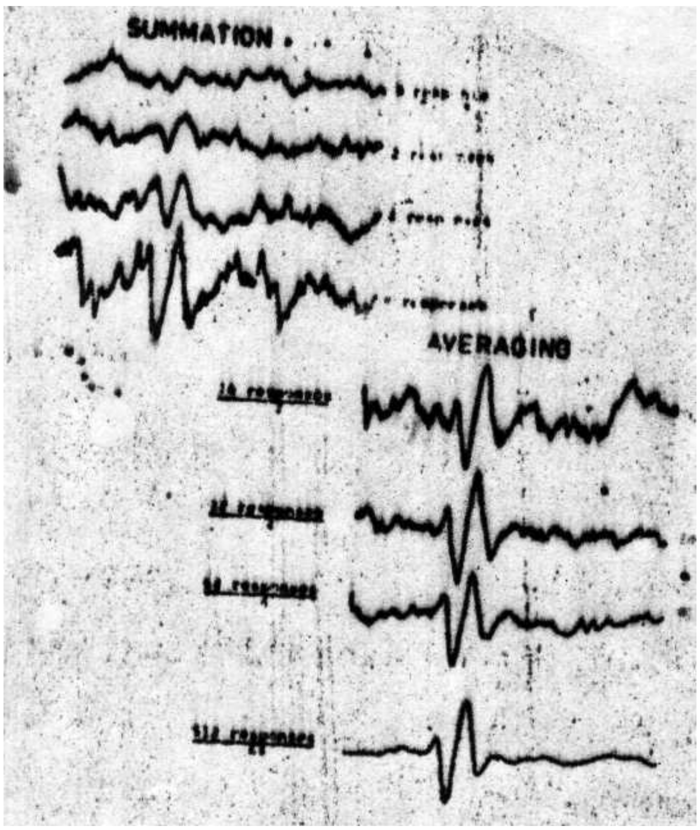
Effects of non-random background noise

According to Coats (1983), if the stimulus rate is an even multiple of the frequency of the non random noise (e.g. 10/sec in the presence of 60 Hz hum), the background noise will"average out" at a slower rate.

Approximate frequency ranges of interfering signals (coats 1983).

Signal	Cut off points (Hz) with 6dB/octave Roll-off	
	Low	High
10 Electrodermal responses	0.01	5
2. Electrode junction potentials EEG	O(DC)	6
3. EEG	0.05	3D
4. Movement potentials	0.05	50
5. 60Hz power line hum	60	6O
6. Muscle potentials (EMG)	10	5 K
7. Stimulus artifact(Square wave)	10	20K
8. Radiated electromagnetic signals	10	20K
9. Internal amplifier noise	0 DC	OO

Fig.2 Illustration of the summation and averaging techniques used for ERA. (adapted from Gibson, WPR., 1978)



ARTIFACT REJECTION:

"Published reports dealing with artifact rejection in the determination of auditory evoked potentials and most of the Commercial artifact rejection systems are based on the same criterion of the EEG signal amplitude exceeding a certain value. They merely represent different technical implementations. At any rate priority should be given to those technical solutions whereby the EEG sweeps disturbed according to the criterion are not included into the averaging." (Panter and Khovles, 1984).

THE AVERAGER:

The averaging process is really at the heart of modern evoked potential techniques (Dobie, 1980).

According to(Dobie (1980) potentials recorded from the scalp are a combination of signal and noise. The noise may be so much larger that the signal is undetectable, but if the electrical activity is recorded in response to a large number of stimuli and these traces are added together algebrically, the signal since it occurs always with the same latency, grows in amplitude. The noise on the other hand is as often positive as negative at any point in time after the stimulus and tends to approach zero.

Figure 2 shows an illustration of the summation of averaging techniques used for electrical response audiometry.

The improvement in the S/N ratio is proportional to N (number of responses averaged) thus to, improve signal detectability by tenfold, an N of 100 is required, however to improve it by another tenfield, we need N = 10,000. If the signal is too small or the noise too large, the averaging process becomes impractical (Dobie, 1980).

Satyan (1984) reports, Mathematically the principle underlying the extraction of a signal from noise by summating techniques is as follows-

The response amplitude of a synchronized response (A) increases in direct proportion to the number of summations (N) i.e.

$$\sum_{i=1}^{N} A_i = A_1 + A_2 + A_3 \ldots A_N = N.A. \text{ ----- I}$$

The Noist (B) will add up according to the r.m.s.values

$$\sum_{i=1}^{N} B_i^2 = \sqrt{B_1^2 + B_2^2 + B_3^2 + \ldots\ldots B_N^2} = B\sqrt{N} \text{ --------II}$$

So by combining I and II, S/N ratio may be calculated as follows:

$$\frac{\sum_{i=1}^{N} A_i}{\sqrt{N \sum_{i=1} B_i^2}} = \frac{NA}{B\sqrt{N}} = \sqrt{N}\,\frac{A}{B}$$

The signal-to-noise ratio has therefore been improved by the square root of N.

DISPLAY

It is important to be able to examine the results of averaging at the time of testing and before a permanent record is made. This information is displayed on an oscilloscope, the advantage being, one can actually see each response building during averaging, often one can spot the sudden baseline fluctuations which occur whan a large transient artifact contaminates the response (Satyan, 1984).

STIMULUS ARTIFACT REJECTION

1. Separating the acoustical transducers from the subject either by stimulating in free field (197l) or by connecting the earspeaker to the patient by a flexible tube (Sohmer and Pratt, 1976).

2. Shielding the earspeaker (Coats, Martin and Kidders, 1979).

ELRCTRODE ARTIFACT

Thornten (1981) noted that it can be resected by using electrode material made of silver. Silver has a low contact potential and further improvement can be made by using a fluid column electrode in which the electrode itself does not touch the skin, the connection being made by a saline solution or electrode jelly. Low frequency noise may be reduced by using a reversible electrode such as silver coated with silver chloride.

Artifact rejection becomes particular important near the auditory threshold, since only wave V of the ABR wave complex can be traced close to the threshold. It could be shown that frequent and/or sufficiently large artifacts can both strongly disturb an existing ABR or even eliminate it, (False negative results) and also simulate non-existent waves of the ABR (false positive results) (Panters and Khovles 1984).

The clinical uses of ABR may be divided conveniently into those attempting neuro-otological diagnosis (Gibson 1978).

As a means of Neuro-otological diagnosis - the maturation of the auditory pathway in premature infants and neonates, BER provides an interesting

Correlate of auditory development: Hecox and Galamboss (1974) have described the development of BER in human subjects and have shown that how the waveform alters during the first few weeks of life. At birth, the latency of the later waves is progressively more delayed compared to the adult BER and only the third and fifth waves are prominent. Over the next threes months, the latency of each of the latter waves shortens until the waveform resembles that of an adult and gradually the other waves of the response become more prominent.

Gibson (1978) reports: BSER offers two clinical services for neonates.

1. Offer a reliable screening test for auditory acuity which is harmless to apply.

2. Can be used to assess the maturity of the infants. The future should bring reports of BER in various abnormalities such as hyper-bilirubinaemia, Mongolism, gargoyliam etc.

Multiple Sclerosis: It is a fairly common disorder affecting mainly young adults. Patchy plaques of demyelination occur in the white matter of the brain and spinal cord and lead to a variety of neurological signs (Gibson, 1978).

Robinson and Rudge (1975) interpreted thirty patients with multiple sclerosis. Several patients had internucleas opthalmo-plegia, but none revealed any hearing loss. Twenty-two of the group of 30 patients showed an abnormal delay of the later waves of the BER, Robinson and Rudge (1977) believe that pairs of click stimuli 5 ats apart, presented at a fast repetition rate stress the auditory system and make the abnormality of the V wave marked in multiple sclerosis.

Gibson (1978) found in a small series of 12 patients that often the V response follows the response by a latency gap of more than 5 msec. The centralateral-ipsilateral recordings may show obvious differences, when compared with normal subjects.

Eigth Nerve Tumours: Four different BER findings have been reported that occur in patients with eighth nerve tumours:

1. Loss of BER wave form following N I:

Selters and Brackmann (1977) have investigated a series of 100 patients clinically suspected of retrocochlear disorders and subsequent investigation showed that 36 had acoustic neuroma, 10 had other retrocochlear tumours and 44 were rumour free. These authors reported that 46% of the tumour group gave pporly developed BER waveforms and the N V was unrecognizable.

2. Latency delay of N V

Selters and Brackmann (1977) noted that 54% of the tumour patients in their series had a recordable NV wave on stimulating the affected ear but this wave often showed a latency delay when compared with the NV produced on stimulating the normal ear. A latency delay of over 0.2 ms was believed to be significant if there was an auditory threshold difference of 0-50dB, 0.3 ms with a difference of 50-66 dB and 0.4 ms with a difference of over 65 dB. Using these criteria) 96 percent of tumours patients were successfully identified and 12 percent of false positive diagnosis were reached.

3. Differences between ipsilateral and contralateral recordings:

Thornton (1974) showed an abnormality of the first wave, when recorded from the ipsilateral side of the head using binaural stimulation and suggested that careful examination of the traces might indicate that the stimulus entering only from the normal contralateral ear was travelling unhindered up the brainstem. He postulated that by comparing the recordings using bilateral and monaural stimulation, it may be possible further to localize the site of dysfunction.

4. Latency delay between the Third and Fifth peaks:

Selters and Brackmann(1977) measured the time elapsing between the N III and N V peak and found significant delays only in those patients with large (over 3 cm diameter) tumours. This may prove to be a useful means of predicting tumour size.

It may be concluded that BER shows promise in the early detection of eighth Nerve Tumours.

MID BRAIN TUMOURS

Starr and Achor(l975) and Starr and Hamilton (1976) reported BER findings in patients with various midbrain tumours. They found that the BER waveform could usually be identified to the level of the site of dysfunction, for instance with tumours above the superior olivary complex I, II and III were identified but IV and V were absent.

OTHER CENTRAL LESIONS

Thronton (1974) reports a fascinating case of a diver who suffered 'the staggers' a vestibular form of decompression sickness during a deep dive using oxygen/helium mixture. The bubbles released from the blood are thought to cause microlssions within the brainstem. When first tested, BER showed an abnormally small N 3 response and an absence of sixth wave. One year latter his BER appeared to be within normal limits.

COMATOSED PATIENTS

Starr and Achor (1975) performed BER investigations on 37 comatosed patients, BER was not altered in respect of latency , in any of the conditions.

BRAIN DEATH

Starr and Achor (1975) have used BER to assess brain death in 20 cases. They found that typically only first wave was obtainable.

As a measure of auditory acuity: This test measures the threshold of the auditory response at the level of the inferior colliculus and higher lesions may upset hearing without being detected by BER methods. Nevertheless, BER indicates the hearing threshold in the vast majority of cases (Gibson, 1973).

The first wave to a click or high frequency tone pip is an excellent audiometric indicator. Davis and Hirsch (1973) report that the threshold of detectability is usually at or below l0dBSL.

Patients with cochlear lesions often show an abnormally rapid change in both intensity/latency function and intensity/amplitude function which may be related to recruitment.

Yamada (1975) cited by Gibson, 1978, shows how eight patients with a conductive hearing loss could be distinguished from normal subjects by the intensity/latency function of the fifth wave.

BSER proves useful in evaluating patients with suspected functional hearing losses. The use of BSER in monitoring brainstem function in neurosurgical procedures or even in obstetrics, can be envisioned. The state of the art will be surely, very different a few years from now. (Dobie, 1980).

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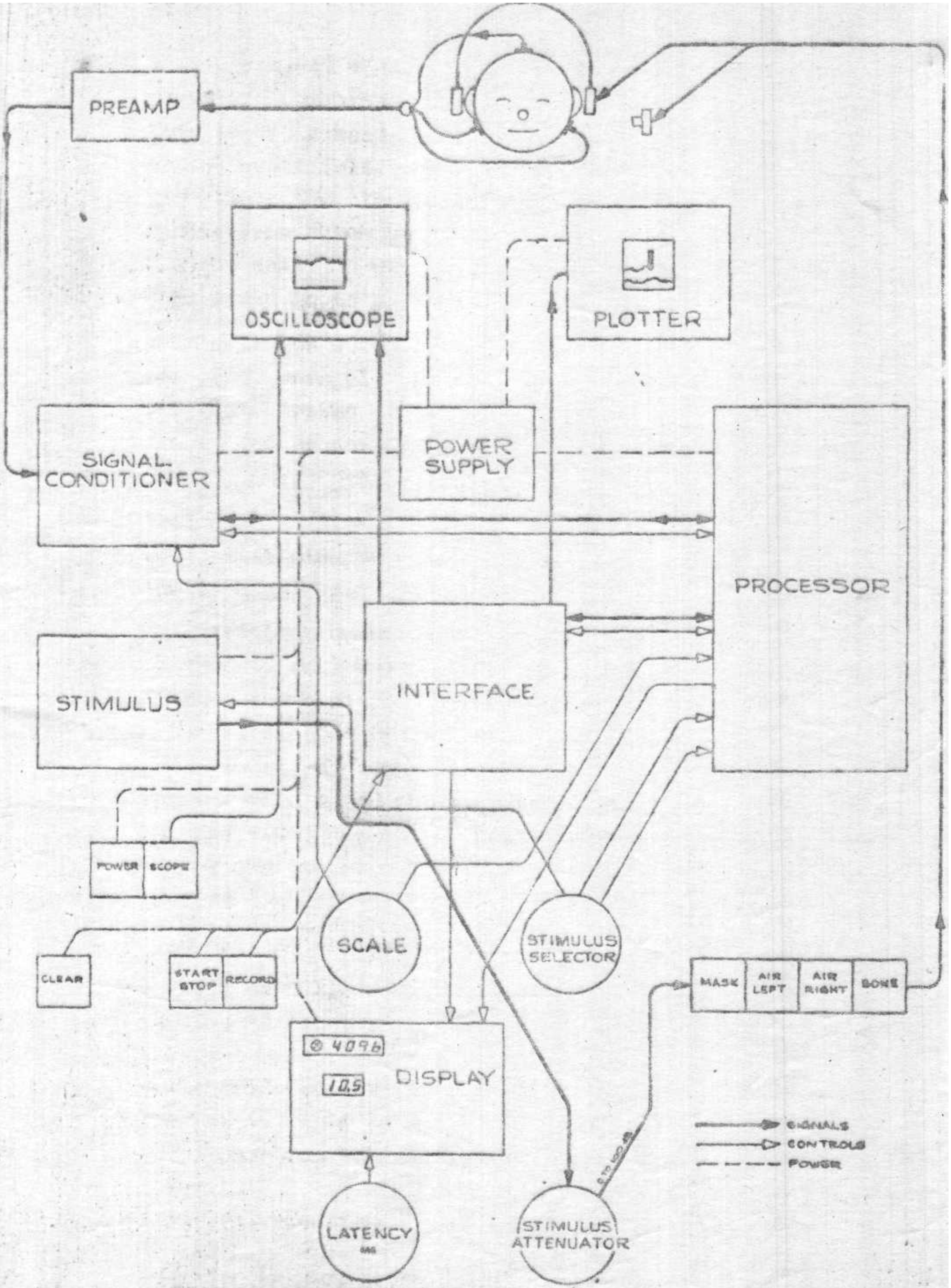

Figure : Flow chart of ERA: TA-1000 used in the present study.

METHODOLOGY

1. SUBJECTS

Fourteen normal hearing (7 males and 7 females) subjects with the age range of 18 to 22 years (mean age 19.9 yrs) seven males with mean age 19.8 years and seven females with mean age 19.9 years were selected for this study. All the subjects had normal hearing ($\leq$ 15 dB HTL ANSI 1969). 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 be able to relax and feel comfortable with electrodes on, within 10-15 minutes after their placement.
3. They should not have had any history of epilepsy or other neurological complaints.
4. Their electrophysiological input should come below 500 microvolts within 10-15 minutes after electrode placement.

II. EQUIPMENT

The equipment used was, electric Response Audiometry, model TA - 1000.

Brief Description of the instrument

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

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

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

Accessory group used was :-

1. A binaural air-conduction head set with cord set.
2. Inter connecting cables, chart paper and pens.
3. Sets of electrodes, electrolyte gel and electrode adhesive pad was substituted by Johnsonplast,

CONTROLS AND THEIR FUNCTION

The TA-1000 is operated with only (l) four knobs and (2) nine push button switches. All knobs are clearly marked to indicate their function.

1. Four knobs

The stimulus function switch permits selection of 2 KHz 4 KHz or 6 KHz acoustic log on stimulus equivalent frequences.

at repetition rate of 3 or 20 stimuli per second and patient response intervals of 10 ms or 20 ms 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 MY, 2 MV and 5 MV/division sensitivities are available. For 2048 samples 0.2 MV, 0.5 MV, 1 MV and 2 MV/division sensitivities are available. For 4096 samples, 0.1 MV, 0.2 MY, 0.5 MV and 1 MV/division sensitivities are available.

4. TA-1000 has a calibrated latency cursor, whieh 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.

(2) Push Button Switches

1. Power switch energizes the system and indicate the system status.

2. Scope switch controls the oscilloscope display.

3. Clear Push-button clears the micro-processor averages memory, resets the sample display counter and corrects the micro-processor operating node to correspond to the current control status.

4. Start/stop push button initiates the microprocessor average function. The average 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 plotter readout.

6. Mask Push-button applies broad-band noise masking to the contralateral ear only when either Air left or Air Right stimulus is active.

7. Air Left applies the stimulus to the desired earphone.

8. Air Right applies the stimulus to the desired earphone.

9. Bone, Push-button applies the stimulus to the bone-vibrator transducers.

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/briefly/light to indicate the presence of excess input to the system.
(3) The TWF/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 EEG activity, the raw signal from which the averaged response is desired.

III. 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 A.C. current was cannalized to I.T.L. Model SVS-200L Stabilizer with input 170-270 volts and output of 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 treated 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. 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 also checked for its proper position. The tubular penholder was uncapped.

Instructions: The subjects were instructed to lie in relaxed recumbent position on an examination table which was covered by a cushion bed and a pillow. Subjects were briefed with the information that the electrodes would be placed and then earphones from which he could hear click like sounds. The subjects were not sedated. They were told to be in a relaxed state and then they could go to sleep.

Electrodes: They were checked with a gentle tug on both both ends. They were cleaned with cotton soaked in rectified spirit (electrodes are of solid sterling silver).

Cotton soaked in rectified spirit was briskly rubbed on the skin areas 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 electrolyte gel was placed on the electrodes to fill the recess in the electrodes to the 'slightly rounded condition and to get applied to the skin. Electrodes were placed on the previously cleaned areas, pressing slightly. The excess of paste which oozed out from the electrode holes and sides was cleaned with dry cotton. Then Johnson adhesive paste was used to hold the electrodes into firm contact all around.

Electrode placement was as follows:

Red: (+) signal,to high forehead.

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

Black: ground, at left mastoid of the nontest ear.

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 electrode cable, plug into the corresponding preamplifier receptacle (they have a blue colour code).

Preamplifier and the ERA were interconnected by means of the cable and receptacles which are colour coded (yellow).

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

Experiment was performed at three different settings for ERA.

(A) First ten waveforms of ongoing EEG were taken at random intervals. ERA was set as follows:

1. Power Push button switch pressed.
2. TWF/RUN/EEG was kept on EEG.
3. Scope push button switch pressed, to get an oscilloscope display of the ongoing electrical activity.
4. At random intervals, Record push button switch pressed to get a graphic readout.

(B) Second setting BSER (with stimuli) - ERA was set as follows:

1. TWF/RUN/EEG was kept on RUN
2. Stimulus frequency on 2 KHz or 4 KHz, 20 pulses per second and 10 Ms sample time.
3. The scale switch on 2048 samples and 0.2 MV/D.V
4. Stimulus intensity 80 dB HL.
5. CLEAR was pressed and then AIR RIGHT or AIR LEFT as desired by the Investigator.

Four BSER waveforms were taken for each subject at two frequencies (2 KHz and 4 KHz) at a single intensity (80 dB HL) in right and left ear respectively.

(C) Third setting for Averaged ongoing electrical activity (without stimulus).

ERA was set as follows:

1. TMF/RUN/EEG was kept on /RUN/.
2. Stimulus function switch kept at a repetition rate of SO stimuli per second.
3. Scale function switch kept at 2048 samples for averaging.
4. Start stop push button pressed to initiate the microprocessor average function.
5. Scope push button switch pressed, to get an oscilloscope display.
6. Record push button switch pressed, to get a graphic readout after the completion of 2048 samples, 20 times/sec.

For remaining three waveforms recorded at 2048 samples, 5 stimuli/sec and 1024 samples, 20 stimuli/sec, and 1024 samples 5 stimuli/sec, the relative positions of the stimulus function switch and scale function switch were altered according to the parameter which is being recorded. Rest of the setting was the same.

Thus fourwaveforms of averaged ongoing electrical activity (without stimuli) were obtained.

Daring the process of experiment, following things were noted down:

1. Change in the ongoing EEG 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 predetermined number of samples.
4. Motor movements of the subjects and the subsequent effect on the waveform.
6. In one subject, the sensitivity had to be changed to .5 MV to get the required waveform for one ear (left ear).

Artifacts were found by comparing the BSER waveform and the averaged (without stimuli) waveforms (ongoing electrical activity). The BSER waveforms (with stimuli) differed from those by the averaged (without stimuli) waveforms markedly. In addition to this the factors which affected the BSER waveform during the process of experiment were taken into account.

I to VII Peak latency readings were noted from the graph for BSER.

Amplitude of BSER was determined for V, VI and VII wave to To determine the amplitude in microvolts (MV), the marker amplitude M was noted down either in l, 2 or 4 divisions. And amplitude of wave V, VI and VII were noted down. Max. value 4 divisions. Scale switch amplitude S was .2 MV/div.

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

T = 2.5

M = 2.0

S = 0.2

Amplitude =TS/ M = 2.5 x.3

2

= .25

All the subjects were tested in the same manner.

***

RESULTS AND DISCUSSION

EEG - In this experiment, EEG is taken to be equivalent to ongoing background electrical activity and it was sought to see whether there is any relationship between the brainstem evoked response and the ongoing REG activity.

REG was obtained from fourteen subjects (7 males and 7 females, age ranging from 18 to 22 years. Ten EEG patterns were obtained from each subject, at random. These EEG patterns were obtained during the initial phase of testing in most of the subjects.

Ongoing background electrical activity is more in amplitude druing the recording of first few patterns but as soon as the subjects were completely relaxed, during the passage of time, the latter patterns obtained resembled quieter ongoing electrical activity.

In the presence of some attention seeking stimuli like/loud sounds disturbances in the testing environment etc.) resulted in the increase in the amplitude of background electrical activity. This was observed in every subject (Both males and females).

Due to biophysical induced artifacts, the EEG patterns grew in amplitude and were markedly different from the quieter patterns. The biophysical induced artifacts were the result of the patients movements, contraction of the neck muscles, coughing.

These biophysical artifacts can as well affect the auditory brainstem response.

During myogenic disturbances, the preamplifier light would glow, indicating that the subject is not relaxed and at that time, the background activity resulted in increase in amplitude.

It was found that the amplitude of the evoked response was reduced with the amplitude of the ongoing EEG activity and was increased when the amplitude of the ongoing EEG activity was increased.

EEG activity in case of females was more than in the case of males but this was not observed in all the subjects of either sex.

ARTIFACTS:

For finding artifacts in brainstem evoked response audiometry, averaging of the background bioelectrical activity was done at 2048 samples 20 times/sec and 5 times/sec and l024 samples 5 times/sec and 20 times/sec. Four averaged waveforms of background ongoing electrical activity were thus obtained, (i.e. no stimulus was presented through the earphones).

1. (a) Marker height (M): In case of four female subjects it is more than one in all the samples (i.e. 2048 & 1024) at

20 times/sec and 5 times/sec). When it is one as seen in three subjects at 1024 samples, 5 times/sec and in one subject at 1024 samples, 20 times/sec., it tends to resemble the BSER waveform. In all these cases were marker height was one,the preamplifier light would glow indicating that the subject is not relaxed or indirectly the presence of biophysical artifacts. These muscle potentials are in frequency range of the ABR (60 to 3 KHz) and the consequences of these heavy disturbances can result in the simulation of waves similar in configuration to those obtained in the ABR, which do not really exist.

(b) Marker height (M) - Males - Marker height is more than one in all the samples for five subjects (i.e. 2048 and 1024 at 20 times per sec. and 5 times per sec). It is one at 1024 samples, 5 times per sec. in case of two subjects and one at 1024 samples, SO times per sec. in case of one subject. When it is one, the ongoing bioelectrical activity is affected by muscle artifacts and tends to simulate the BSERA waveform configuration.

When the marker height was more than two, the multiple peaks were obtained in the averaged ongoing electrical activity waveform indicating that the computer has not efficiently averaged the background electrical activity.

Marker height in case of BSERA (i.e. when logon stimuli was Presented:

In all female subjects, marker height is one for (Rt.ear 80 dB at 2 KHz and 4 KHz, left ear 80 d3 at 2 KHz and 4 KHz).

In male subjects, marker height is one in three subjects in both ears and at both frequencies (2 KHz and 4 KHz), in one subject it is two in all the waveforms. In remaining three subjects, marker height is two excepting at Lt, ear 80 dB, 2 KHz, Rt. ear 80 dB 4 KHz, Rt. ear 80 dB 2 KHz where it is one.

From this we come to an understanding that for BSER, marker height is usually one and does not exceed two, when it exceeds two, the computer might not have efficiently averaged and can serve as an artifact, while evaluating the BSERA waveform. Also the bipphysical artifacts can complicate the identification of the ABR and diminish its reliability.

2. Stopping of the number of samples before reaching the programmed number (2048 samples or 1024 samples).

ABR_: In case of two female subjects, the sampling stopped at 1460, 930 for right ear and for Lt. ear 174, 464, 422. In the case of second subject, it stopped at 1429,1818 samples in right ear at 2 KHz and at 4 KHz, it stopped at 1786 samples in right ear. The remaining five subjects, the sampling for ABR was done to the predetermined levels.

In case of one male subject, the sampling stopped at 1719 for left ear, in the remaining six subjects, no such phenomenon was observed.

This means that computer is not able to sweep through all
and
the memory bins/can be an instrument artifact, but when sensitivity of the instrument is increased from 0.2 to 0.5, 2048 samples for ABR are obtained but peaks are not at all clear.

3. Comparison of the averaged ongoing bioelectric patterns and the BSER waveforms.

In case of BSERA in females, all the waveforms at (Rt, ear 80 dB 2 KHz, Rt. ear 80dB 4KHz and Lt. ear 30 dB 2 KHz and Lt. ear 80 dB 4 KHz) are rising upwards towards the end of the graph excepting two female subjects at 80 dB 4 KHz in Lt. ear, the wavefroms move downwards towards the end of the graph and in one at 80 dB, 2 KHz in Lt. ear at 0.5 sensitivity, the waveform moves downwards towards the end of the graph.

In case of BSER in males, all the waveforms are rising upwards towards the end of the graph excepting in case of one subject in left ear at 80 dB at 2 KHz it moves downwards towards the end of the graph.

The averaged ongoing bioelectric patterns in case of females, moves downwards towards the end of the graph for all recordings (2048 samples at 20/sec and 5/sec and 1024 samples at 20/sec and 5/sec) in four female subjects and in the remaining three subjects the patterns are rising upwards for 2048 samples, 5 times/sec, in one subject. In the other, they are rising upwards for 2048, 1024 samples 5/sec and in third one, the same case is seen with 2048, 1024 samples 20/sec. However, it is seen that in most subjects, the ongoing averaged pattern moves downwards towards the end of the graph.

In case of male subjects, though the patterns do not resemble for all males but the frequency of occurence of the averaged ongoing pattern moving downwards towards the end of the graph is higher.

From this, we can deduce an artifact, that while evaluating BSER waveforms, if the waveforms does not rise upwards towards the end of the graph, it should be carefully looked upon or repeated testing should be done to ensure oneself of the results.

4. Recording artifact: In one female subject, the visual oscilloscope display and the graphic display ,did not correlate, out on pressing the record for the second time in the same subject, for the same waveform correct graphic display was obtained.

5. Amplitude values for BSERA are highly susceptible to muscle artifacts - these amplitude values are difficult to replicate and can be influenced by minor changes in the recording technique.

This was seen in several subjects both males and females, especially while doing BSERA, due to biophysical induced artifacts (motor movement), preamplifier and limit will glow and the amplitude values for different waves tends to be affected.

6. One repeating the averaged ongoing activity, for different values like 2048 samples 20/sec and 5/sec and 1024 samples 20/sec and 5/sec. It was seen that the waveform obtained was different in each case, that means from time to time background electrical activity varies and is not constant over a period of time. This was seen in both males and females.

7. Correlation between the peaks of BSERA and the averaged ongoing electrical activity:

This was seen in atleast three females and two males, In two female subjects, the third peak in both the cases approximately occured at the same latencies and in one female, the latencies of V peak were seen to coincide with that of the peak in the averaged ongoing activity. In male subjects, also V peak of BSERA was seen to occur approximately at the same latency as that of averaged ongoing electrical activity peak. From this we must draw a caution while inferring the BSERA results.

It appears that the background activity is more sensitive to those sources including "State" while the BSERA is more sensitive to those sources including "Signal-strength,"

8. Peak II, VII and VI in many cases both males and females are not visible in the BSERA waveform. They are easily obliterated.

9. BSER seen in Bilateral profound hearing loss cases revealed following findings:

(a) Marker height was more than two.

(b) BSER waveforms resembled averaged ongoing electrical activity with multiple peaks.

(c) Presence of muscle artifacts during testing, can result in the peaks which simulate those of actual BSER peaks and hence may give rise to false-positive results.

The ongoing electrical activity patterns, the artifacts in some of the subjects and some of the typical BSER waveforms are shown in the graphs.

The data about Absolute Latency (I to VII) peaks and Absolute amplitude of (VI and VII) peaks and their means for 2 KHz and 4 KHz in right and left ear at 80 dB HL are shown in Tables 1-17.

The percentage of normal hearing subjects (males and females) who show readable II, VI and VII peaks is shown in the tabular form (Table 18 (a), (b) and (c).

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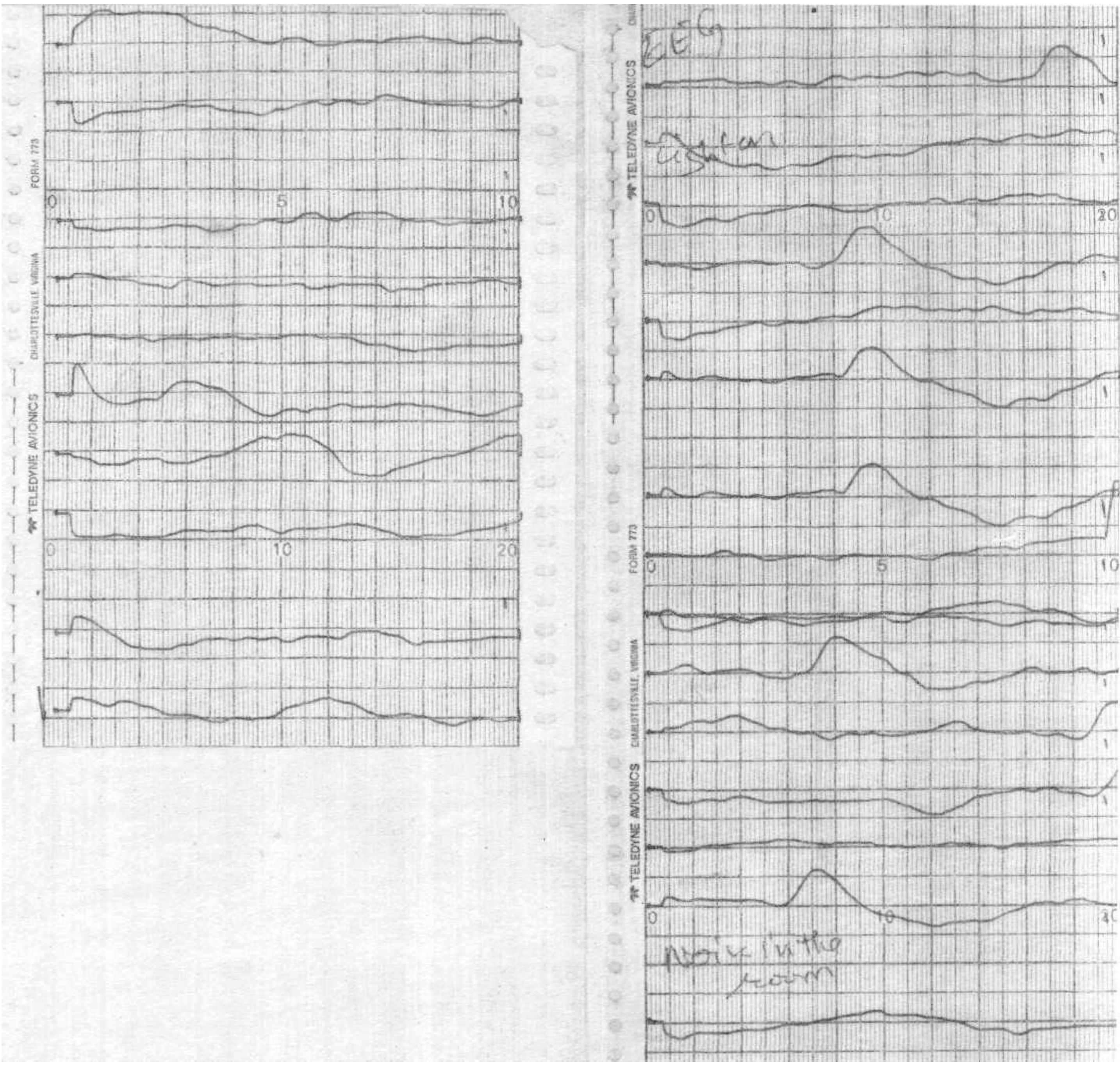
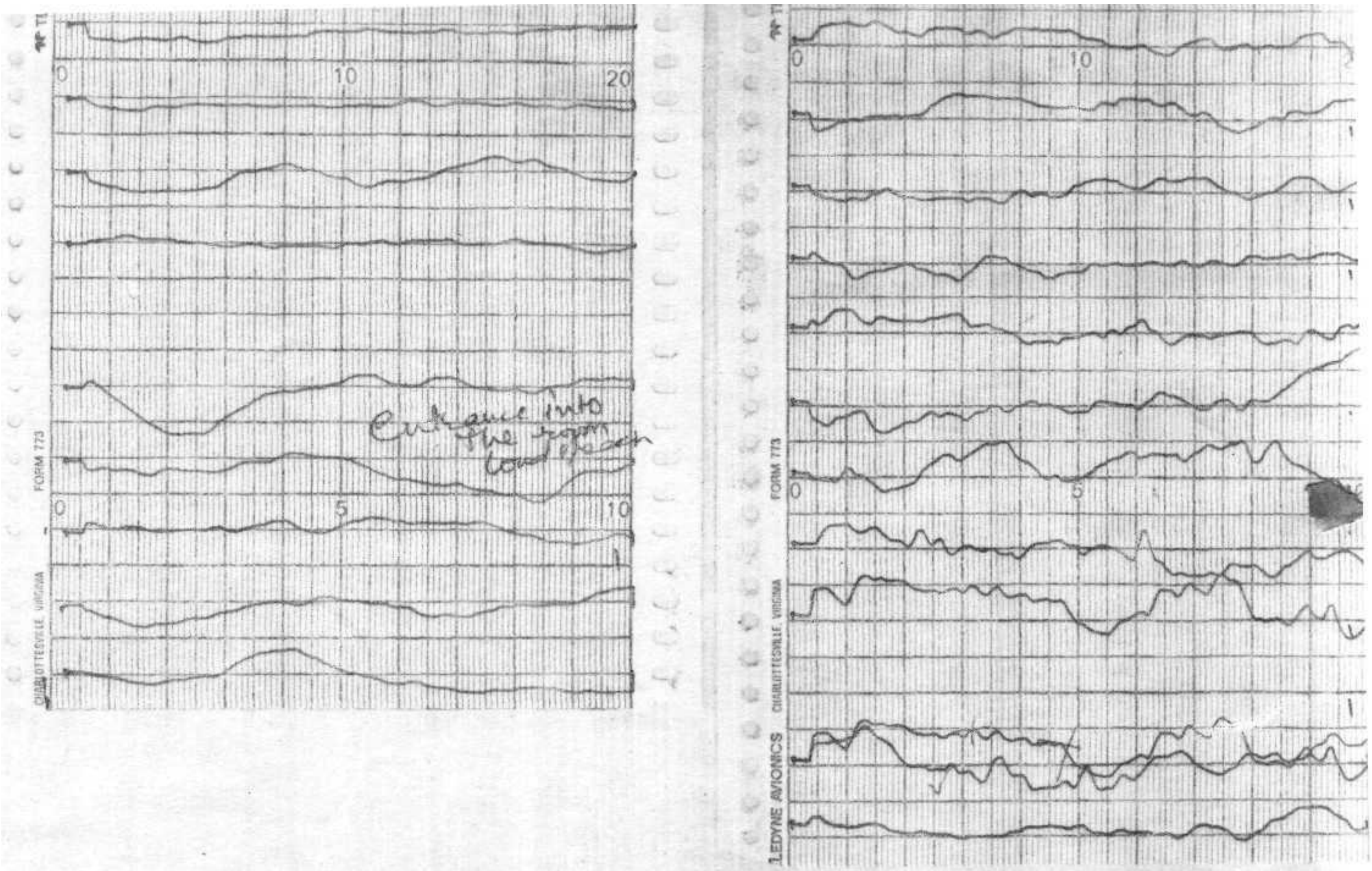
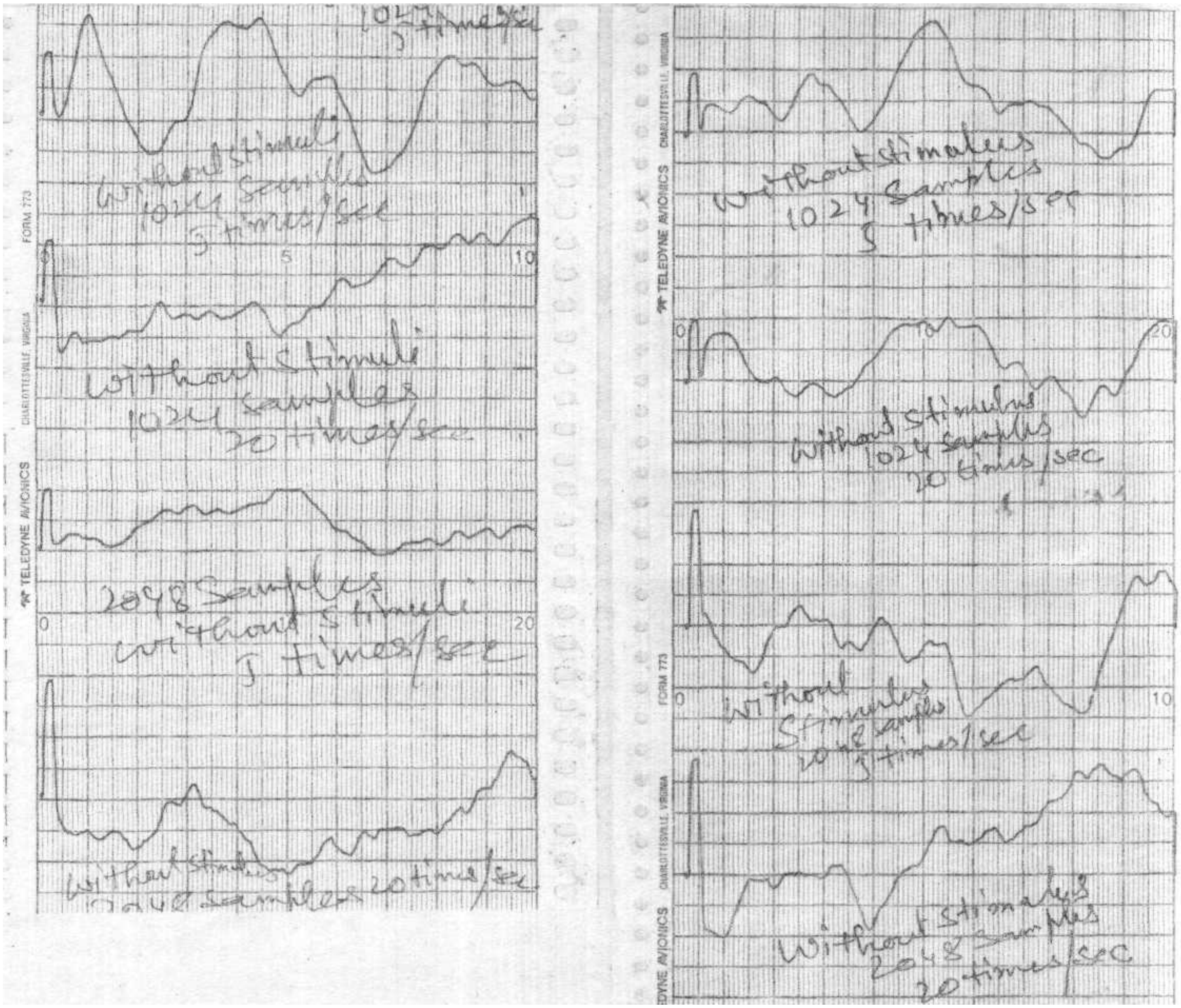
%



Ongoing background electrical activity in two of the normal hearing subjects in this study.



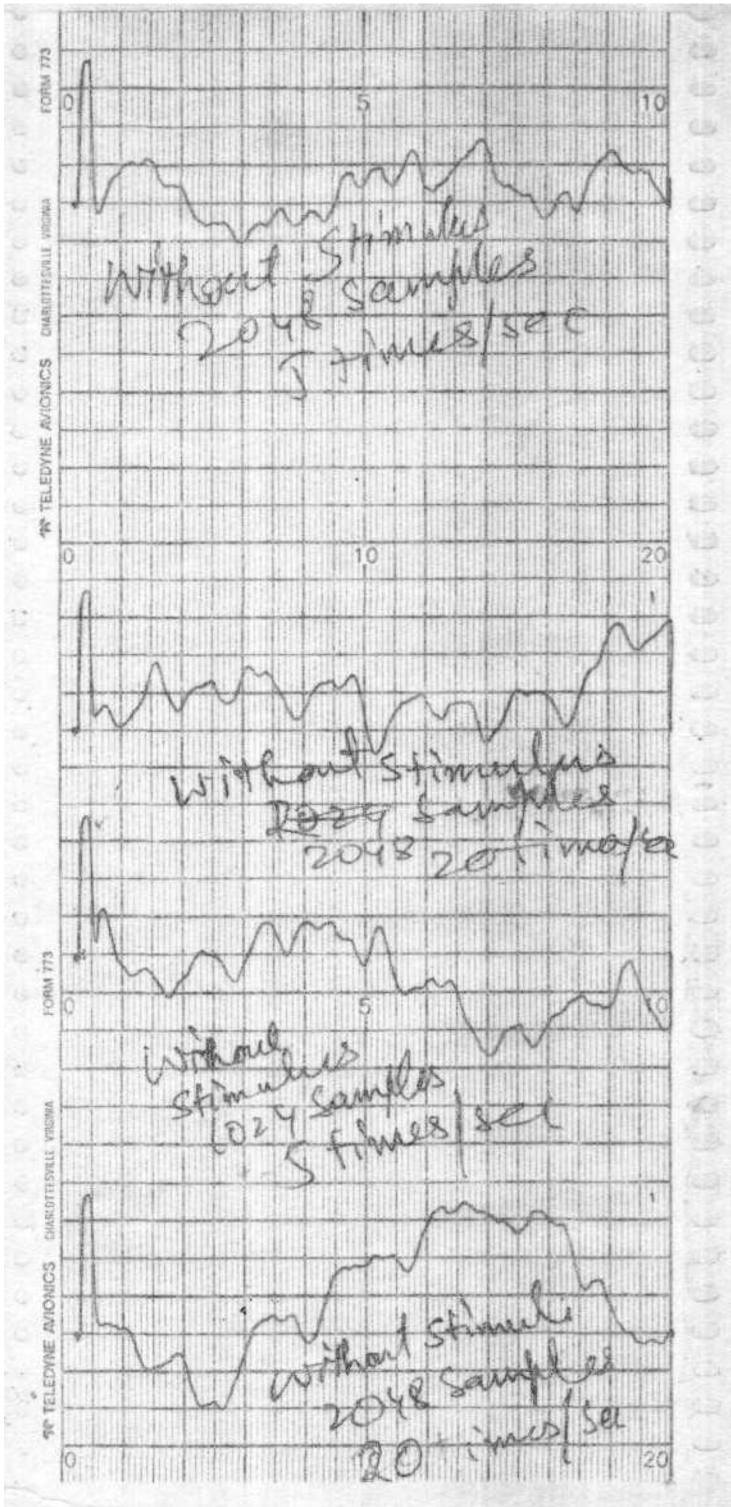
Ongoing background electrical activity in two of the normal hearing subjects in this study.



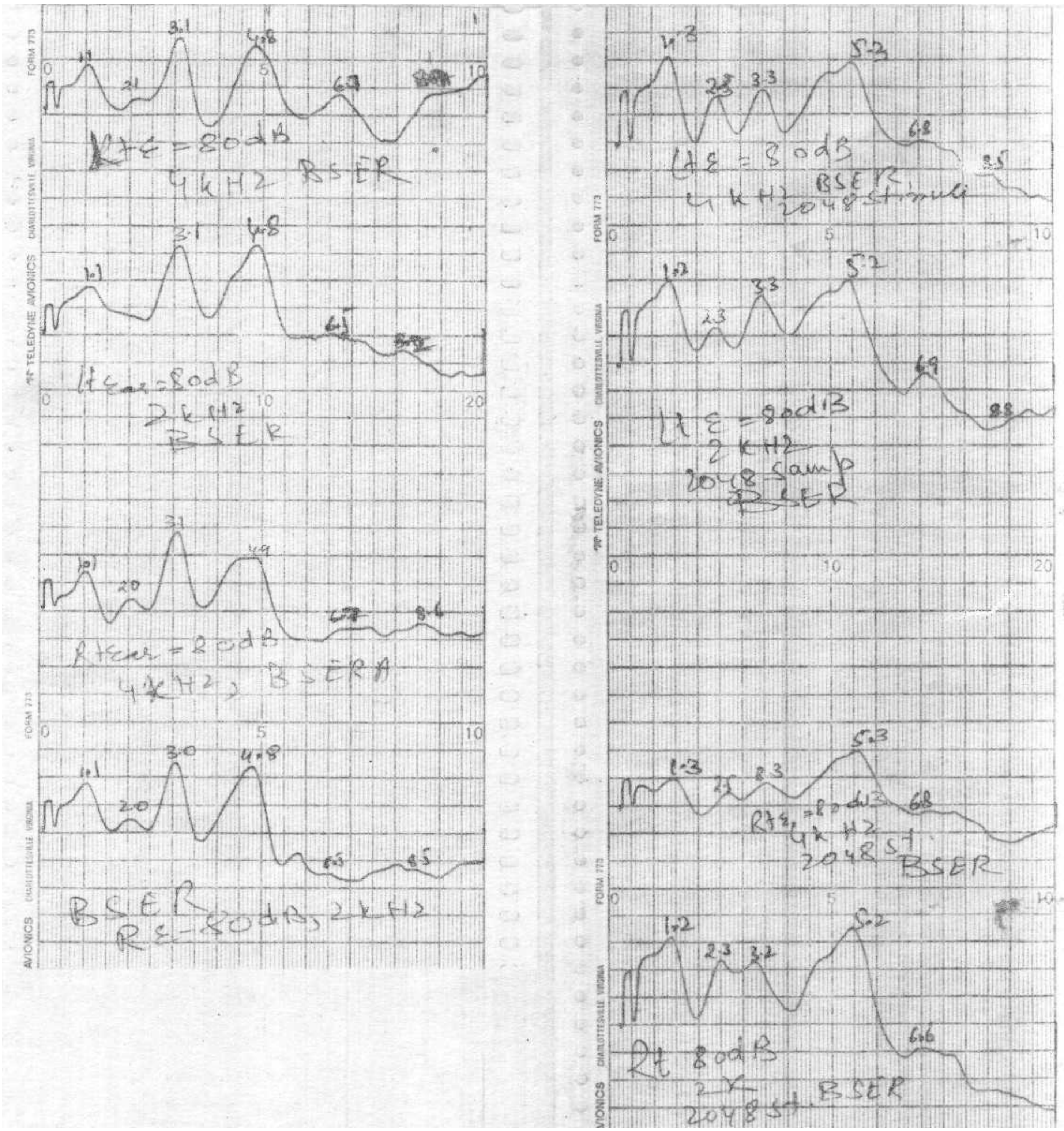
Averaged ongoing electrical activity (without presenting any stimulus through earphones) in tvo of the normal hearing subjects in this study.

ARTIFACTS:

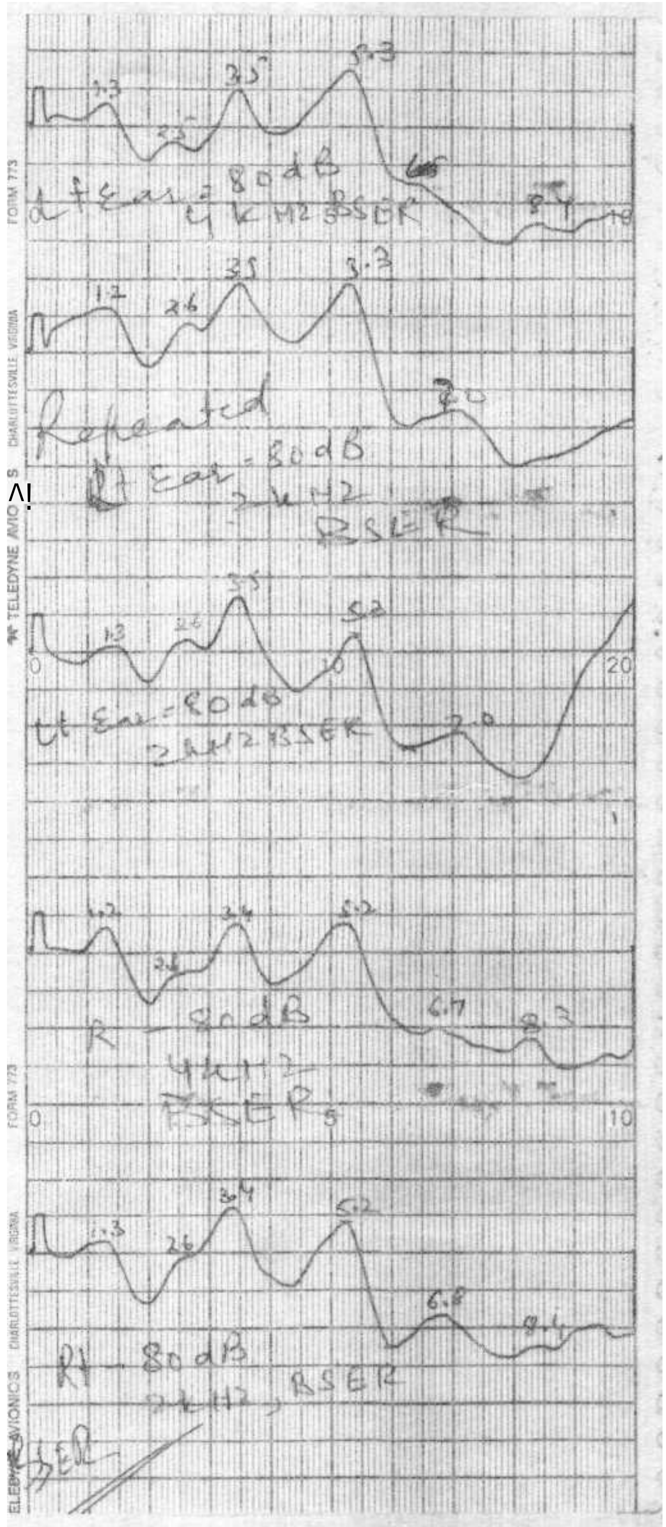
1. Recording artifact
2. Stopping of the samples before reaching the predetermined number.
3. Averaged ongoing electrical activity (without stimulus)



Averaged ongoing electrical activity (without stimulus) in one of the normal hearing subjects in this study.



BSER traces for two of the normal hearing subjects at 80dB HL for 2 KHz and 4 KHz in this study.



Typical BSER pattern for one of the normal hearing subjects at 80dB HL Logan stimuli for 2 KHz & 4 KHz in this study.

Sl.No of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.5	3.4	5.3	6.8	8.8	1.3	2.4	3.5	5.4		
2	1.2	2.3	3.4	5.0	-	8.4	1.3	2.3	3.5	5.4	6.8	
3	1.1	-	3.2	4.9	6.5	8.7	1.1	2.4	3.2	4.9	6.6	
4	1.3	2.1	3.3	4.9	6.3	-	1.3	2.3	3.3	4.9	6.5	
5	1.2	2.3	3.2	5.2	6.6	-	1.3	2.5	3.3	5.3	6.8	
6	1.6	-	3.4	5.5	6.6		1.6	-	3.5	5.5	.	
7	1.2	2.0	3.5	5.3	-	-	1.1	2.0	3.5	5.2	6.8	

TABLE l: Absolute Latency Values for males for Right Ear at 80dB stimuli.

SL.No. of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.6	3.3	5.3	6.8	-	1.3	2.4	3.4	5.3	6.9	0.7
2	1.3	2.2	3.4	5.3	-	-	1.2	2.1	3.4	5.4	6.5	-
3	1.2	-	3.2	4.9	6.7	-	1.2	2.1	3.3	5.0	6.6	8.5
4	1.3	2.1	3.3	4.9	6.3	-	1.4	-	3.3	5.0	6.2	8.5
5	1.2	2.3	3.3	5.2	6.9	-	1.3	2.3	3.3	5.3	6.8	8.5
6	1.4		3.4	5.3	6.4	-	1.5	-	3.6	5.4	-	-
7	1.2	2.0	3.5	6.4	6.8	-	1.2	2.0	3.5	5.0	6.8	-

TABLE 2: Absolute Latency Value for males for Left ear at 80dB Stimuli

SOL.No.of Subjects	Frequency 2KHz VI	VII	Frequency 4 KHz VI	VII
1	0.15	0.15	-	-
2	-	0.35	0.22 -	
3	0.35	0.30	0.22 -	
4	0.37	-	0.45 -	
5	0.20	-	0.10 -	
6	0.12		-	-
7	0.24	-	--	

TABLE 3: Absolute Amplitude Values for VI and VII Males for Right Ear at 80 dB stimulus.

Sl.No. of subjects	Frequency 2 KHz		Frequency 4 KHz	
	VI	VII	VI	VII
1	0.45 -		0.275	0.07
2	-	-	0.140	-
3	0.30 -		0.350	0.20
4	0.22 -		0.310	0.31
5	0.19 -		0.125	0.08
6	0.20 -		-	0.20
7	0.20 -		0.300	

TABLE 4: Absolute Amplitude Values for VI and VII for males for Left Ear at 80 dB Stimuli.

Sl.No of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.5	3.4	5.3	6.8	8.8	1.3	2.4	3.5	5.4		
2	1.2	2.3	3.4	5.0	-	8.4	1.3	2.3	3.5	5.4	6.8	
3	1.1	-	3.2	4.9	6.5	8.7	1.1	2.4	3.2	4.9	6.6	
4	1.3	2.1	3.3	4.9	6.3	-	1.3	2.3	3.3	4.9	6.5	
5	1.2	2.3	3.2	5.2	6.6	-	1.3	2.5	3.3	5.3	6.8	
6	1.6	-	3.4	5.5	6.6		1.6	-	3.5	5.5	.	
7	1.2	2.0	3.5	5.3	-	-	1.1	2.0	3.5	5.2	6.8	

TABLE l: Absolute Latency Values for males for Right Ear at 80dB stimuli.

SL.No. of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.6	3.3	5.3	6.8	-	1.3	2.4	3.4	5.3	6.9	0.7
2	1.3	2.2	3.4	5.3	-	-	1.2	2.1	3.4	5.4	6.5	-
3	1.2	-	3.2	4.9	6.7	-	1.2	2.1	3.3	5.0	6.6	8.5
4	1.3	2.1	3.3	4.9	6.3	-	1.4	-	3.3	5.0	6.2	8.5
5	1.2	2.3	3.3	5.2	6.9	-	1.3	2.3	3.3	5.3	6.8	8.5
6	1.4		3.4	5.3	6.4	-	1.5	-	3.6	5.4	-	-
7	1.2	2.0	3.5	6.4	6.8	-	1.2	2.0	3.5	5.0	6.8	-

TABLE 2: Absolute Latency Value for males for Left ear at 80dB Stimuli

Sl. No. of Subjects	Frequency 2KHz VI	Frequency 2KHz VII	Frequency 4 KHz VI	Frequency 4 KHz VII
1	0.15	0.15	-	-
2	-	0.35	0.22 -	
3	0.35	0.30	0.22 -	
4	0.37	-	0.45 -	
5	0.20	-	0.10 -	
6	0.12		-	-
7	0.24	-	--	

TABLE 3: Absolute Amplitude Values for VI and VII Males for Right Ear at 80 dB stimulus.

Sl.No. of subjects	Frequency 2 KHz		Frequency 4 KHz	
	VI	VII	VI	VII
1	0.45 -		0.275	0.07
2	-	-	0.140	-
3	0.30 -		0.350	0.20
4	0.22 -		0.310	0.31
5	0.19 -		0.125	0.08
6	0.20 -		-	0.20
7	0.20 -		0.300	

TABLE 4: Absolute Amplitude Values for VI and VII for males for Left Ear at 80 dB Stimuli.

Sl.No of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.5	3.4	5.3	6.8	8.8	1.3	2.4	3.5	5.4		
2	1.2	2.3	3.4	5.0	-	8.4	1.3	2.3	3.5	5.4	6.8	
3	1.1	-	3.2	4.9	6.5	8.7	1.1	2.4	3.2	4.9	6.6	
4	1.3	2.1	3.3	4.9	6.3	-	1.3	2.3	3.3	4.9	6.5	
5	1.2	2.3	3.2	5.2	6.6	-	1.3	2.5	3.3	5.3	6.8	
6	1.6	-	3.4	5.5	6.6		1.6	-	3.5	5.5	.	
7	1.2	2.0	3.5	5.3	-	-	1.1	2.0	3.5	5.2	6.8	

TABLE l: Absolute Latency Values for males for Right Ear at 80dB stimuli.

SL.No. of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.6	3.3	5.3	6.8	-	1.3	2.4	3.4	5.3	6.9	0.7
2	1.3	2.2	3.4	5.3	-	-	1.2	2.1	3.4	5.4	6.5	-
3	1.2	-	3.2	4.9	6.7	-	1.2	2.1	3.3	5.0	6.6	8.5
4	1.3	2.1	3.3	4.9	6.3	-	1.4	-	3.3	5.0	6.2	8.5
5	1.2	2.3	3.3	5.2	6.9	-	1.3	2.3	3.3	5.3	6.8	8.5
6	1.4		3.4	5.3	6.4	-	1.5	-	3.6	5.4	-	-
7	1.2	2.0	3.5	6.4	6.8	-	1.2	2.0	3.5	5.0	6.8	-

TABLE 2: Absolute Latency Value for males for Left ear at 80dB Stimuli

SL.No.of Subjects	Frequency 2KHz VI	VII	Frequency 4 KHz VI	VII
1	0.15	0.15	-	-
2	-	0.35	0.22 -	
3	0.35	0.30	0.22 -	
4	0.37	-	0.45 -	
5	0.20	-	0.10 -	
6	0.12		-	-
7	0.24	-	--	

TABLE 3: Absolute Amplitude Values for VI and VII Males for Right Ear at 80 dB stimulus.

Sl.No. of subjects	Frequency 2 KHz		Frequency 4 KHz	
	VI	VII	VI	VII
1	0.45 -		0.275	0.07
2	-	-	0.140	-
3	0.30 -		0.350	0.20
4	0.22 -		0.310	0.31
5	0.19 -		0.125	0.08
6	0.20 -		-	0.20
7	0.20 -		0.300	

TABLE 4: Absolute Amplitude Values for VI and VII for males for Left Ear at 80 dB Stimuli.

Sl.No of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.5	3.4	5.3	6.8	8.8	1.3	2.4	3.5	5.4		
2	1.2	2.3	3.4	5.0	-	8.4	1.3	2.3	3.5	5.4	6.8	
3	1.1	-	3.2	4.9	6.5	8.7	1.1	2.4	3.2	4.9	6.6	
4	1.3	2.1	3.3	4.9	6.3	-	1.3	2.3	3.3	4.9	6.5	
5	1.2	2.3	3.2	5.2	6.6	-	1.3	2.5	3.3	5.3	6.8	
6	1.6	-	3.4	5.5	6.6		1.6	-	3.5	5.5	.	
7	1.2	2.0	3.5	5.3	-	-	1.1	2.0	3.5	5.2	6.8	

TABLE l: Absolute Latency Values for males for Right Ear at 80dB stimuli.

SL.No. of Subjects	Frequency 2 KHz						Frequency 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.6	3.3	5.3	6.8	-	1.3	2.4	3.4	5.3	6.9	0.7
2	1.3	2.2	3.4	5.3	-	-	1.2	2.1	3.4	5.4	6.5	-
3	1.2	-	3.2	4.9	6.7	-	1.2	2.1	3.3	5.0	6.6	8.5
4	1.3	2.1	3.3	4.9	6.3	-	1.4	-	3.3	5.0	6.2	8.5
5	1.2	2.3	3.3	5.2	6.9	-	1.3	2.3	3.3	5.3	6.8	8.5
6	1.4		3.4	5.3	6.4	-	1.5	-	3.6	5.4	-	-
7	1.2	2.0	3.5	6.4	6.8	-	1.2	2.0	3.5	5.0	6.8	-

TABLE 2: Absolute Latency Value for males for Left ear at 80dB Stimuli

SOL.No.of Subjects	Frequency 2KHz VI	VII	Frequency 4 KHz VI	VII
1	0.15	0.15	-	-
2	-	0.35	0.22 -	
3	0.35	0.30	0.22 -	
4	0.37	-	0.45 -	
5	0.20	-	0.10 -	
6	0.12		-	-
7	0.24	-	--	

TABLE 3: Absolute Amplitude Values for VI and VII Males for Right Ear at 80 dB stimulus.

Sl.No. of subjects	Frequency 2 KHz		Frequency 4 KHz	
	VI	VII	VI	VII
1	0.45 -		0.275	0.07
2	-	-	0.140	-
3	0.30 -		0.350	0.20
4	0.22 -		0.310	0.31
5	0.19 -		0.125	0.08
6	0.20 -		-	0.20
7	0.20 -		0.300	

TABLE 4: Absolute Amplitude Values for VI and VII for males for Left Ear at 80 dB Stimuli.

Absolute Latency	Frequency 2 KHz	Frequency 4 KHz
I	1.27	1.28
II	2.24	2.31
III	3.34	3.40
IV+V	5.15	5.22
VI	6.56	6.70
VII	8.63	-

TABLE 5: Means of Absolute Latencies for (I-VII) for Males for Right Ear at 80dB Stimuli

Absolute latency	Frequency 2 KHz	Frequency 4 KHz
I	1.27	1.30
II	2.22	2.18
III	3.34	3.40
IV-V	5.18	5.20
VI	6.65	6.63
VII		8.55

TABLE 6: Means of Absolute Latencies for (I-VII) for Males for Left ear at 80dB Stimuli.

Absolute latency	frequency 2 KHz	Frequency 4 KHz	Frequency 2 KHz	Frequency 4 KHz
	(a)		(b)	
I	.160	.167	.075	.115
II	.194	.172	.192	.164
III	.113	.129	.097	.122
IV-V	.230	.243	.203	.191
VI	.181	.141 .	.242	.258
VII	.208	-	-	0.100

TABLE 7: (a) Standard deviation of Absolute Latencies for (I-VII) for Males for Right Ear at 80 dB stimuli.

(b) Standard deviation of Absolute Latencies for (I-VII) for Males for Left ear at 80 dB stimuli.

Absolute Amplitude	Frequency 2 KHz	Frequency 4 KHz	Frequency 2 KHz	Frequency 4 KHz
	(a)			
VI	.238	.247	.26	.250
VII	.233	-	-	.172

TABLE 8: (a) Means of Absolute Amplitude of VI and VII for Males for Right Ear at 80 dB stimuli.

(b) Means of Absolute Anplitude/VI and VII for Males /of for Left Ear at 80 dB stimuli.

Absolute Amplitude	Frequency 2 KHz	Frequency 4 KHz	Frequency 2 KHz	Frequency 4 KHz
	(*)		(b)	
VI	.1030	.1463	.1013	.0942
VII	.0760			.0993

TABLE 9: (a) Standard Deviation of Absolute Aaplitade of VI and VII fer Males for Rt. Ear at 80dB stimuli

(b) Standard Deviation of Absolute Amplitude of VI and VII for Males fer Left Ear at 80dB Stimuli.

Sl.No. of	Frequency 2 KHz					frequency 4 KHz						
	I	II	III	IV-V	VI		I	II	III	IV-V	VI	VII
1	1.4		3.2	4.9	-	-	1.3	2.4	3.2	4.8	6.8	-
2	1.1	2.0	3.0	4.8	6.5	8.5	1.1	2.0	3.1	4.9	6.7	8.6
3	1.4	-	3.1	4.9	6.6	-	1.3	2.8	3.4	5.0	6.8	-
4	1.0	2.3	3.3	6.2	6.6	-	1.2	-	3.3	5.1	6.9	-
5	1.2	2.3	3.3	6.1	6.6	8.8	1.3	2.3	3.4	5.0	6.8	-
6	1.0	-	3.8	6.2	6.9	-	1.0	-	3.2	5.1	6.5	-
7	1.3	2.6	3.4	6.2	6.8	8.4	1.2	8.4	3.4	5.2	6.7	8.9

TABLE 10: Absolute latency valuea for females for Right ear at 80 dB stimuli

Sl .No. of subjects	FREQUENCY 2 KHz						FREQUENCY 4 KHz					
	I	II	III	IV-V	VI	VII	I	II	III	IV-V	VI	VII
1	1.3	2.3	3.2	4.9	6.7	-	1.2	2.3	3.2	4.9	-	-
2	1.1	-	3.1	4.8	6.5	8.2	1.1	2.1	3.1	4.8	6.7	-
3	1.4	-	3.2	5.0		-	1.0	2.5	3.3	5.2	7.0	8.2
4	1.0	2.3	3.3	5.1	6.7	-	1.1	2.3	3.1	5.1	6.4	8.4
6	1.3	2.3	3.4	5.1	-	-	1.2	2.3	3.2	5.0	6.8	-
6	1.0	-	3.5	5.5	7.0	8.5	0.9	-	3.1	5.3	6.0	-
7	1.3	2.6	3.5	5.3	7.0	-	1.3	2.5	3.5	5.3		8.4

TABLE 11: Absolute latency values for females for left ear at 80dB stimuli.

Sl.No. of subjects	FREQUENCY 2 KHz		FREQUENCY 4 KHz	
	VI	VII	VI	VII
1	-	-	0.15	-
2	0.25	0.18	0.27	0.26
3	0.05	-	0.27	-
4	0.44	-	0.16	-
5	0.15	0.09	0.10	-
6	0.50	-	0.19	- -
7	0.27	0.22	0.10	0.08

TABLE 12: Absolute Amplitude Values for VI sad VII for females for Right ear at 80dB stimulus.

S1. No. of subjects	FREQUENCY 2 KHz		FREQUENCY 4 KHz	
	VI	VII	VI	VII
1	0.10	-	-	-
2	0.05	0.18	0.21	-
3	-	-	0.27	0.05
4	0.20	-	0.28	0.10
5	.	-	0.25	-
6	0.30	0.05	0.15	-
7	0.30	-		0.25

Table 13: Absoulte Amplitude Values for VI and VII for females for Left ear at 80dB stimilus.

Absolute Latency	Frequency 2 KHz	Frequency 4 KHz	Frequency 2 KHz	Frequency 4 KHz
		(a)		(b)
I	1.20	1.20	1.20	1.14
II	2.30	2.32	2.37	2.33
III	3.25	3.28	3.31	3.21
IV & V	5.04	5.01	5.10	5.08
VI	6.66	6.74	6.78	6.68
VII	8.56	8.45	8.35	8.33

TABLE 14: (a) Means of Absolute Latencies for (I-VII) for Females for Right Ear at 30dB Stimuli.

(b) Means of Absolute Latencies for (I-VII) for Females for Left Ear at 80dB Stimuli.

Absolute Latency	Frequency 2 KHz	Frequency 4 KHz	Frequency 2 KHz	Frequency 4 KHz
		(a)		(b)
I	0.173	0.115	0.163	0.137
II	0.244	0.192	0.150	0.150
III	0.171	0.121	0.167	0.146
IV-V	0.171	0.134	0.238	0.195
VI	0.15D	0.127	0.186	0.238
VII	0.208	0.212	0.212	0.115

TABLE 15: (a) S.D. of Absolute Latencies for (I-VII) for Right Ear for females at 80dB stimuli.

(b) S.D. of Absolute Latencies for (I-VII) for Left Ear for females at 80dB stimuli.

*

Absolute Amplitude	Frequency 2 KHz	Frequency 4 KHz	Frequency 2 KHz	Frequency 4 KHz
			(b)	
VI	0.276	0.177	0.190	0.233
VII	0.163	0.165	0.115	0.133

TABLE 16: (a) Means of Absolute Amplitude of VI and VII for Right Ear at 80dB stimuli

(b) Means of Absolute Amplitude of VI and VII for Left ear at 80dB stimuli

Absolute Amplitude	Frequency 2 KHz	Frequency 4KHz	Frequency 2KHz	Frequency 4KHz
	(a)		(b)	
VI	0.1700	0.0710	0.1140	0.0531
VII	0.0665	0.1202	0.0910	0.1040

TABLE 17: (a) S.D. of Absolute Amplitude of VI and VII for Right Ear for females at 80dB Stimuli.

(b) S.D. of Absolute Amplitude of VI and VII for Left Ear at 80dB Stimuli.

	MALES II PEAK				FEMALES II PEAK			
	right ear		left ear		right ear		left ear	
	2 KHz 80 dB	4 KHz 80 dB	2 KHz 80 dB	4 KHz 80 dB	2 KHz 80 dB	4 KHz 80 dB	2 KHz 80 d B	4 KHz 80 dB
No.of subjects (male & female) tested in which II peak is readable / Total No. of subjects tested.	5 /	6 /	8 / 7	5 / 7	4 / 7	5 / 7	4 / 7	6 /
	671.	85.7%	71.4%	71.4%	57.1%	71.4%	57.1%	85.4%

TABLE 18(a)- Percentage of subjects (Males and Females) who show readable II Peak in Right and Left ear at 2 KHz and 4 KHz for 80 dB stimulus.

No. of subjects tested in which peak is readable.

Total No. of subjects tested

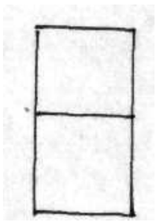
	MALES (VI PEAK)				FEMALES (VI PEAK			
	Right ear		Left ear		Right ear		Left ear	
	2 KHz 80 dB	4 KHz 80 dB	2KHz 80 dB	4 KHz 80 dB	2 KHz 80 dB	4 KHz 80 dB	2 KHz 80 dB	4KHz 80 dB
No.of subjects (Males & Females) tested in which VI peak is readable. / Total No.of subjects tested.	5/7	5/7	6/7	6/7	6/7	7/7	5/7	5/7
	71.4%	71.4%	85.7%	85.7%	85.7%	100%	71.4%	71.4%

TABLE 18(b)Percentage of sabjects (Males & Females) who show readable VI peak in Right and Left ear at 2 KHz and 4 KHz for 80 dB stimulus.

No. of subjects tested in which peak is readable / Total No.of subjects tested

	MALES VII PEAK				FEMALES VII PEAK			
	Right ear		Left ear		Right ear		Left ear	
	2 KHz 80 dB	4 KHz 80 dB	2 KHz 80 dB	4 KHz 80 dB	2 KHz 80 dB	4 KHz 80 dB	2 KHz 80 dB	4 KHz 80 dB
No. of subjects (Males & Females) tested in which VII peak is readable. / Total No. of subjects tested.	3/7	0/7	0/7	4/7	3/7	2/7	2/7	3/7
	42.8%	0%	0%	57.1%	42.8%	28.5%	28.5%	42.8%

TABLE 18(c) Percentage of subjects (Males & Females) who show readable VII peak in Right and Left ear at 2 KHz and 4 KHz for 80 dB stimulus



No. of subjectes tested in which peak is readable.

Total No. of subjects tested.

SUMMARY AND CONCLUSION

The present study was undertaken with the aim of helping the Audiologists to detect artifacts, which can interfere with the production of actual brainstem evoked responses. Interest was focussed on the relationship between ongoing background electrical activity and the brain stem evoked responses. The percentage of normal hearing subjects exhibiting sixth and seventh peaks (males and females) was also found.

This study also includes the data about Absolute Latency of (I to VII) peaks and Absolute Amplitude of (VI and VII)peaks.

This study was carried out in a sound treated room at Audiology Department of AIISH, Mysore. Fourteen (7 males and 7 females) normal hearing subjects were tested. ERA model TA-1000 was used. Each subject was tested under three different settings for ERA, for three different measures.

(a) First ten patterns of ongoing background electrical activity were taken.

(b) BSER (with stimuli) at 80 dB HL for 2 KHz and 4 KHz in right and left ears (separately) were recorded.

(c) Averaged ongoing electrical activity (without stimulus) for 1024 samples and 2048 samples at 5 times/sec and 20 times/sec were recorded.

The following conclusions have been drawn:

1. Marker height in case of BSER (with stimuli) is usually one and does not exceed two, while in the case of averaged ongoing electrical activity (without stimuli) it is more than one and in subjects where it is one, is due to the presence of biophysical artifacts.

2. Wave forms in case of BSER (with stimuli) are rising upwards towards the end of the graph and in averaged ongoing electrical activity (without stimulus) waveforms move downwards towards the end of the graph. Though it is not true in all subjects, but in suspected cases repeated testing should be done to ensure one self of the results.

3. Averaged ongoing electrical activity (without stimuli) waveforms can sometimes simulate, the BSER (with stimuli) waveform as seen in five subjects. Hence interpretation should be made with caution.

4. Amplitude values are highly susceptible to muscle artifacts.

5. In three subjects, the number of samples stopped before reaching the predetermined number (2048 samples or 1024 samples) and in one subject, recording artifact was observed.

6. Amplitude of the evoked response increased with the amplitude of the ongoing electrical activity and reduced when the amplitude of the ongoing electrical activity decreased.

7. BSER waveforms (with stimuli) for Bilateral profound hearing loss cases resembles Averaged ongoing electrical activity (without stimuli).

not

8. The following peaks were/seen in all the subjects (II, VI and VII) and are easily obliterated.

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