COMPARISON OF IPSILATERAL AND CONTRALATERAL RECORDING IN BRAIN-STEM EVOKED RESPONSE AUDIOMETRY.

Regiataration No. 8510.

Sunitha Ahear

DISSERTATION SUBMITTED IN PART FULFILMENT FOR SECOND YEAR M. Sc, (SPEECH AND HEARING)TO THE UNIVERSITY OF MYSORE.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
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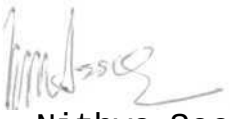
TO MY FAMILY FOR EVERYTHING

C_E_R_T_I_F_I_C_A_T_E

This is to certify that the Dissertation entitled "Comparison of Ipsilateral and Contralateral Recording in Brain-Stem Evoked Response Audiometry" is the bona fide work in part fulfilment for the Degree of Master of Science (Speech and Hearing) of the student with Registeration No. 8510.



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Director
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C E R T I F I C A T E

This is to certify that this Dissertation entitled "Comparison of Ipsilataral and Contralateral Recordings in Brain-Stem Evoked Response Audiometry" has been prepared under my supervision and guidance.

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D E C L A R A T I O N

I hereby declare that this Dissertation entitled "Comparison of Ipailateral and Contralateral Recordings in Brain-Stem Evoked Response Audiometry" 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.

Registeration No. 8510,

MYSORE,

May , 1987.

A_C_K_N_O_W_L_E_D_G_E_M_E_N_T

My sincere gratitude to Dr.M.N.Vyasa-murthy for sparing his valuable time to give a patient hearing, support and guidance in my study.

I extend my thanks to Dr. M. Nithya Seelan, Director, All India Institute of Speech and Hearing, Mysore.

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I am also indebted to my father for his constant encouragement and painataking efforts in typing this Dissertation.

My grateful thanks are also due to my Subjects who made 'IT' all possible.

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INTRODUCTION

If one could directly record from several different levels of the subcortical auditory pathways in man, one would see in the first 10 msec following an appropriate acouatic stimulus series of potentials corresponding to the successive activation of peripheral, pontomedullary, pontine and mid-brain portions of the pathway. When these acouatic nerve and brain-stem potentials are volume conducted to recording electrodes at the vertex and earlobe, they form a composite aeriea of potentials which are known as the brain-stem auditory evoked responses, (Stockard, at al,1978).

Auditory Brain-Stem Responses (ABR's) are usually recorded between electrodes on the vertex and on the ipailateral mastoid or sarlobe, a montage that is called 'Ipeilateral'. In adult patients, it is possible to obtain useful information from a 'Contralateral' montage, recording between the vertex and the contralateral mastoid or earlobe, (Edward, et al, 1985).

The principal advantage of recording ipsilateral and contralataral response simultaneously in adults is that there is a general correspondence between waveforms from the two derivations, which allow the relatively minor changes that occur to be helpful in differentiating components.

The developmental course of the contralateral response is not known. The usefulness of the response as a measure of auditory brain-stem maturity is, therefore, also unknown (Edward, et al, 1978).

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Aim of the Study:

Comparison of ipsilataral and contralataral recordings in BSERA.

Need for the Study:

The contralataral responses show minor but predictable differences from the ipsilateral response. There are morphological changes in the ABR's associated with moving the reference electrode from the ipailateral (re: the stimulated ear) mastoid to the contralataral mastoid. Both responses are recorded with the active electrode on the vertex of the skull.

The changes associated with the contralataral reference may include :-

i) a decrease in the definition of wave I,
ii) an increase in the definition of wave III,and
iii) a separation of IV and V.

The contralateral derivation can be used to resolve waves (e.g., II and IV) that are not distinct with an ipsilateral reference. The diagnostic importance of contraiateral referenced responses is uncertain.

If wave I is not discernable, the distinction between conductive impairment and an immature brainstem auditory system cannot ba made with acceptable confidence, (Fria, 1980).

Tarkildsen and othera (1977) offered suggestions to Clinicians performing ABR testing:-

1) when a click stimulus is used, do not expect to find an ABR in an ear that has greater than a 70 dB hearing threshold at frequency above 1 KHZ,

2) when ABR waveforms in an ear having a

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hearing threshold lass than 70 dB cannot be reproduced at least down to 30 dB S.L. that is highly significant diagnostic finding, and

3) when absence or distortion of tha ABR in a normal or near normal hearing ear is found, that is a diagnostic sign.

Distortion of tha ABR waveforms in the contralateral ear is also an important diagnostic finding.

It is desirable to hava ipailateral and contralateral recordings in BSERA.

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REVIEW Of LITERATURE

REVIEW OF LITERATURE

1.1 BSER in Audiology, Otology, Neurology and Paediatric:

Since 1970, the BSER technique has emerged as a vital adjunct to the clinical armamentarium of the audiologist, otologist, neurologist, neuro-aurgaon and paediatrician, who jointly determine hearing sensitivity, lesion site and Central Nervous System (CNS) integrity, pathology and maturation.

BSER applications in audiologic-otologic disorders and site-of lesion testing have shown that the responses are useful in detection of the hearing abnormalities, (Shaia and Albright, 1980). Popularity of BSER is because of its reproducti-bility, case of adminiatration, low inter and intra-subject variability, and accuracy in estimating hearing senitivity, (Clemis and Mcgee, 1979; Davis, 1976a, Davis and Hirsh, 1976; Emmett and Shea,1980, among others).

Still another recent application has been the use of BSER in neurological disease (Starr, Sohmer and Celesia, 1978). Brain-stem lesions cause a selective absence or alteration of one or more of the responses components; patients with brain-stem damage (due to various types of tumours, demylinating 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. Many

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of the pathological conditions hava been corroborated with finding at autopsy (Berry,Briant and Winchester, 1976; Shagass,1972; Sohmer, Feinmesser and Bauberger-Tell,1972; Starr and Achor, 1975).

An interest in the 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 preadolacent children (Ellingson Danahy and Neison, et al, 1974; Jewett and Ramano, 1972; Monod and Garma, 1971; Starr, Amlie, and Martin at al,1977). A related application is an attempt to discover electrophysio logic correlates underlying demyalinating diseases such as multiple sclerosis (Chiappa, Harrison and Brooks et al, 1980).

The 1970's saw the introduction and recommended use of BSER testing in certain clinics (Goldstein, 1979). However, there is still an interest in determining the origin of certain of the BSER waves. (Allen and Starr, 1978; Achor and Starr 1980a; Buchwald and Huang, 1975; Plantz, Williston and Jawett, 1974 among others), for determining the effects of sedation on animals and children (Bobbin May and Lemoine, 1979; Crowley, Davis and Beagley, 1975) and determining the effects of various stimuli and other recording parameters, (Anthony, Durrett Polec et al, 1979; Boston and Ainslis, 1980; Cullen Berlin and Gondra, 1976 among others).

1.2 Functional Anatomy of Auditory System:
IMPLICATIONS FOR BSER:

The surface recorded brain-stem auditory evoked potentials (BAEPs) comprising the response are, at most, only about 1% of the amplitude of the on-going spontaneous EEG activity and, therefore, must be extracted from this and other 'noise' using computer averaging techniques. The earlobe negative acoustic nerve action potential (N_1) and the four successive vertex positive BAEPs are conventionally designated aa wave I through v and plotted ear lobe-negative up, (vertex-positive up) as shown in Fig.1 (Stockard et al, 1978).

…/

The precise depth correlates of the scalp recorded BAEPs are unknown but certainly much more complex than is suggested by Fig.1.

As a result of convergence and divergence of serially linked BAEP generators, non-serial linkage of generators, simultaneous activity in multiple generators, and sustained activity in single generators, there cannot be a strict one to one correspondence between different BAEPs and different anatomic loci. The degree of correspondence that does exist, however, allows one to use the latency between the peaks (inter-peak latency) of wave I and III as an indirect measure of conduction in the extra-axial and pontomedillary segments of the auditory pathways and the III-V inter-peak latency as a measure of conduction in the more rostral pontine and mid-brain segments of the pathways, (Stockard et al, 1978).

"A number of structural features could be expected to provide an anatomic basis for generation of the BSER. Detection of such responses of the head would require that a large number of individual neurons fire in synchrony. The moat likely place for this is the cochlear nerve. In the CNS, fibre tracts are less likely to discharge with the necessary degree of synchrony, since then all consist of mixtures of second, third, fourth or higher order pathways, including the TB, LL branchium of the IC and auditory radiation(Fig.2 and Fig.3). An exception to this might be the dorsal acoustic stria, which consists mostly of the axons of fusiform and giant cells projecting to the IC from the dorsal CN (Fig.3). The fibres of the dorsal acoustic stria, however, spread out in a fan like arrangement as they sweep across the medulla and,therefore, may be less effective in providing a concentrated source of potentials for detection at a distance",(Moore, 1983).

One special arrangement of neurons favouring surface detection is that in which a dipole generator might appear. Such an arrangement is seen in the MSO, where inputs from both aides of the auditory system converge on a single layer of neurons. The number of neurons located here are reletively small compared to

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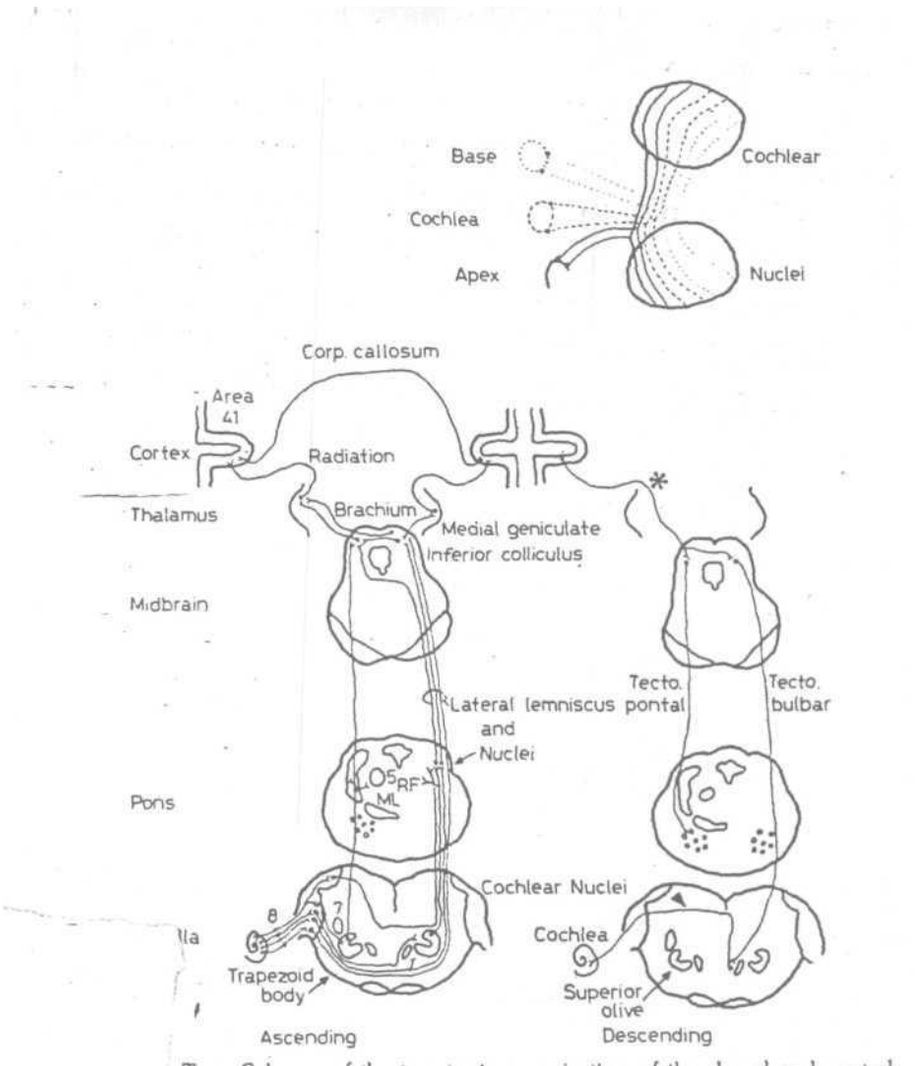
FIGURE 2: Top Scheme of the Tonotopic Organisation of the Dorsal and Ventral Cochiear Nuclei.



Top. Scheme of the tonotopic organization of the dorsal and ventral cochlear nuclei. Cochlear nerve fibers establish an orderly correspondence of successively more apical regions of the cochlea with progressively more ventrolateral sectors in each part of the cochlear nucleus. Bottom. The main ascending and descending pathways of the central auditory system. Key: corticotectal tract (•); crossed olivocochlear tract (*arrowhead*); medial lemniscus (*ML*); reticular formation (*RF*); motor trigeminal nucleus (5); motor facial nucleus (7); spiral ganglion (8)

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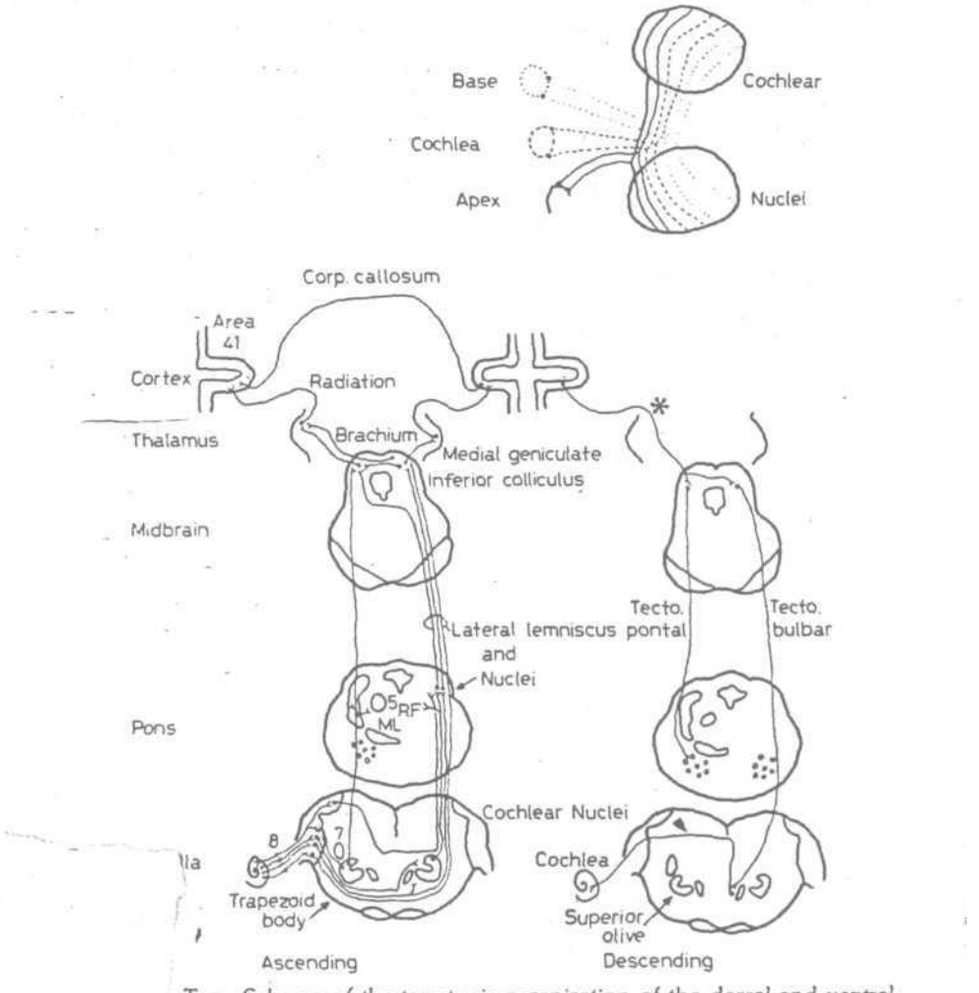

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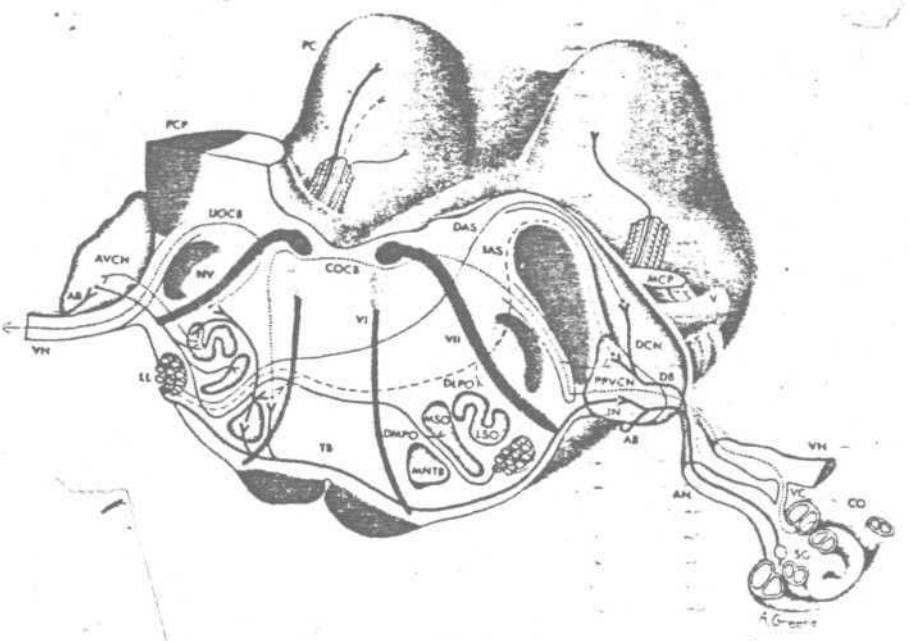
FIGURE 3: Bulber Auditory Connections.

Functional Anatomy of the Auditory System



Schematic illustration of bulbar auditory connections. In a wiring diagram such as this, the cochlear nerve is represented by a single channel, although the existence of two populations of spiral ganglion cells innervating inner and outer hair cells separately adds another consideration in interpreting central processes. Key: ascending branch of cochlear nerve (*AB*); cochlear (auditory) nerve (*AN*); anteroventral cochlear nucleus (*AVCN*); cochlea (*CO*); crossed olivocochlear bundle (*COCB*); cerebral peduncle (*CP*); dorsal acoustic stria (*DAS*); descending branch (*DB*) of cochlear nerve; dorsal cochlear nucleus (*DCN*); dorsal periolivary region (*DLPO*); dorsomedial periolivary nucleus (*DMPO*); intermediate acoustic stria (*IAS*); posteroventral AVCN (interstitial nucleus) (*IN*); lateral lemniscus (*LL*); lateral superior olive (*LSO*); middle cerebellar peduncle (*MCP*); medial trapezoid nucleus (*MNTB*); medial superior olive (*MSO*); inferior colliculus (*PC*); posterior cerebellar peduncle (*PCP*); posteroventral cochlear nucleus (*PPVCN*); spiral ganglion (*SG*); trapezoid body (*TB*); descending trigeminal tract and nucleus (*T, NV*); uncrossed olivocochlear bundle (*UOCB*); vestibulocochlear (*VC*) anastomosis (Oort); vestibular nerve (*VN*); abducens nerve root and nucleus (*VI*); facial nerve root (*VII*)

the cell groups ordinarily considered as possible generators of the BSER. Other ceil groups where binaural convergence may play a role in the generation of BSER occur in the LL, IC and MGB. Recent evidence that these nuclei may make a major contribution to the BSEH has been provided by Moller and Janetta, (1962).

Another factor that should be considered in the generation of a synchronized discharge of sufficient magnitude for a BSER is the size of the neurons and their fibres. Larger cells generate larger potentials as a rule, but their fibres tend to be thicker. Thicker fibres have faster conduction velocities and provide for larger responses at minimum latencies. One example of a large fibre projection in the dorsal CN is that of the fusiform and giant cells which project to the IC via the dorsal acoustic stria, (Brawar, Morest and Kane, 1974).

Finally, at all levels of the auditory pathways there are specific morphological types of neurons which differ in the arrangement of their synaptic connection and in their electro-physiologic response properties (Morest, 1975b). It is likely that the processing of acoustic information by the Central auditory nervous system depends on the organisation of these different types of neurons, (Moreat, Kiang and Kane, at al, 1973; Morest, 1975a). Unfortunately, it is not clear how specific population contributes to BSER. When it is clarified BSER will be a more powerful investigation too.

1.3 Basic and Clinical Aspects of Brain-Stem Recordings:

Patients are tested in the supine position and are sedated with chloralhydrate whenever there is significant muscle artifact visible in the amplified and filtered EEG activity from which the BAEPs are extracted. It is ideal to have the patients go to sleep during the recordings since sleep does not alter the BAEP signals but greatly reduces electromyographic (EMG) 'noiseI.

i.3a Normative IPL and RA Values:

Recordings of BAEPs in a normal subject gives 99% tolerance limits (upper limits of normal) for IPLs involving the vertex - positive waves I, II, III and V and vertex negative waves I_N, III_N and V_N in young adults with normal audiograms (Fig.4). The figure also shows norms for inter-peak latencies (IPLs) when recording simultaneously between the vertex and ear contralateral to acoustic stimulation (C_z-Ac_c).Wave V is usually resolved as a separate peak in these recordings derivation even when it cannot be separated from wave IV, in C_z -A_i, as shown in Fig.5. This is useful because waves IV and V tend to fuse in tha standard recordings derivation but need to be distinguished in clinical BAEP intarpretation-wave IV probably reflects activity in the pons, (Stockard at al, 1978), while wave V appears to be generated mainly in the coudal mid-brain (Starr and Achor,1975,Stockard,Rossiter,1977).

Simultaneous recordings in C_z-A_i. and C_z -A_c also help to identify waves II and III in difficult cases because of tha tendency for wave III to be attenuated more than II in C_z -A_c (Fig.5) and for tha two waves to move closer together (Fig.4). In some cases, II and III may fuse completely in C_z -A_c but this also helps to identify these waves in C_z-A_i. Interpeak latencies involving waves VI and VII show low intra-individual variability but sufficient variability among individuals in cross-sectional studies of a normal population that they are useful only in longitudinal studies of certain individuals who have well-defined waves VI and VII to begin with,(Stockard & Rossitar,1977).

The medial surface of the earlobe is tha optimal periaural recording site because it records the highest amplitude wave I (due mainly to an increase in the I_N, valley), as shown in Fig.6. The ear electrode is active for wave I and the earlobe negative (vertex-positive) peak of this wave is best considered as 'near field' potential recorded at the ear ; I_N is more prominent at the vertex as can be seen from the recordings

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FIGURE 4: Simultaneous Recordings: Vertex-Earlobes Ipsilateral (A_i) and Contralateral (A_c) to Click.

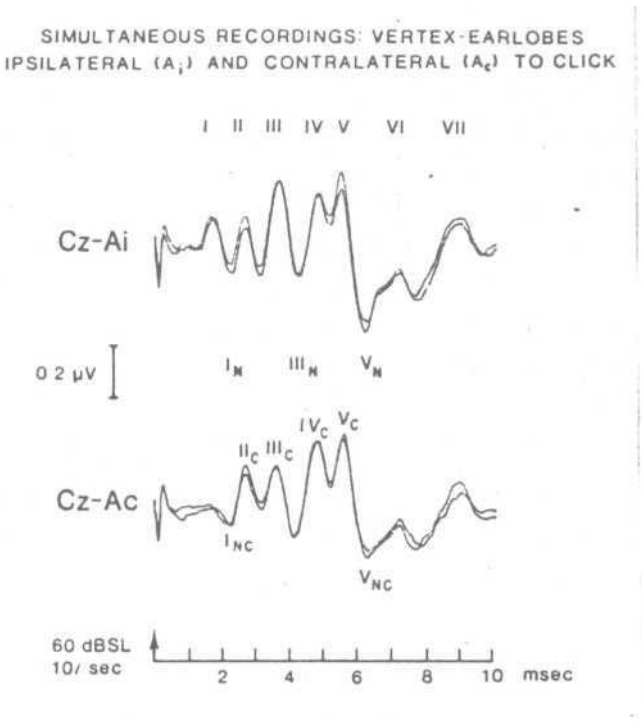
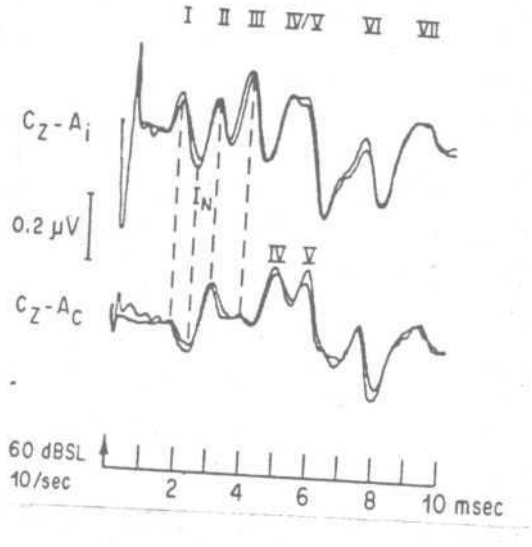


FIGURE 5: Effects of Simultaneous Recording in C_z-A_i and C_z-A_c on Amplitude of BAEPs.



at the botton of Fig.6 between the vertex and a non-cephalic reference. Idantification of the vertex positive (earlobe-negative) peak of wave I is important because it is the eletrophysiologic bench-mark from which more proximal central auditory conduction is assessed in BAEP Interpretation, (Stockard, et al, 1978).

Wave I can be distinguished from earlier non-neural components such as stimulus artifact and cochlear microphonics by reversing the polarity of the stimulus; this results in complete reversal of the polarity of electrical and mechanical stimulus artifact and microphonics but does not change the polarity of wave I. Wave I can be distinguished from the following neural component. Wave II by virtue of the relative sparing of the latter wave in the C_z-A_c derivation while the vertex positive (earlobe negative) peak of wave I is truncated (Fig.4 and 5), comparison of vertex (C_z) to periaural electrodes ipsilateral (A_i) Vs contralateral (A_c) to click stimulation and, in some cases vertex to ipsilateral earlobe or ipsilateral mastoid ware made.

1.3b The Morphological changes in the ABR associates with moving the reference electrode from the ipsi-lateral (re: the stimulated ear) mastoid to the con-tralateral mastoid. Both responses were recorded with the active electrode on the vertex of the skull (Fig.7).

The changes associated with the contralateral reference may include:-

i) a decrease in the definition of wave I,
ii) an increase in the definition of wave II with diminished definition of wave III,and
iii) a separation of waves IV and V.

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FIGURE 6: Absolute (peak-to-trough) and Relative Amplitudes of Waves IV/V and I.

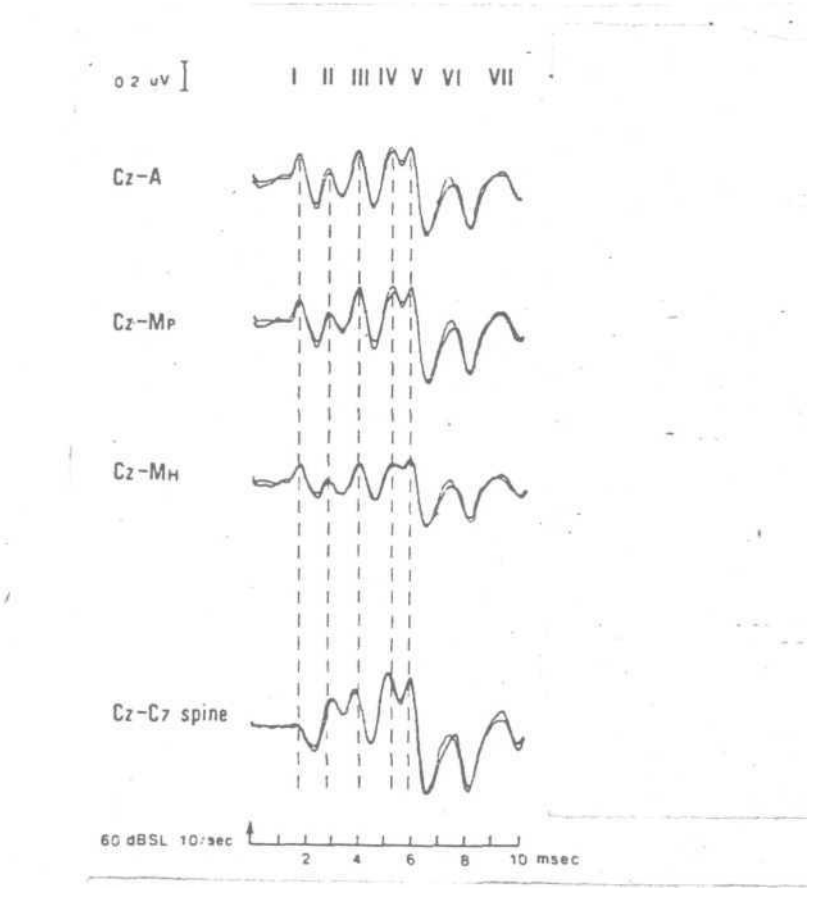
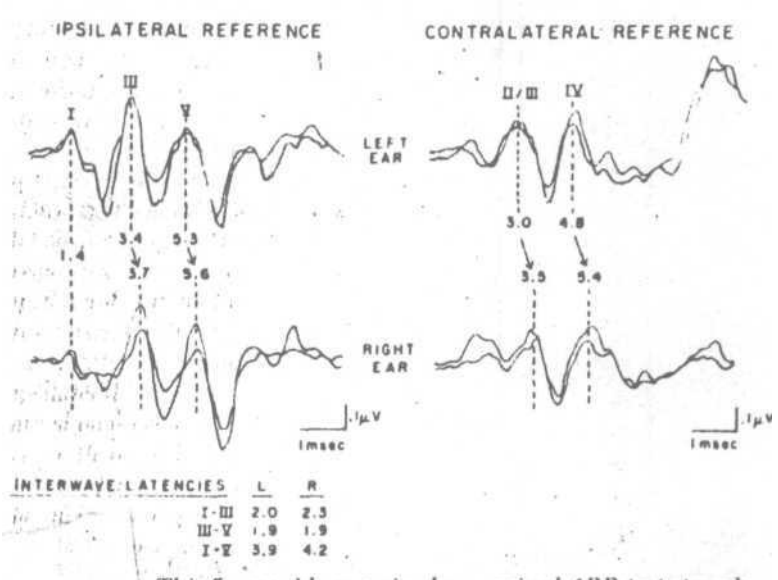


FIGURE 7: Ipsilateral Reference and Contralateral Reference.



This 5 year old caucasian boy received ABR tests to rule out 'retrocochlear impairment. This patient contracted beta strep meningitis at 1 month of age with ensuing hydrocephalus. A right ventriculoperitoneal shunt procedure was performed at that time. This shunt malfunctioned twice in the following 3 years and was revised. The patient was asymptomatic following the second shunt revision, but was admitted to the hospital for a CT Scan to determine the extent of residual hydrocephalus. The scan revealed a cyst in the superior cistern immediately posterior to the midbrain. A second scan was performed with enhancement and in addition to the previously noted cyst, revealed an extra-axial cyst involving the right cerebellopontine angle. At that time an audiogram and ABR tests were requested. The child had normal hearing, but the acoustic reflex to ipsilateral stimulation was elevated for the right ear. The ABR responses to 70 dB nHL clicks are shown above for ipsilateral and contralateral reference recordings. Stimulation of the left ear with an ipsilateral reference produced a normal response (interwave latencies are shown below the ipsilateral responses). Stimulation of the right ear with an ipsilateral reference, however, revealed slightly prolonged latency for waves III and V; consequently the I-III and I-V interwave latencies were greater when stimulating the right ear. The delay in right responses is even more apparent in the recordings referenced to the contralateral mastoid. Here, the III/III wave complex and wave IV are approximately 0.5 msec later for the right ear. Taken together, the ipsilateral and contralateral reference recordings are consistent with the clinical diagnosis of a right cerebellopontine angle cyst.

The contralateral darivation can be used to resolve waves (e.g., II and IV) that are not distinct with an ipsilateral reference.

If wave I is not discernable, the distinction between conductive impairment and an immature brain-stem auditory system cannot be made with acceptable confidence, (Fria, 1980).

1.4 Pathological Factors Influencing BAEPa:

In moat laboratories, the criteria for BAEP abnormality employed in neurologic applications of the test are based on prolongations of inter-peak latency and, to a lesser extent, reductions in the amplitude of the IV/V complex relative to wave I (Starr and Achor, 1975), Stockard, et al, 1977), and/or wave III (Chiappa, Gladstone, and Young, 1979). There is complete absence of wave IV/V in the presence of wave I or wave III as a relative amplitude (RA) abnormality. IPL and RA values also normally show intra and inter-individual variability, and interpretation of changes requires a knowledge of the normal variability of IPL and RA as a function of technical, physiologic, otologic and pharmacologic factors.

Amplitude abnormalities can be defined in several ways. Stockard and others (1977) applied the following criteria in detecting definite waveform and amplitude abnormality:-

1. The positive to negative peak to peak amplitude of the waves IV/V complex or of wave V is reduced by more than 3 standard deviations below the clinic norm,
2. Wave I peak to peak amplitude exceeds the amplitudes of waves IV/V or of wave V, and
3. test retest variations show that the preceding abnormality does not vary by more than 10%.

Starr and Achor (1975) suggested that a binaurally stimulated wave IV/V to wave I amplitude ratio of less than 1.0 was evidence of amplitude abnormality. In terms of monoaural stimulation at or below 65 dBHL, a IV/V to I amplitude ratio of less than 0.5 is definitely

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abnormal and a ratio between 0.5 to 1.0 suggests central auditory abnormality.

Rosenhammer's findings concerning ABR were highly significant. Largs cerebellopontine angle tumours (CPATs) greater than 20 mm causing brain-stem distortion failed in all cases to yield a reproducible waveform in ipsilateral ears across a 30 dB range (N=14). There were abnormal signs in all the contra-lateral ears as well, which indicated four basic type of abnormalities, i.e., :-

1. Wave IV and V were preserved in some cases down to 30 dBSL, but waves I, II and III were severely deformed and only reproducible at high levels,
2. Waves I, II and III showed greater ampli-tude and reproducibility than waves IV/V at high levels, but in some cases less of either quality was observed at low levels of stimulation,
3. the waves IV/V relationship to wave I, II and III deteriorated rapidly as the presenta-tion level was lowered, and
4. there was, for some patients, preservation of waveform peaks within the first 5 ms.but conspicuous deterioration in the second 5 ms.

Medium (10-20 mm) CPAT's yielded in all cases no reproducible ABR in the ipsilateral ear across a 30 dB range (N=12). Abnormal of the first and second type (described above for large CPATs) were also seen in the contralateral ear in B of these patients. Small CPATs (smaller than 10 mm) also yielded no reproducible ABR in the ipsilateral ear across a 30 dB range in any of the cases (N=5) 4 of the 5 patients with small lesions also showed abnormality of the first and second types in the contralateral ear (Martin, 1975). Discrete brain-stem lesions have complex effects on the ABR.

1. A lesion of a single brain-stem auditory structure may effect only a single component of the ABR, but more typically the effect is on the ABR, -(1). A lesion of a single brain-stem auditory structure may effect only a single component of the ABR, but more typically the effect is on several components,
2. lesions of certain portions of the classical primary auditory pathway (i.e. the dorsalcochlear nucleus, the dorsal acouatic

stria, the lateral superior olivary nucleus, the posterior portion of the lateral lemniscus and the inferior colliculus) are not associated with changes in the ABR prior to component (P_5)

3. Except for mid-line lesion the effects of brain-stem lesions on the ABR are quite different for ipailateral and contralateral stimulation,
4. the predominant effect of brain-stem on the ABR is an attenuation of the amplitudes of the components with only occasional increase in their latency. Opposite effects are rare,and
5. the effects of some brain-stem lesions on the ABR may only be transient (Achor and Starr, 1979).

TABLE I:

Maximum allowable normal inter-wave latency delay time:

Wave Intervals	Maximum allowable delay(mz)
I - III	2.6
I - IV/V	4.4
I - V	4.6
III - IV/V	2.3
III - V	2.4

(Stockard at al, 1977).

1.5 Non-Neurologic factors Influencing BAEPs:

Table 2 reviews briefly some of the determinants of IPL and RA in the absence of neurologic disease since they define the limits of normality and, thus, the criteria for abnormality of BAEPs.

TABLE 2: factors of affecting inter-peak latencies and relative amplitude of BAEPs:

Interpeak Latencies	Relative Amplitudes
Temperature	filters
Age	Signal to noise characterstics
Sex	Stimulus mode
Audiogram phase	Audiogram shape
Stimulus phase	Stimulus phase
Stimulus intensity	Stimulus intensity
Stimulus rate	Stimulus rate
Reference sits	Reference site
Drugs	Drugs

(Stockard et al, 1978)

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1.6 Stimulus Variables:

Intensity:

1.6a Latency Effects:

When click intensity is reduced from 70 to to 30 dBSL in adults, the magnitude of the latency shift is greatest in wave I and least in wave V. Tha largest shift usually appears between 50 and 40 dBSL where amplitude dominance is transferred from the first to the second major peak of the VIII nerve action potential (AP), causing a sudden jump in latency (Eggermont and Odanthal, 1974a). This jump is not paralleled by the shift in wave V (Fig.8) smaller but significant decreases are also seen in IPLs involving wave I between 70 and 60 dBSL (I-III, $P < 0.02$), 60 and 50 dBSL (I-III, $P < 0.02$); I-V, $P < 0.001$), and 40 and 30 dBSL (I-V, $P < 0.01$) significant alterations also seen in children.

It can be concluded that when latency intensity norms are applied, they must be specific for the intensity range tested and the portion of that range under consideration (Moore, 1983).

1.6b Amplitude Effacts:

The amplitude of the IV-V complex is also less affected by stimulus intensity x than are earlier components (Terkildsen, Osterhammel, and Huisfin't Veld, 1973; Pratt and Sohmer, 1976). The changes in mean amplitude from 0.49 uV at 70 dBSL to 0.28 uV at 30 dBSL in adults represent an average 41 per cent reduction in amplitude over the 40 dB range. Wave I amplitude over the same range is reduced by 81 per cent. The most abrupt change in amplitude is seen between 60 and 70 dB, where wave I doubles in amplitude in both new borns and adults. In certain adults, in whom integrity of the peripheral auditory apparatus can be established by conventional audiometry, the close interaar symmetry of IPLs (fig.9) can be used to increase the sensitivity of the test. In normal hearing patients for example interaural asymmetries in I-V IPL of 0.5 ms

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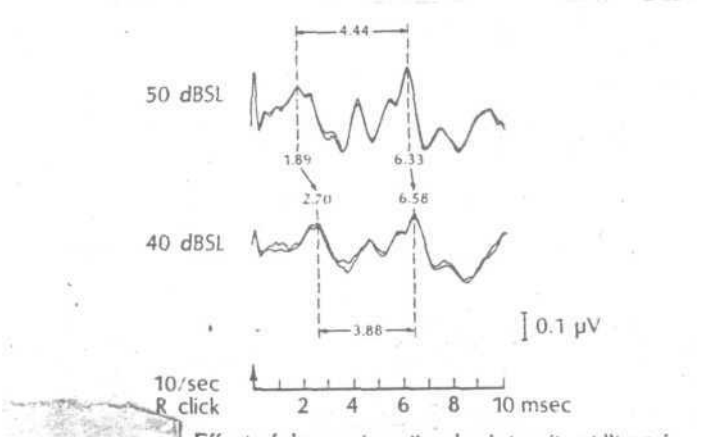
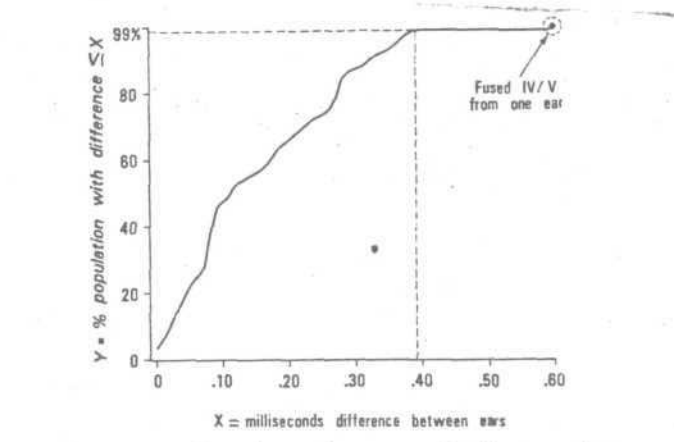
FIGURE 8: Effects of Decreasing Stimulus Intensity at Transitional Intensity Zone.



Effect of decreasing stimulus intensity at "transitional" intensity zone (male, age 25). The jump in wave I latency caused by the transfer of amplitude dominance from the first to the second peak of the auditory nerve potential is not paralleled by the shift in wave V latency. The I-V IPL is altered by the differential effect of intensity on the two components.

FIGURE 9: Cumulative frequency Distribution of Interaural I-V IPL Differences in 100 Neurologically and Audiometrically Normal Subjects.



Cumulative frequency distribution of interaural I-V IPL differences in 100 neurologically and audiometrically normal subjects. Note that 99 percent of normal subjects have interaural I-V IPL difference of less than 0.4 msec. The subject with a higher value had a fused IV-V complex in the BSER from one ear and discrete waves IV and V from the other ear, yielding a spuriously high inter-ear asymmetry (I-V IPL vs I-IV-V IPL); this emphasizes the importance of proper component identification in such assessments of interaural IPL symmetry.

or greater are abnormal whether or not the IPLs considered separately from each ear are normal (Fig.10), (Moore, 1983).

1.6c Repetition Rate:

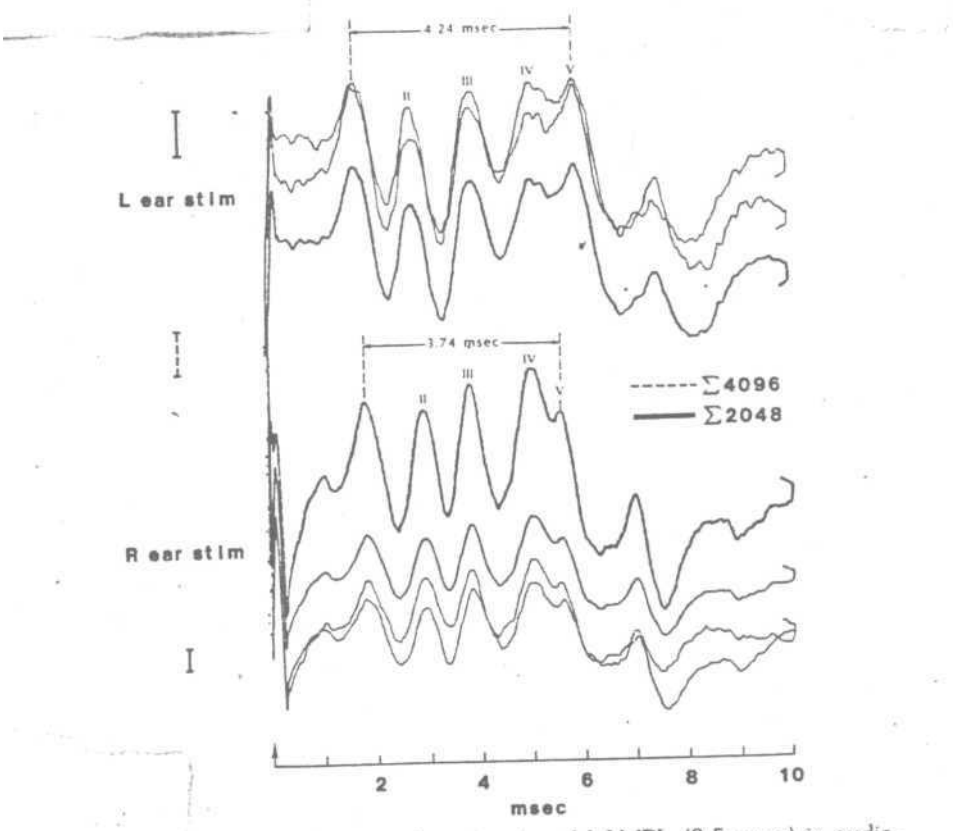
The effects of increasing stimulus rate on wave V latency and IPLs of the BSER is widely appreciated (Pratt and Sohmer, 1976; Zollner, Karnhl, and Stange, 1976; Don, Allen, and Starr, 1977; Rowe, 1978). Rate effects have reportedly been enhanced by advancing age (Fugikawa and Weber, 1977). Wave V rate related shifts are equivalent at two intensities in Fig.11. Since wave I shifts on the other hand are highly dependent on intensity, rate related IPL changes are difficult to predict, (Moore, 1983).

1.7 Effects of Recording Parameters:

"In a study by Hashimoto, Ishiyama, and Tozuka, et al, (1979), use of vertex to periaural electrodes contralateral to click stimulation was proposed to uncover abnormalities of inter-peak latency which were not seen in the routine vertex-to-ipsilateral ear derivation. The authors failed to consider, however, the normal increase in inter-peak latency in this recording derivation as compared to the standard recording referenced to tha stimulated ear (Stockard, Stockard and Westmoreland, et al, 1979). While wave I (and I^2_N) latencies are slightly altered between these derivations, wave V is significantly more prolonged, resulting in a mean difference in the 1_N-V IPL of 0.11 msec ($P < 0.01$) (Moore, 1983).

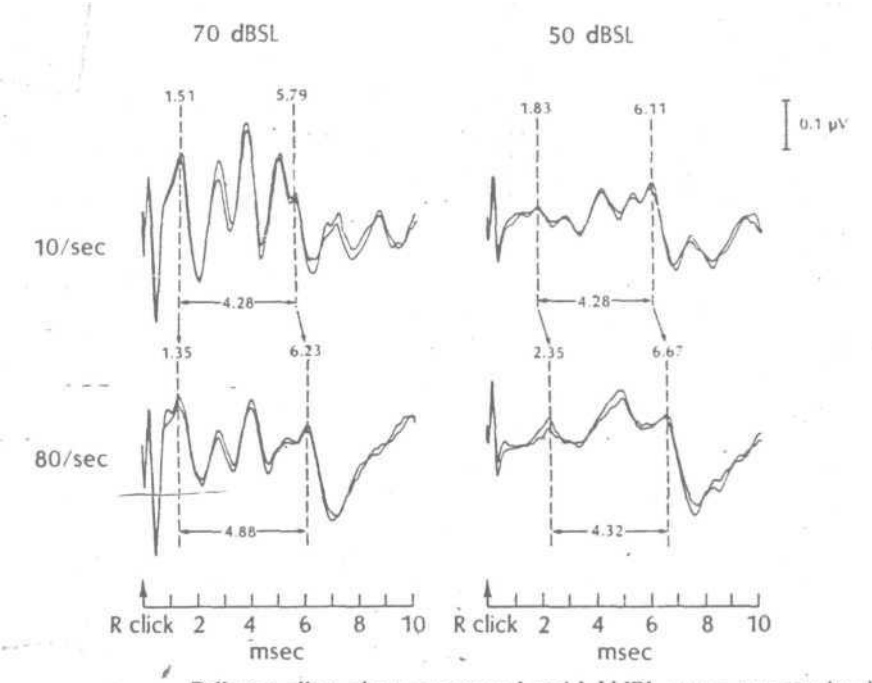
Predictable morphologic changes related to these recordings derivation are useful for proper identification of BSER components in clinical studies (Stockard, et al, 1978).

FIGURE 10: Abnormal Interaural Asymetry of I-V IPL (0.5 msec) in Audiometrically Normal Subjects Despite Normality of IPL's When Considered Separately.



Abnormal interaural asymmetry of I-V IPL (0.5 msec) in audiometrically normal subject despite normality of IPLs from each ear when considered separately (female, age 26, history of right visual blurring, no brain stem signs). Interear asymmetry of IPLs, in addition to case history suggestive of optic neuritis, helped to established early diagnosis of multiple sclerosis in this patient, who was asymptomatic at the time of testing, but subsequently proved to have demyelinating disease.

FIGURE 11: Differing Effect of Rate on Wave I and I-V IPL at two Intensity Levels with R Click Stimulation.



Differing effect of rate on wave I and I-V IPL at two intensity levels with R click stimulation (female, age 33). At 50 dB SL ("transitional" intensity zone), wave I latency increased with higher rate, while at 70 dB SL, wave I latency decreased with increased rate. In contrast, rate effect on wave V is approximately equal at the two intensities. The differential effect of rate and intensity on components I and V results in a change in the magnitude of the rate effect on the I-V IPL with stimulus intensity.

Much still needs to be done in relation to the ipsilateral and contralateral tracings in BSER, conclusive literature on which, at present, is so scant.

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METHODOLOGY

METHODOLOGY

2.1 Subjects:

20 normal hearing subjects (14 females and 6 males) in the age group of 17 - 25 years were tested for the purpose of this study.

Selection criteria required the subjects to have audiometerically and otologically normal ears. No family history of hearing loss was reported among the 20 subjects.

2.2 Equipment:

Electric Response Audiometer TA-1000 was used, (Fig.12).

Brief Description of the Equipment:

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

It consists of a SLZ-9793 desk top console which contains all of the operating controls, indication and readouts for the system. SLZ-9794 pre-amplifier is a isolated EEG pre-amplifier with frequency response and gain specifically designed for ERA. It has TDH-39 earphones and circumaural cushion MX-41/AR and a bone vibrator. There are 3 electrodes of standard silver chloride which are fixed after cleaning skin with spirit with electrolyte gel and adhesive tape. It also has calibrated paper to record the responses.

Controls and their Operation:

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

The active state of the selected function is indicated by means of internal lamps, in all buttons. Knobs are marked to indicate their functions.

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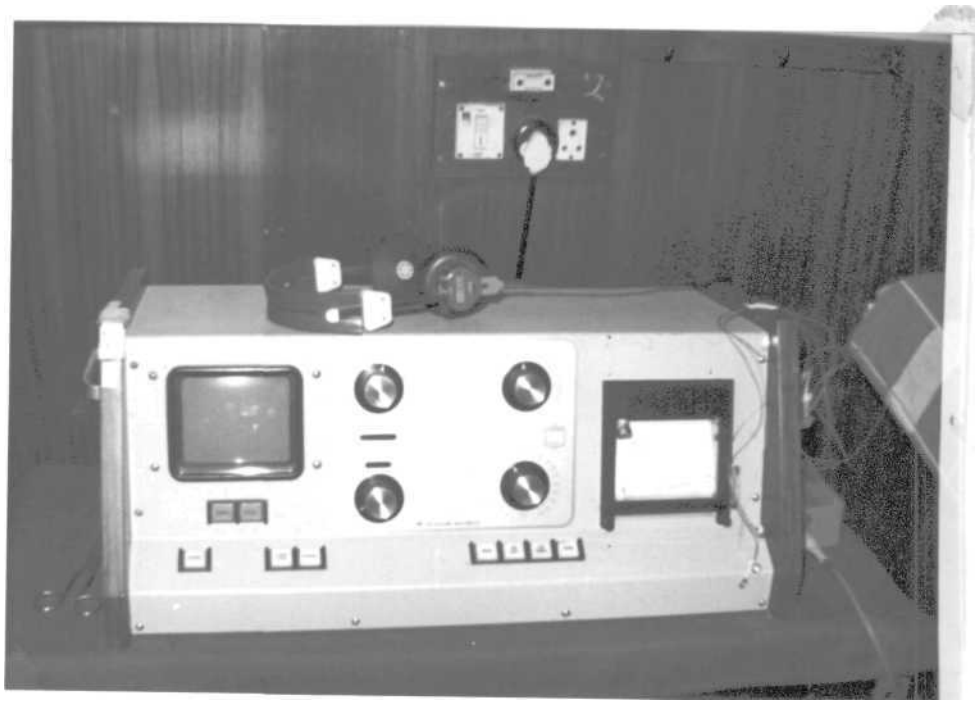
FIGURE 12: Model TA - 1000



Push Button Switches:

1. Power switch energizes the system and indicates the system status,
2. score switch controls the oscilloscope display,
3. clear switch clears the micro-processor averager memory resets the sample display counter and connects the micro-processor operating mode to correspond to the current control status,
4. start/stop push button initiates the micro-processor averager function. As the number of sample accumulates, the averager can be stopped to evaluate intermediate results and re-started without disturbing the averager action. The averager function is automatically terminated when the selected number of samples has accumulated or when any average memory channel is full; automatic termination required a clear to permit restart,
5. record push button indicates that the plotter readout of the averager is not active,
6. mask push button applies broad band noise to the contralateral ear only when either air left or air right stimulus is active,
7. air left stimulus is used for left earphone,
B. air right stimulus is used for right ear-phone, and
9. bone push button stimulus to bone vibrator transducer.

TA-1000 has 4 Knobs :

1. The stimulus function knob which permits selection of frequencies 2 KHZ, 4 KHZ or 6 KHZ at a repetitive rate of 5 or 20 stimuli per second, and patient's res-ponse intervals of 10 msec or 20 msec immediately following the acoustic logon stimulus,
2. stimulus attenuation knob permit to estab—list the presentation level from 0 dBHL to 100 dBHL,
3. the scale function knob which permits selection of system sensitivity and number of average responses samples, i.e., for 2048 samples 0.2, 0.5, 1 and 2/uV per div. sensitivities are available.

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For 4096 samples 0.1/uV, 0.2/uV, 0.5/uV and 1/uV par div. sensitivities are available, and

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

2.3 Test Environment:

The study was carried out in an :-

1. Acouatically sound treated dimly lit room,
2. Room was well ventilated,
3. Room was away from noise sources and electrical appliances; fans were not used at the time of testing,
4. Room was away from excessive vibrations, and
5. Curtains were drawn to avoid direct sun-light.

2.4 Test Procedure:

Subjects were tested in supine position, no sedation was given. Ideally subjects were asked to go to sleep during the recording since sleep does not alter the BAEP signals, but greatly reduces electro-myographic (EMG) noise. Subjects were asked to relax on a bed with a pillow under the neck to encourage neck muscles to relax.

Skin was cleaned with spirit. Surface electrodes were also cleaned with spirit and placed on the skin. Electrode gel was smeared on the electrodes. Each electrode was then fixed to the skin with adhesive tape.

Placement of Electrodes:

a) Red or signal electrode on high forehead,
b) white or reference electrode on mastoid of test ear, and
c) black or ground electrode on mastoid of non-test ear. The AC logon stimuli was given to right earphone only.

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During the test, the electrodes were not changed by removing them from the skin but for contralateral testing the reference and ground electrodes were changed in the electrodes socket.

AC logon stimuli were presented at three intensities (100 dB, 80 dB, and 60 dB respectively). Recordings of parameters such as latency, amplitude were made. The test conditions were identical for both ipsilateral and contralateral tests.

The power switch was put on. The TWF/RUN/EEG switch was on 'RUN' position. The scale switch was set to 2048 samples and 2/uV/Div. Rate of presentation of stimuli was kept constant 20/sec. The frequency under test was 2 KHZ. A sample time of 10 msec was chosen.

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

The test data was rejected when :-

a) tha limit light flickered often during the testing,

b) the counter stopped before reaching 2048 samples, and

c) if the oscilloscope display faded out completely during recording.

2.5 Treatment of Data:

The following were determined:-

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

b) Amplitude: Amplitude was measured in uV (microvolts), the marker amplitude M(l/2/3/4 div.) and the amplitude of the desired trace feature 'T' was noted. The scale switch amplitude 'S' (2/uV/div) was noted. The formula used: Amplitude=TS/M.

From the data so obtained computation for the following was done using Wilcoxon matched pair signed

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rank test (Siegel, 1956).

1. Mean and standard deviation for Absolute Latency and Absolute Amplitude for peaks II, III, IV and V in both ipsilateral and contralateral conditions for AC logon stimuli at intensities of 100 dB, 80 dB and 60 dB respectively, and

2. significance of difference for AC logon at intensities of 100 dB, 80 dB and 60 dB for peaks II, III, IV and V where the ipsilateral and contralateral data was compared for both amplitude and latency.

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RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The aim of the present study was comparison of ipsilateral and contralateral recordings for II, III, IV and V peaks.

The raw data was analysed for mean and standard deviation for II, III, IV and V peaks at different intensities 100 dB, 80 dB, and 60 dB respectively for AC logon stimuli. The test frequency was 2 KHZ.

TABLE I: It shows the mean and standard deviation for Absolute Latency and Absolute Amplitude for Peak II in the ipsilateral and contralateral conditions.

TABLE II: It shows the mean and standard deviation for Absolute Latency and Absolute Amplitude for Peak III in both ipsilateral and contralateral conditions.

TABLE III: It shows the mean and standard deviation for Absolute Latency and Absolute Amplitude for IV peak in both ipsilateral and contralateral conditions.

TABLE IV: It shows the mean and standard deviation for Absolute Latency and Absolute Amplitude for peak V in both ipsilateral and contralateral conditions.

TABLE V: It illustrates the significance of difference of AC logon stimuli for peak II where ipsilataral and contralateral recordings are compared at intensities 100 dB, 80 dB and 60 dB, respectively.

TABLE VI: It illustrates the significance of difference for AC logon stimuli for peak III where ipsilateral and contralateral recordings are compared at 100 dB, 80 dB and 60 dB respectively.

TABLE VII: It illustrates the significance of difference for AC logon stimuli where IV and V peaks are compared to both ipsilaterai and contralateral recordings at intensities 100 dB, 80 dB and 60 dB respectively.

Discussion:

Wilcoxon matched pairs signed rank test was used (Siegel, 1956).

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The results so obtained reflect a more conclusive separation of IV and V peaks in contralateral recordings at lower intensities level, i.e. 80 dB and 60 dB.

The Absolute Latency and Absolute Amplitude is not significantly different for ipsilateral and contralateral recordings, but the morphological changes so indicated by the two separate recordings, i.e., ipsilateral and contralateral as also supported by the literature has its own potential in diagnoses.

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TABLE 1: Mean and Standard Deviation for Absolute Latency and Absolute Amplitude for Peak II in Ipsilateral and Contralateral Conditions.

Intensity	Ipsilateral		Contralateral		Ipsilateral		Contralataral	
	Latancy				Amp1itude			
	M		M		M		M	
100	1.54	.80	1.45	1.0	.095	.085	.061	.070
80	1.64	1.03	1.69	1.28	.092	.116	.128	.153
60	1.34	1.54	.94	1.48	.046	.075	.067	.146

TABLE II: Mean and Standard Deviation for Absolute Latency and Absolute Amplitude for Peak III in both Ipailateral and Contralateral conditions.

Intensity	Ipsilateral		Contralateral		Ipsilateral		Contralateral	
	Latency				Amplitude			
	M		M		M		M	
100	2.98	0.132	2.98	.156	.356	.237	.204	.123
80	3.05	.781	2.77	1.23	.266	.165	.210	.130
60	2.83	1.69	2.75	1.66	.133	.136	.113	.110

TABLE III: Mean and Standard Deviation for Absolute Latency and Absolute Amplitude for IV Peak in both Ipailateral and Contralateral Conditions.

Intensity	Ipsilateral		Contralateral		Ipsilateral		Contralateral	
	Latency				Amplitude			
	M	σ	M	σ	M	σ	M	σ
100	3.42	3.41	3.80	.935	.180	.130	.254	.156
80	2.21	2.07	3.43	1.79	.119	.169	.196	.175
60	1.75	2.22	1.39	2.18	.039	.965	.046	. 10

TABLE IV: Mean and Standard Deviation for Absolute Latency and Absolute Amplitude for Peak V in both Ipsilateral and Contralateral Conditions.

	Ipsilateral		Contralateral		Ipsilateral		Contralateral	
Intensity	M		M		M		M	
100	4.79	.171	4.93	.225	.563	.214	.353	.227
80	5.05	.182	5.17	.178	.465	.186	.372	.179
60	5.26	1.27	5.55	.264	.307	.195	.222	.140

TABLE VI Significance of Difference for II Peak: Comparison of Ipsilateral and Contralateral Recording are Compared at Intensities 100 dB, 80 dB and 60 dB.

Mode	Intensities		
	100	80	60
Ipsilateral	X	X	X
Contralateral	X	X	X

KEY: X indicates no significant difference P > .01 level

TABLE VI: Significance of Difference for III Peak: Comparison of Ipsilateral and Contralateral Recordings are Compared at Intensities 100 dB, 80 dB and 60 dB.

Mode	Intensities		
	100	80	60
Ipsilateral	X	X	X
Contralateral	X	X	X

KEY: X indicates no significant Difference P >.01 level.

TABLE VII: Significance of Difference in Comparison of IV peak with V peak for Ipsilateral and Contralataral Recordings are Compared at Intensities 100 dB, 80 dB and 60 dB respectively.

Mode	Intensities		
	100	80	60
Ipsilateral	X	X	X
Contralateral	X	-	-

KEY: X indicates no significant difference P > .01.
- indicates significant difference at .05 level.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present study was conducted to compare the ipsilateral and contralateral tracing of BSERA for AC logon stimuli.

20 subjects with normal hearing in the age group of 17 to 25 years were selected for the purpose of study. The frequency under test was 2 KHZ. The scale was set to 2048 samples and 2 /uV/Div. Rate of presentation of stimuli was kept constant 20/sec. A sample time of 10 msec waa chosen. AC logon stimuli was presented at 100 dB, 80 dB and 60 dB respectively. The test environment was identical for both ipsilateral and contralateral recordings.(Figs.13,14,15,16 and 17).

For II peak ipsilataral and contralateral tracing, no significant difference was observed.

For III peak ipsilateral and contralateral tracing no significant difference was observed.

For IV and V comparison in ipsilateral and contralateral tracing, no significant difference was observed at 100 dB, 80 dB, and 60 dB (ipsilateral and 100 dB contralateral). But at .05 level significant difference was observed at 80 dB and 60 dB contra-lateral tracings.

Implication of the Study:

The principal advantage of recording ipsi-lateral and contralateral responses simultaneously in adults is that there is a general correspondence between waveforms from the two derivations which allows the relatively minor changes that occur to be helpful in differentiating components.

There are several possible explanations for the lack of similarity between neonatal ipsilateral and contralateral recordings as compared to adults. The intensity of the stimulus reaching the contralateral cochlea differs from that presented to the test ear by an amount known as the interaural attenuation (IA).

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FIGURE: 13: Ipsilateral and Contralateral Recording Samples.

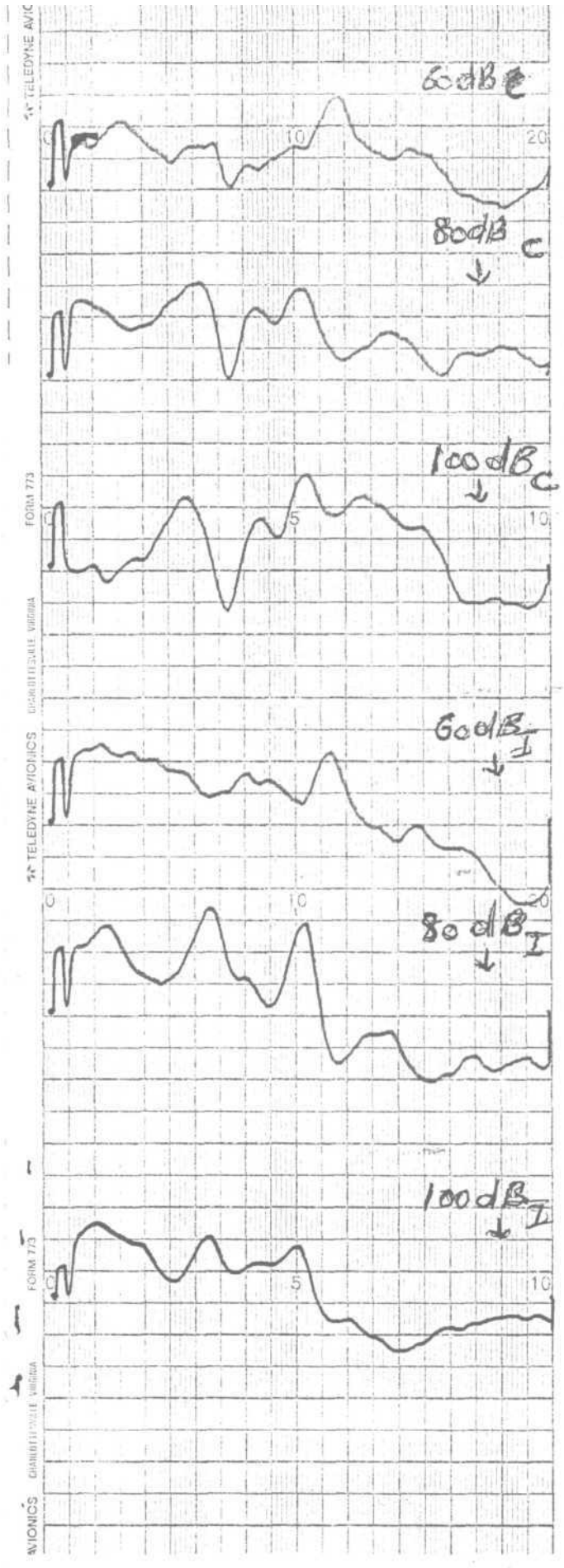


FIGURE 14: Ipsilateral & Contralateral Recording Samples

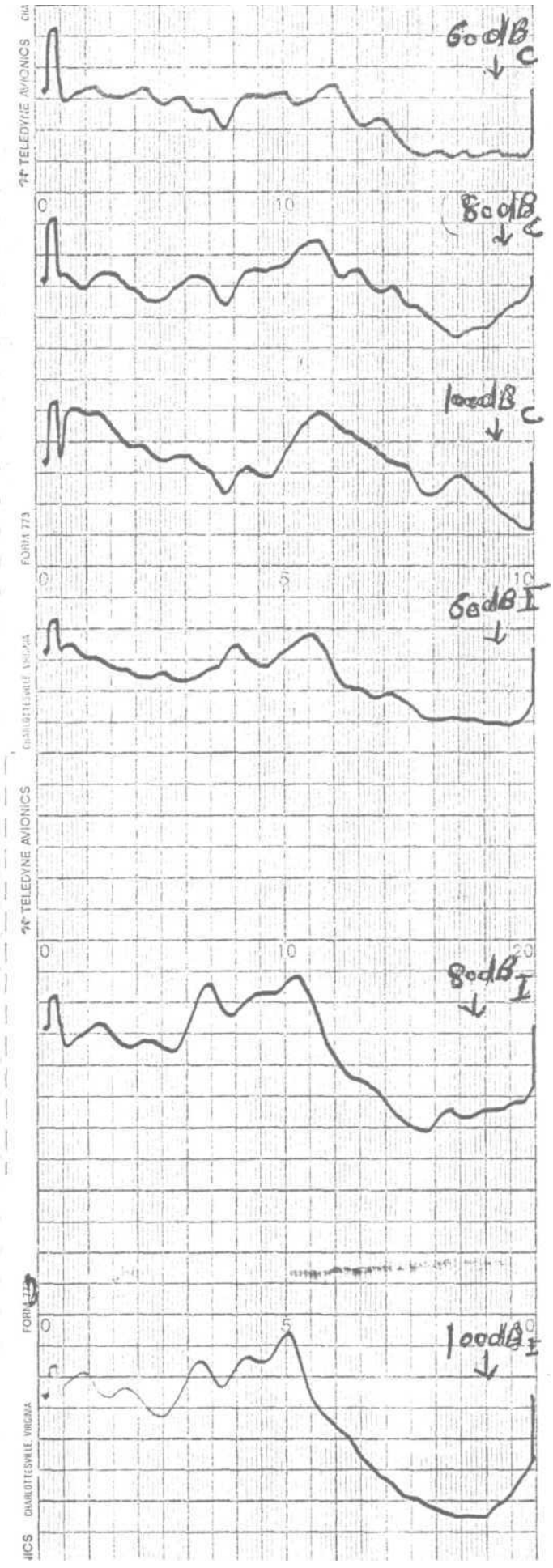


FIGURE 15: Ipsilateral and Contralateral Recording Samples

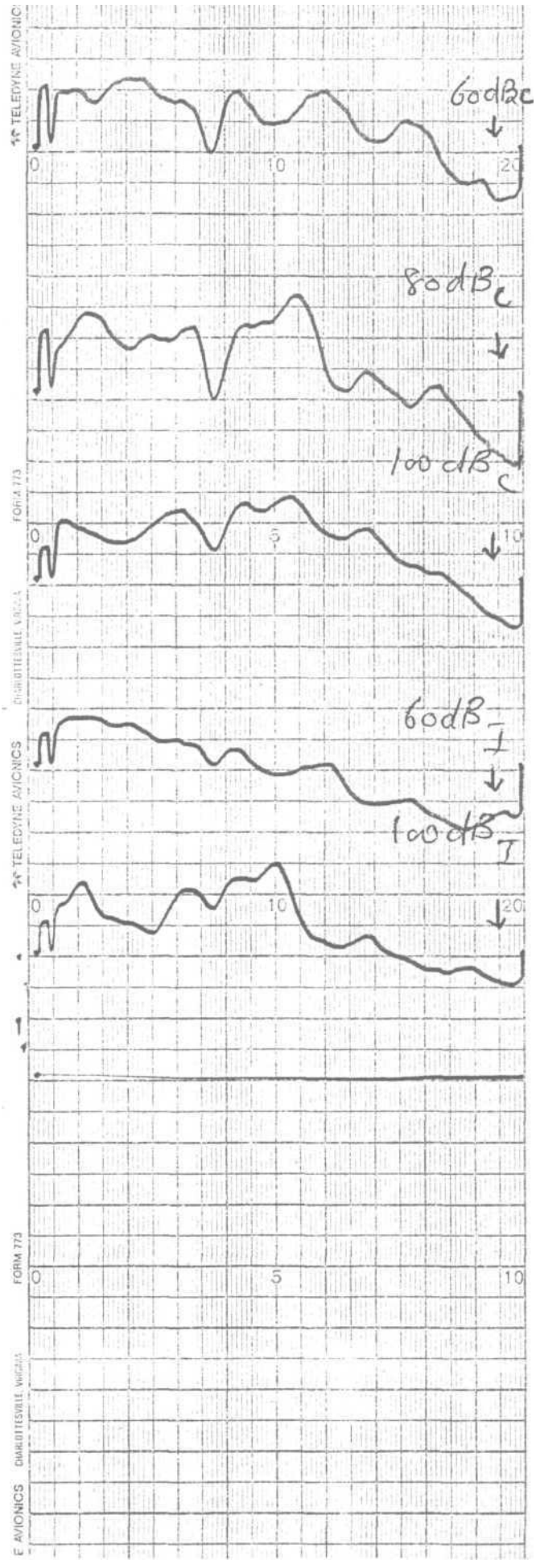


FIGURE 16: Ipsilateral and Contralateral Recording samples.

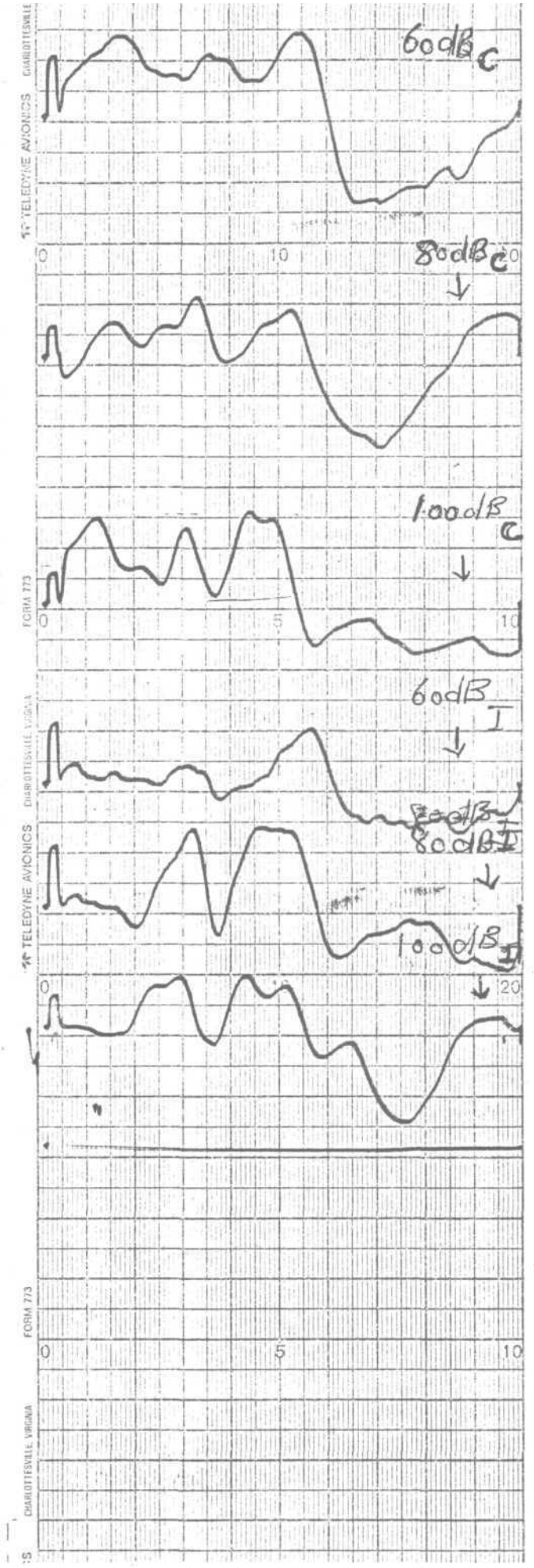
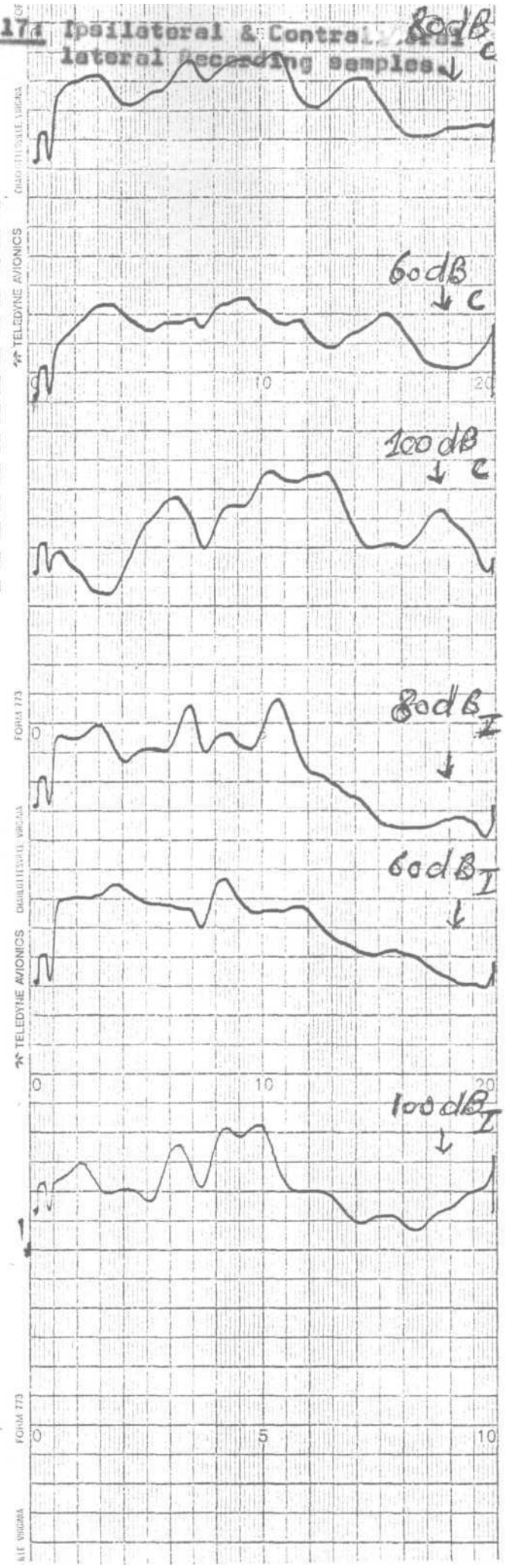


FIGURE 17 Ipsilateral & Contralateral Recording samples



The lower the IA, the greater the likelihood of eliciting a response from the contralateral cochlea. The IA of neonate may differ from the adults. It is also possible that the generators differ for the two population, (Edward, 1985).

The contralataral responses showed minor but predictable differences from ipsilateral response. In the contraiateral recordings wave I is greatly reduced in amplitude. Wave III is smaller in amplitude. Wave V latency is usually about .1 msec to .2 msec later thereby increasing the wave IV to wave V latency interval and allowing independent resolution of the two peaks which are frequently fused in the ipsilateral recordings.

The results agree with Edward, 1985 results.

The BSER does appear to be a powerful tool for diagnosis of acoustic neuroma. Contralateral and ipsilateral recordings as indicated by research (Moore, 1985; Martin, Achor and Starr, 1980 among others) have their own place in the technique of BSERA.

It can be concluded that comparison of ipsilateral recording with contralateral recording are vital in clinical application of BSERA.

Limitations:

The present study was limited to a single frequency 2 KHZ and AC logon stimuli of 100 dB, 60 dB and 60 dB. The developmental course of the contralateral response is not known. The usefulness of the response as a measure of auditory brain-stem maturity is, therefore, unknown. Much research is warranted in this direction.

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