THEEFFECT OF BINAURAL NOISE AND SENSITIVITY
ON BRAIN-STEM EVOKED RESPONSE

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CERTIFICATE

This is to certify that this Dissertation entitled "THE EFFECT OF BINAURAL NOISE AND SENSITIVITY ON BRAIN-STEM EVOKED RESPONSE" is the bonafide work submitted in part fulfilment for the Degree of Master of Science (Speech and Hearing) of the student with Register No.8411.

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CERTIFICATE

This is to certify that this Dissertation entitled "THE EFFECT OF BINAURAL NOISE AND SENSITIVITY ON BRAIN-STBM EVOKED RESPONSE" Has been prepared under my guidance and supervision.

GUIDE

DECLARATION

This Dissertation entitled "The Effect of Binaural Noise and Sensitivity on Brain-Stem Evoked Response" is the result of my own study undertaken 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.

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INTRODUCTION

The presence of electrical potentials in the brain was firs noted by Caton (1875) who managed to record electrical changes in the exposed brain of rabbits and monkeys. Despite extensive investigation of the functions of the nervous system, it was not until over fifty years later that Hans Berger, a neurologist from Jena recorded the first human electroencephalogram (EEG) from electro placed on the scalp (Berger 1929).

Evoked Responses:-

When any sensory system is stimulated, action potentials are generated in the afferent neurons and propagated centrally through a variable number of synaptic relays. The electrical activity which accompanies these events is detectable using appropriat ly placed electrodes and amplification. These electrical signs of activity in the afferent pathways are called evoked responses or evoked potentials.

The aim of evoked response audiometry is to record the potentials which arise in the auditory system as a result of sound stimulation. The waves having latency greater than 10 m.secs (time interval from stimulus to appearance of response) have been studied for some years (cortical responses). More recently the electrical events occurring during the first 10 ms have received greater attention (Cochlear, 8th Nerve and Brain-Stem responses).

The Clinical Uses of Evoked Response Audiometry:-

There are three main applications for ERA within the clinic.

1. As a means of estimating hearing acuity.
2. As a method of diagnosis-identifying the cause of a hearing defect or detecting some lesion which is affecting the

auditory pathway.

3. As a means of monitoring the effects of surgical or pharmacological intervention upon the auditory mechanism.

Nature of the Auditory Evoked Response:-

Auditory evoked responses are classified by response latency Response waveform or by probable site of origin (Table-1). There are four latency classifications, each measured in msecs: Early response- 0-8 ms; middle response- 8 to 50 msec; Late response- 50-300 msec; Very late response- 300 msec and beyond (fig.l)

When considered with respect to the temporal characteristics of the response waveform, 3 classifications may be used: fast, with relatively rapid or high frequency components; slow, with low-frequency components; and very slow which is actually a prolonged shift in the baseline of the recordings, or a DC shift. The probable site of origin of each type of response is still a matter of speculation in many cases. There appears to be a consensus, however, that responses may be obtained specifically from the cochlea and auditory nerve, the Brain-Stem, the primary and secondary auditory cortical projection areas and cortical association areas.

Historical aspects of Brain-Stem Evoked Response:-

The acoustic brainstem response represents synchronous neuroelectric activity of many neural elements from locations deep within the brain that can be recorded with surface electrodes.

Table: Response Latency Classification

Classification	Origin	Waveform	Latency (msecs)	Amplitude (uV)
Early	Brain-Stem	Fast (100-3000 Hz)	4-8	0.01 - 1
Middle	Primary Cortical Projection Areas	Fast (5-100 Hz)	8-50	1.0 - 3
Late	Primary Cortical Projection Areas and Secondary Association areas	Slow (2-10 Hz)	50-300	8.0 - 20
Very late expectancy wave	Secondary Association Areas	Slow	230-360	10-90
Contingent negative variation (CNV)	Prefrontal cortex and Secondary Association Areas	DC	300 plus	20 - 30

Adapted from

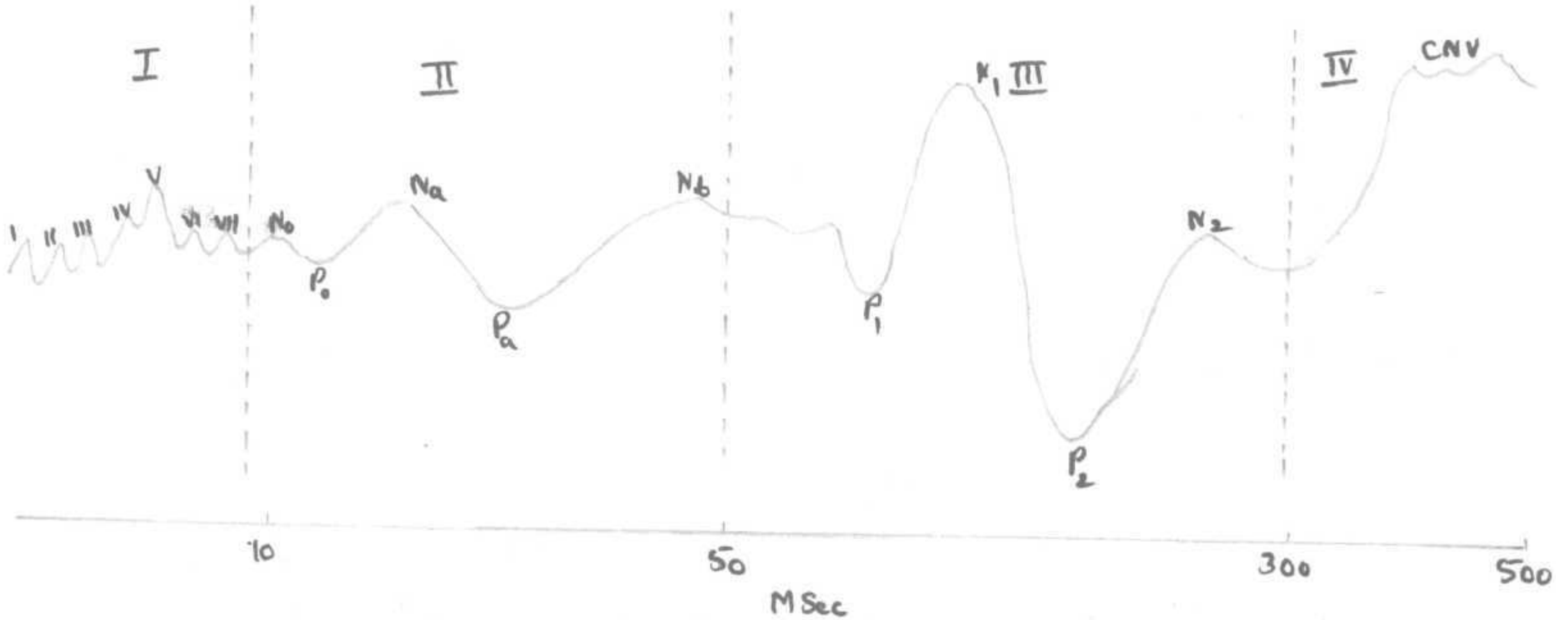


Fig.1: Schematic representation of four classes of auditory evoked potentials
(Adapted from Skinner, P.H., 1978)

The first published reports of the human ABR (Auditory Brainstem Response) appeared in articles by Sohmer and Feinmesser (1967) and Yoshie (1968). Sohmer and Feinmesser (1967) observed series of 4 negative waves referenced to the bonybridge of the no The first two waves were clearly counterparts to the N1-N2 comple recorded with a transtympanic electrode, and these waves were bel ved to reflect the activity of the acoustic nerve. The third and fourth waves however, were of speculative origin, although they were believed to reflect either the repetitive firings of the acoustic nerve or activity in the brainstem auditory nuclei.

Fair-Field Potentials:-

In the United States, Jewett and his colleagues introduced the concept of "far-field" potentials. This engineering term was used to describe the situation where electrodes on the surface of the scalp recorded the activity of distant neural generators. Jewett et al (1970) published an early report of the ABR in 3 human subjects, but the classic paper was published by Jewett and Williston (1971).

Jewett and Williston (1971) demonstrated that the normal human ABR consisted of 5 to 7 vertex positive waves occurring in the first 9 msecs following a click stimulus.

Wave I : from the auditory trunk
Wave II : from cochlear nucleus
Wave III : from the superior olivary complex
Wave IV : from the nucleus of the lateral lemniscus
Wave V : from the inferior colliculus

This wave series was impressively consistent across and within subjects. Wave V was the most prominent component of the response, and the most robust in its resistance to the effects of increased stimulus repetition rate. Wave VI was a fairly consistent part of the response, but wave VII occurred inconsistently across subjects.

Starr and Achor (1977) doubt, however that the wave v is generated by the inferior colliculus and have suggested that the generator lies caudal to this site.

Effect of Stimulus Parameters on Brainstem Response:-

Blegvad (1976) has shown that if the stimulus is delivered to both ear simultaneously, then binaural summation occurs. A 50 dB binaural stimulus evokes an equal amplitude to that of an 80 dB monaural stimulus. The implications during free-field testing are evident.

The amplitude and latency functions of brainstem response are remarkably constant on repeated or prolonged stimulation. Thorntor (1974) and Thornton and Coleman (1975) found no significant variations in normally hearing subjects who had four replicates of four stimulus levels during two test sessions.

With increasing stimulus intensity, the amplitude of the first wave increases in a similar manner to the action potential to transtympanic ECochG. except that it is some twenty times smaller. The amplitude of the later waves from the brainstem nuclei increase little with increasing stimulus intensity and at high intensities the amplitude occasionally is decreased. The latency of each of the waves decreases by almost similar amounts as the stimulus intensity increases.

A number of investigators have stated that the frequency of the stimulus does not affect the form of the evoked response.

Clinical Applications of Brainstem Evoked Response:-

Audiological Applications:- In the audiological setting, the ABR is most often used in the evaluation of auditory sensitivity in neonates and infants (Hecox and Galambos 1974), in young children who are too young, or immature to be tested with conventional audiometry, in children vith malformations of the External Ear and meatus (Hieber, Hecox and Cone,1979), in malingerers of all ages, and in special populations such as the deaf-blind (Stein, Daniels, Ozdamor 1979), the Mentally Retarded (Buchwald and Squire 1979) and the multiply handicapped.

Another audiologic application of the ABR is in the screening of hearing in infants. One additional application of the ABR is to differentiate between a cochlear and a retrocochlear lesion in cases of sensori-neural hearing loss. (Galambos and Hecox 1977; Yamada et al 1975; Sanders et al 1978; Salters and Brackmann 1977),

Neurologic Applications:- Utilization of the ABR in neurologic applications has expanded since the initial reports of Sohmer, Feinmesser and Szabo in 1974 and Starr and Achor in 1975 such that it has become a growing new subdiscipline of neurology and neurosurgery. The clinical value of the ABR in the diagnosis and localization of the brainstem lesions has now been demonstrated for a wide variety of neurologic disorders. The effects on the ABR of tumours and structural lesions in the auditory pathway in the brain stem and midbrain have been reported by several groups of investigators (Starr and Achor, 1975; Stockard, Stockard and Sharbrough, 1977).

Need for the Study:-

The effect of noise on brainstem evoked response is of interest from several perspectives. Studies on ipsilateral and dontralateral masking effects on brainstem evoked response have been carried out by various investigators. The studies have shown that there is an increase in latency and decrease in amplitude especially for wave V. The effect has been ascribed to central masking. An attempt has also been made to improve the frequency specificity of the brainstem evoked response (Don and Eggermont 1978; Picton et al 1979).

It is not known how the binaural noise affects the latency and amplitude of brainstem evoked response. Hence, an attempt is made to study the effects of binaural noise on brainstem evoked response in normal hearing subjects.

It is not known how the different values of sensitivity affects the brainstem evoked response. There is a need to know at which sensitivity values, the brainstem responses would be better. Hence, an attempt is made to study the effect of sensitivity on brainstem evoked response in normal hearing subjects.

Statement of the Problem:-

1. To study the effect of binaural noise on latency and amplitude of brainstem evoked responses in normal hearing subjects.
2. To study the effect of change of sensitivity on latency and amplitude of brainstem evoked responses in normal hearing subjects.

Questions:-

Questions:-

1. Is there any effect of binaural noise on the latency and amplitude of the brainstem response obtained at 2KHz?
2. Is there any effect of binaural noise on the latency and amplitude of the brainstem response obtained at 4 KHz?
3. Is there any effect of binaural noise on the interpeak latency of the brainstem response obtained at 2 KHz?
4. Is there any effect of binaural noise on the interpeak latency of the brainstem response obtained at 4 KHz?
5. Is there any significant effect of sensitivity values on amplitude and latency of the brainstem response obtained at 2 KHz?
6. Is there any significant effect of sensitivity values on amplitude and latency of the brainstem response obtained at 4 KHz?

Clinical Implications of the Study:-

The results of the present study would be useful in interpreting the brainstem evoked responses obtained in the presence of binaural noise.

Information will be obtained regarding the amplitude and latency of brainstem response in normals using the following sensitivity values: 0.2uv,0.5 uV, 1.0 uV and 0.1 uV.

Definitions of the terms used:-

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

Absolute latency:- The time relationship between stimulus onset and associated response.

Interwave latency:- Refers to the time difference between two component waves. eg. I-V latenqy

Response amplitude:- Refers to the height of a given vave componen measured in microvolts from the peak of the wave to the following trough. Also called as absolute amplitude.

Relative amplitude:- The absolute amplitude of ABR components can be expressed in relation to one another commonly called as "relative amplitude".

REVIEW OF LITERATURE

The presence of electrical potentials in the brain was first noted by Caton (1875) who managed to record electrical changes in the exposed brain of rabbits and monkeys. It was not until over fifty years later that Hans Berger, a neurologist from Jena, recorded the first human electroencephalogram from electrodes pla on the scalp (Berger, 1929).

The History and Development of Evoked Response Audiometry:-

Measurement of the electrical potentials which arise in the auditory system as a result of sound stimulation has been a tool for animal research for many years. Until recently this technique could not be applied to the human except under surgical condition: because of the small potentials which arise in the human auditory system. The development of small computers has made it possible to extract these minute potentials from background electric interference and has made electric response audiometry practical in the clinical setting.

There are three types of evoked response audiometry: Electrocochleography; Brainstem evoked response audiometry and Cortical evoked response audiometry.

The auditory brainstem response represents synchronous neuroelectric activity of many neural elements from locations deep within the brain that can be recorded with surface electrodes.

The first published reports of the human ABR appeared in articles by Sohmer and Feinmesser (1967) and Yoshie (1968). Sohmer and Feinmesser (1967) observed a series of 4 negative waves referenced to the bony bridge of the nose.

In the United States, Jevett and his colleagues introduced t concept of far-field recordings. This engineering term was used to describe the situation where electrodes on the surface of the scalp recorded the activity of distant neural generators.

Jewett and Williston (1971) demonstrated that the normal human ABR consisted of 5 to 7 vertex positive waves occurring in first 9 msec following a click stimulus. The presumed source of each of these waves are as follows:-

Wave I : from the auditory trunk
Wave II : from cochlear nucleus
Wave III : from the superior olivary complex
Wave IV: : from the nucleus of the lateral lemniscus
Wave V : from the inferior colliculus
Wave VI : from the medial geniculate body
Wave VII : from the primary auditory reception areas.

Anatomical Origins of Response Components:-

From the very beginning, various investigators have speculated about the origin of ABR component waves. There seemed to be good evidence that the first and perhaps the second wave reflected activity of the bipolar cells of the acoustic nerve, but later waves we only suspected to reflect activity of brainstem auditory structures Several investigators have attempted to verify experimentally the neural generators of ABR component waves.

The literature in this area can be divided into two categories those investigating neural generators in animals (such as the cat) and those investigators aimed at obtaining human data to confirm wave sources.

Animal Studies:-

Animal studies were carried out by the following investigators: Jewett (1970); Lev and Sohmer (1972); Buchwald and Huang (1975); and Starr and Achor (1978). These studies showed that th integrity of the inferior colliculus was essential to wave V; integrity of the acoustic nerve and cochlear nucleus for waves I and ! respectively. Waves I and V appeared to reflect activity from un^ lateral neural generators, waves II and III originated in bilater generators, waves IV appeared to have its origin in either a midline or bilateral generator (Allen and Starr, 1978).

Human Studies:-

Lev and Sohmer (1972) speculated that the similarity between the cat and human ABR suggested that the human response may reflec similar neural generators. Subsequent studies (Sohmer et al 1974; Starr and Achor, 1978; Starr and Hamilton, 1976; Stockard and Rossieter, 1977) examined alterations of the ABR in patients with confirmed 8th nerve and brainstem lesions. These studies demonstrated that wave I was typically the only remnant when lesions involved the ponto-medullary junction or when the brainstem was extensively damaged. Alterations of waves II and III were associa with lesions in the medulla and pons; i.e. the cochlear nucleus, trapezoid body, and superior olive. Lesions affecting midbrain and structures were associated with changes in waves IV and V.

A composite impression of the data reviewed above has motivated several investigators to assign a specific correspondence between given ABR component waves and specific neural generators. A diagrammatic representation of this correspondence is shown in figure 2.

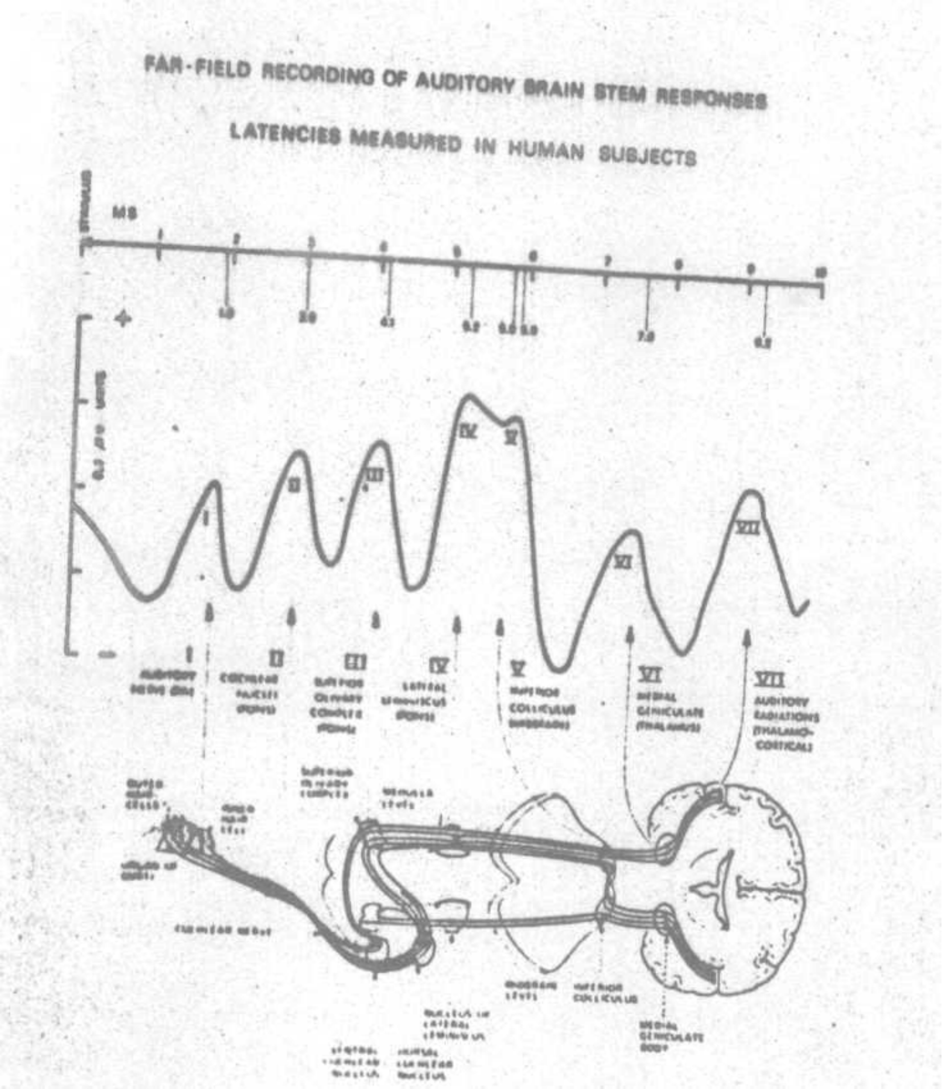


Fig 2:- Anatomic correlation of components of short latency auditory evoked response (ref.Keith, R.W., Central auditory dysfunction. New York, Grune and Stratton, INC, P.11, 1977).

The figure 2 suggests a correspondence between vave I and the 8th cranial nerve; wave II and the cochlear nucleus; Wave III and the superior olivary complex; Wave IV and the lateral lemnisc and wave V and the inferior colliculus. Such an association, especially for waves II through V must be considered hypothetical for at least two reasons. First, the brainstem lesions of patients in human studies more often extensive and diffuse, making a one to one correspondence between given waves and neurologic structures difficult to conceive. Secondly, it has been shown that each surface recorded ABR component wave probably reflects the composite activity of several neural generators. As Starr and Hamilton (1976) point out, a click will evoke cochles nucleus potentials with latencies from 2 to 8 msecs. (Fria,1980)

Consequently the relationship depicted in figure is highly simplified, and it must be recognized that several neural generators interact to produce AER waves II through V.

Normal Response Parameters:-

The use of the ABR for clinical purposes obviously involves the recognition of abnormal results. Such recognition depends on a knowledge of normal ABR characteristics. The clinician must also be cognizant of the variability of normal characteristics between and within subjects, and the variability due to non-pathologic factors, such as the nature of the stimulus, recording procedure, and subjects.

Response Morphology:- Morphology, here refers to visual appearance or waveform. It is a more subjective parameter than the latency or amplitude, because morphology cannot be specified in measurabl units such as msecs or microvolts.

Chiappa et al (1979) described 6 variant forms in normal young adults (fig.3). The variants were labelled A-F and consisted of: A. a single peak with no separation of waves IV and V;
B. Separate IV and V waves with wave IV lower than wave V;
C. Separate waves with wave IV higher than wave V;
D and E. Wave V riding on wave IV and wave IV riding on wave V respectively, with the riding wave looking more like a "shoulde than a peak; and
F. Separate waves of the same height.

In normal adult subjects wave V is the most frequently observed component of the ABR in response to high intensity clicks, whereas waves II and IV are seen with the least frequency (Rowe, 1978).

Response Latency:- The time relationship between any response and the stimulus eliciting that response is commonly called latency. For the ABR this parameter is designated as absolute wave latency or Interwave latency (fig.4). Absolute latency conforms to the traditional definition; the time relationship between stimulus onset and associated response. Interwave latency, however refers to the time difference between two component waves. eg. I-V interwave latency. Both absolute and interwave latency values are typically specified in msecs.

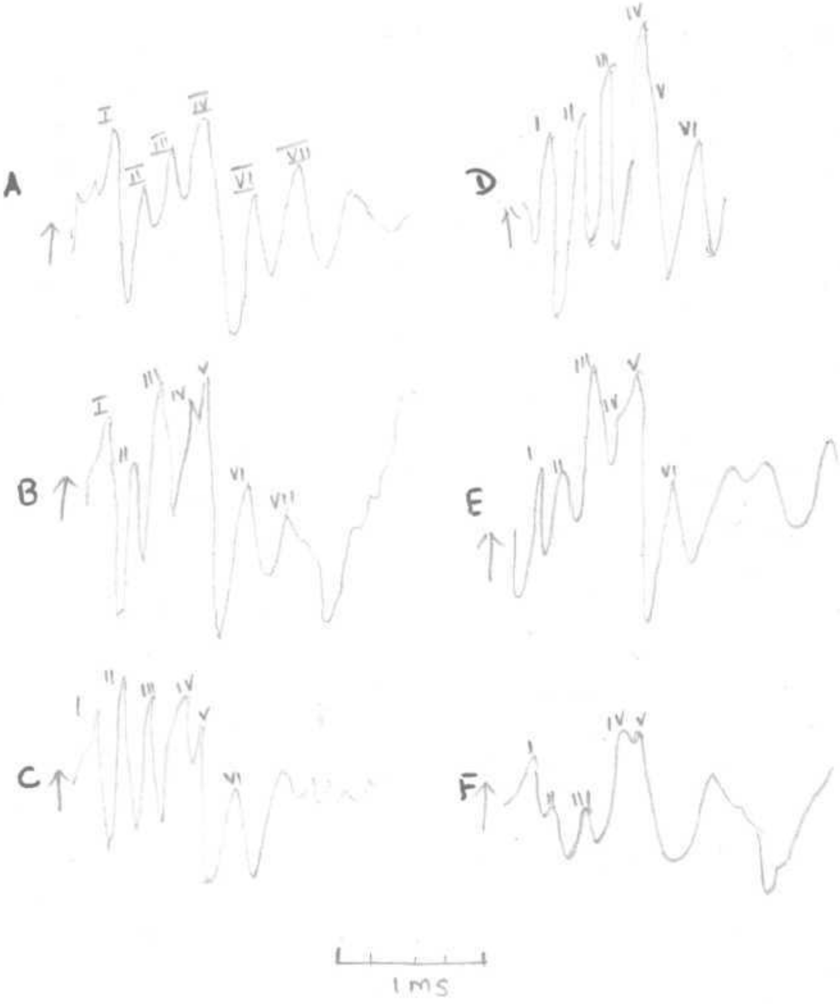


Fig.3 : Possible variations in the morphology of the IV-V complex for normal adult subjects (As reported by Chiappa et al 1979).

Beagley and Sheldrake (1978) observed an interesting coincidence. The absolute latency of ABR component waves, in respons to high intensity clicks is approximated by the Roman numeral designating the wave; eg. Wave I latency falls between 1.0 and 2.0 ms, wave II between 2.0 and 3.0 ms and so on.

Selters and Brackmann (1977) reported that the wave V latency difference between ears of the same normal adult subject was less than 0.2 ms. Rove (1978) reported that normal inter-ear latency differences were within 0.4 ms for waves I through V in 95% of the 25 subjects evaluated.

There is an increasing tendency to foucs on the I-III,-V and I-V interwave latencies. The I-III value estimates transmission time through the ponto-medullary junction and lower pons; and the 111-V values estimates transmission time from caudal pons to caudal midbrain levels. The I-V latency estimates the time needed for impulses to travel the entire system and is sometimes called "central" or "brain-stem" transmission time. The I-V interwave latency approximates 4.0 ms and slightly more than half of this time can be attributed to the I-III interwave latency. (Stockard and Rossiter, 1977).

Response Amplitude:- In the context of ABR, response amplitude refers to the height of a given wave component, and it is usually measured in microvolts (uV) from the peak of the wave to the following trough. This measurement is sometimes called as absolute amplitude. The absolute amplitude of ABR component waves can also be expressed in relation to one another, and these measurements are commonly called relative amplitude (fig. 5)

The variation of normal values for ABR wave component amplitude has been observed to be substantial by a number of investigators (Amadeo and Shagass, 1975; Chiappa et al 1979; Starr and Achor 1975). Hence, Starr and Achor (1975) suggested measuring the relative amplitude of waves V and I.

Factors Affecting Normal Parameters:-

The nature of the stimulus, recording procedures and subjects evaluated all have associated effects on the response (Fria,1980).

I. Stimulus Effects:- Pertinent stimulus characteristics include intensity, repetition rate, polarity, envelope (rise-fall time and duration), and presentation mode (monaural vs. binaural). Certain characteristics have an isolated effect on the response, but there is evidence (Stockard et al 1979) that stimulus factors can exert an interactive influence.

Effects of Intensity:- In the context of ABR measurements, stimulus intensity is designated as either a given number of dBs above an individual's threshold for that stimulus (dBSL) or above the threshold of a panel of normal hearing young adults (dBHL). Certain investigators (for eg. Davis and Hirsh, 1978) have suggested designating intensity as dBnHL whenver levels are referred to threshold of a panel of normal hearing young adults; when levels are referred to individual's threshold for

Fig.4: Diagram shoving the distinction between absolute and intervave latency for component waves of the brainstem electrical response (BER). (Adapted from Fria, T.,1980).

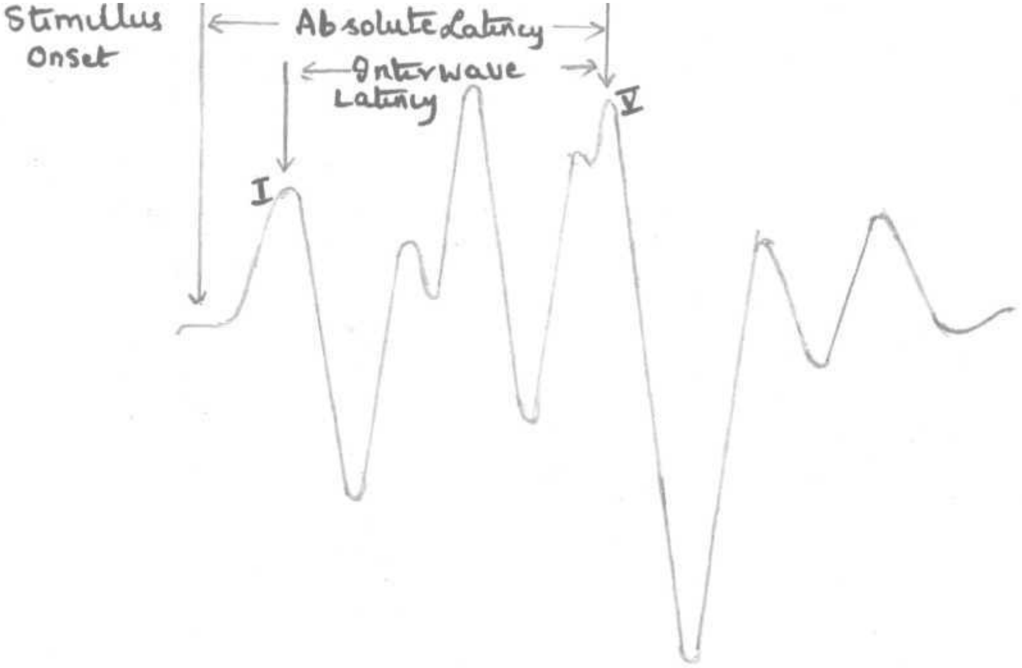
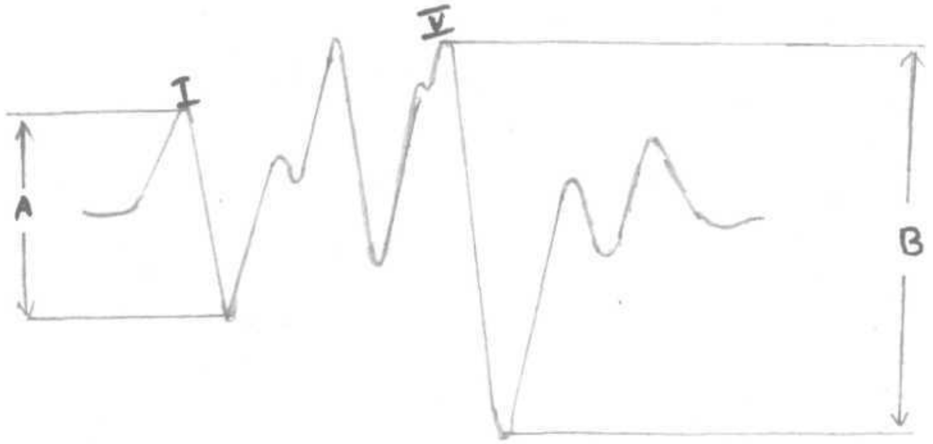


Fig.5: Diagram showing the distinction between absolute and relative amplitude in the context of the brainstem electrical response (BER). (Adapted from Fria, T., 1980).



that stimulus, the designation dBSL is preferred.

At intensities below approximately 40 dB nHL, waves I and III are seen more frequently than II and IV; but wave V often is the only remaining wave in response to stimulus intensities that approximate threshold levels (Rowe 1978).

In general a decrease in stimulus intensity is associated with an increase in component wave latencies (Jewett and Williston,1971; Jewett et al 1970; Hecox and Galambos 1974; Picton et al 1977; Starr and Achor, 1975; Yamada et al 1975). The intensity related effect on latency for a given ABR wave is often displayed on a graph, with the abscissa and ordinate representing intensity and latency, respectively. The curve showing this relationship is commonly called a "latency-intensity function".

The I-V interwave latency is resistant to stimulus intensity changes; but there is some disagreement in the literature on this point. Rowe (1978) and Stockard et al (1978b) observed minimal change in interwave latency when stimulus intensity was decreased.

The general reduction in ABR amplitude with decreasing stimulus intensity has been recognized. Stockard et al (1978b) observed, however, that a 50 dB reduction in stimulus intensity was associated with a 33% decrease in amplitude of the IV-V complex; while the same reduction in intensity was associated with a 90% decrease in wave I amplitude. Consequently, the V:I relative amplitude ratio increased with decreasing stimulus intensity.

Effects of Frequency:- Moore (1983) studied the effects of frequency on BSER. The brainstem evoked response waveforms did not differ appreciably as a function of frequency. However differences manifest when one quantifies the peak latencies, eg. wave I slight differences across frequency are apparent. That is, latency values at the lowest intensity level employed (40 dB) do show a difference in time of occurrence. On the other hand at the highest intensity (-10 dB of attenuation) for all practical purposes, a shift in latency as a function of frequency is not apparent. Interestingly, the effects of intensity at the low (1000 Hz) and high frequency (8000 Hz) are evident. In other word: the very highest intensity level (-10 dB) revealed overlapping data for all frequency employed (Bausch, Rose, and Harner 1980). However, as intensity decreased, latency increased and a clear separation of the 1000 Hz data and the 8000 Hz data is readily apparent. Accordingly, it can be inferred that the results at the highest intensity level primarily originate from the most basal region of the cochlea, but as the stimuli are decreased, the component originate from a more apical region (Elberling, 1974).

Effects of Time Parameters:-

Rise-Decay or rise-fall time of the signal:- The brainstem response may equally be influenced by various rise-decay times of the input signal (Kimmelman, Marsh, and Yamane et al 1979; Kodera, Hink, and Yamada et al 1979; Suzuki and Horiuchi 1981). In this case, a point is reached where response identification become extremely difficult as rise-decay time increases. The neural impulses that make up the brainstem response are best excited by fast-rising stimuli. The latency of the various components are found to shift to a later time of occurrence for I longer rise-decay times. A rise decay time of 5.0 ms causes wave I to disappear into the ongoing background noise of the response trace. Waves III, IV and V can still be detected, although waves VI and VII are out of the range of visual detection. There is a diminution in the magnitude of the various components (Moore, 1983).

Hecox et al (1976) examined the influence of stimulus envelope on wave V latency and amplitude, and observed that stimulus envelope time had the greatest effect on wave V latency. Hecox et al (1976) concluded that the ABR was an "onset" response i.e. its properties were largely dependent on stimulus onset characteristics.

Duration and Interstimulus interval:-

As the duration is increased 3.0 to 100 ms, the latency of all components increases. The amplitude of the various component decreases. The various components are observed to become less distinct, however, all waves can readily be identified at the longest duration, although the double peaked wave IV-V complex has merged into one broad, identifiable peak. When the interstimulus interval is decreased, the various brainstem response waves become less distinct and show an increase in latency but a decrease in amplitude (Moore 1983).

Repetition rater-

Increasing the rate of stimulation also increases the latency but decreases the magnitude of the brainstem response waves

(Campbell, Picton, and Wolfe et al 1981; Chiappa, Gladstone, and Young 1979; Allen, Don, and Starr 1977; Harkins, MdEvoy, and Scorr, 1979; Moore, 1971; Picton et al 1981; Pratt, Ben-David, and Peled et al 1981; Rowe, 1978). The effect is most pronounced for repetition rates greater than 10/sec but the effect does not go unnoticed at rates below 10/sec.

Jewett and Williston (1971) vere the first to observe morphological changes in the ABR as stimulus repetition rate was increased from 2.5 to 50 clicks per sec. The increase in stimulus rate significantly reduced the definition of vaves I through IV. This vaveform degradation vas slight at 10 clicks per sec. but quite noticeable at rates of 20 per sec.

Number of responses (epochs) averaged:-

In certain clinical situations, there is a need to sum or average responses beyond the generally accepted number of about 1000, as when testing small children or other "uncooperative" subjects, when electrodes are not firmly held in place, etc. Such conditions require that we have some notion as the effects on latency and amplitude to the number of responses (epochs) that exceed 1000.

Moore et al (1983) investigated these factors for a minimum of 256 responses to a maximum of 57,344 responses, collected in multiples of 1024 (1 KHz). Data was analysed only for 1028 to 7168 responses. They found no significant effects as a function of epochs averaged. There was however, a tendency at around 8000 responses, to "smooth" the wave IV-V complex so that wave IV was no longer a distinct and separate peak. In theory, there is no apparent reason to suspect that the brainstem response would be electronically altered during a long averaging process, since most signal averagers use digital circuitry (only a few averagers still in use utilize capacitative circuits).

Click polarity:-

Changing click polarity from rare faction to condensation has been reported to have a influence on the morphology of the IV-V complex. Stockard et al (1979) found that wave IV was more prominent than V in 70% of subjects' responses to rarefaction click. The use of alternating click polarity can affect the morphology of wave I due to the possible cancellation of the out-of-phase components when responses to the separate polarities are summed (Stockard et al 1978b,1979).

Filter cut-off points:-

The selection of bandpass filter cut-off points has a noticeable influence on ABR parameters. Jewett and Williston (1971) used filter cut-off points of 10 Hz and 10,000 Hz. Stockard et al (1975b) found that increasing the low frequency cut-off point from 1 Hz. to 300 Hz. resulted in a smaller wave V relative to wave IV. Decreasing the high frequency cut-off point from 3000 Hz. to 300 Hz. resulted in poor resolution of all component waves. In addition, increasing the low-frequency cut-off point results in a progressive decrease in the absolute latencies of all ABR component waves. The V:I relative amplitude increased when the low frequency cut-off point was increased from 1 Hz. to 100 Hz.

Onset of A/Onset of B:-

Another time-dependent phenomenon that has been rather extensively used in psychoacoustic experimentation is the temporal masking paradigm (Durrant and Lovrinic 1977).

Ananthanarayan and Gerken (unpublished manuscript) recorded the brainstem response using a tone-on-tone forward masking paradigm. A masking stimulus 4000 Hz. preceded the 4000 Hz. probe stimulus by t in msec. All stimulus pairs were monaurally presented (rate: 2/sec) and at an intensity level of 60 dB above the masker threshold. The t intervals (masker preceding the probe, offset to onset) were 5,15,45 and 135 msec. The brainstem response obtained from one subject showed prolonged wave V latency when compared to the unmasked condition; this is similar for wave III. A larger wave V latency shift occurred for the simultaneous masking condition and for the t = 5, and 15 msec. forward masking conditions. Wave V amplitude was greater at the t = 5,15, and 45 msec conditions, while wave III amplitude was smaller for these values of t than in the unmasked condition.

Latency shifts decreased monotonically with increasing t and latency for both waves III and V did not return to the unmaske value even at a t of 135 msec, suggesting a forward-masking effect at this longer interval.

Regarding amplitude, wave III exhibited a general reduction in amplitude for the simulataneous masking condition, and a tendency toward recovery of amplitude values with increasing t.

Wave V also exhibited a reduction in amplitude for the simultaneous masking task, but exhibited an increment in amplitude in the forward masking conditions; thus, wave enhancement was t dependent.

A reduction in amplitude and an increase in latency appear to be related to varying durations of neural firing subserving the Brainstem response of interest, and thus, a desynchronization of individual units. These effects are attributed to a peripheral masking effect (Ananthanarayan and Gerken).

Mode of Presentation:-

An additional stimulus related characteristics that has been demonstrated to have an effect on ABR parameters is the mode of presentation is monaural vs. binaural stimulation. In neurologically normal subjects with the same hearing in both ears, binaural stimulation usually results in a response of increased amplitude (Blegvad 1975; Jewett and Williston 1971; Starr and Achor 1975; Stockard et al 1978b).

II. Procedure Effects:-

Variations in recording techniques can influence the parameters of obtained ABRs.

Electrode location:-

The choice of electrode location can effect the response. Ordinarily, three electrodes are used for ABR tests; one on the vertex of the skull, and one on the ipsilateral (relative to the stimulated ear) and contralateral mastoid process. The vertex and mastoid electrodes are often called the "active" and "reference" electrodes respectively.

Stockard et al (1978b) observed that wave I amplitude increased when responses were referenced to the earlobe instead of the mastoid process. This wave I amplitude increase effectively reduce the V:I relative amplitude. Stockard and Colleagues (1978b also found that ABR parameters were markedly altered when recordings were referenced to the contralateral earlobe. With this electrode configuration, waves I and III decreased in amplitude, wave II became more prominent, wave IV and V were clearly separated and wave V latency increased.

III. Subject Effects:-

Awake and Sleep:- Amadeo and Shagass (1973) studied the ABR of 6 normal adults awake and in several stages of natural sleep. They found that natural sleep had no significant effect on ABR amplitude or latency.

Anesthesia:- Goff et al (1977) recorded the ABR in patients prior to and during anesthesia (thiopental sodium) and found that response latency was unchanged generally although anesthesia was associated with a 15% reduction in response amplitude.

Sex:- The difference between ABR pareperties for male and female subjects has been investigated (Beagley, and Sheldrake 1978; McClelland, and McCrea, 1979; Stockard et al 1978b,1979). These authors demonstrated that the absolute latency of wave I was essentially the same for male and female subjects; but wave III and wave V latency was significantly early in females; thai is, the III-V, and i-V intervave latencies were longer in male subjects.

Temperature:- Stockard et al (1978a) found that a decrease in brain temperature was associated with an increase in the I-III, 111-V, and I-V interwave latency. Stockard et al (1978a) indicated that prolonged interwave latency similar to that seen in central lesions could be produced by decreased temperature alone.

Age:- Studies of the ABR in premature and full-term newborns, conducted within 4 days (Starr et al 1977) and 3 weeks of birth (Schulman-Galambos and Galambos, 1975) have demonstrated that absolute latency decreases with maturation. They reported that wave V latency decreased by 0.3 to 0.5 ms with each week of gestation.

Starr et al (1979) found that the I-V interwave latency decreased with maturation, in premature and full term newborns from 7.2 ms at 26 weeks gestational age to 5.2 ms at 40 weeks gestational age.

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

Starr et al (1977) also reported that wave V amplitude increased with maturation. This is consistent with the findings of Stockard et al (1978b) who reported that the V-I relative amplitude ratio decreased (i.e. wave V was smaller than wave I) in the perinatal period. Stockard et al (1978b) also found that absolute response amplitude often was greater in children perhaps due to a smaller head circumference, and less distance between the recording electrodes and response generators.

Rowe (1978) compared responses of old (mean age 61 years) and young (mean age 25 years) adults and found about a 0.2 ms increase in the I-III interwave latency with increased age.

Effects of Masking on Brainstem Response:-

Masking is said to occur when one sound makes another sound difficult or impossible to hear or when the threshold of the signal (the maskee) has been elevated by a second signal or noise (the masker). The phenomenon of masking is a convenient method of study in frequency analysis (Wegel and Lane 1924).

Both ipsilateral and contralateral masking effects have been studied. Either white noise or Narrow-band noise are used in masking.

The effect of contralateral white noise stimulation on ipsilaterally presented click evoked bralnstem potentials was examined by Prasher and Cohen (1984). They found that continuous contralateral noise does not influence the bralnstem response components but pulsed white noise simultaneously presented with the clicks produced a central masking effect which was observed as an amplitude redaction confined to wave V. No change in the latency of wave V was observed to suggest any "cross-over" masking of the click stimulus. The reduction in the amplitude being specific to wave V, suggests that the effect is central and that particular locus for this aspect of central masking is at the level of the inferior colliculus.

Moore and Ananthanarayan (1978) studied the effect of noise on brainstem response under the following conditions: Brainstem response was elicited with probe frequency of 1000 and 4000 Hz. Subsequent responses were obtained in the presence of wide-band noise; at the center frequency of two narrow bands of noise, or away from the narrow bands of noise. In all these three conditions, masking noise was presented simultaneously with the probe stimuli. The mode of presentation for the noise was either ipsilateral or contralateral, and sounds were presented at a SPL of 75 or 90 dB. The noise sources were a 250-8000 Hz. wide band noise, a 1000 Hz. band limited noise or a 4000 Hz. band limited noise.

A clearly identifiable brainstem response was obtained in the unmasked condition. However, when the wide-band noise was introduced, responses tended to decrease in amplitude and latency was prolonged. There was no significant effects on the brainstem response in the presence of the 1000 Hz. narrowband noise. In contrast, the presence of the 4000 Hz. narrowband noise diminished brainstem amplitude and latency was prolonged, particularly at the 90 dB level. The authors interpreted that the 1000 Hz. probe stimulus mainly evoked activity from a more basal, or high frequency part of the cochlea, rather than the apical, or low frequency end and the 4000 Hz. stimulus evoked response in a more basal direction. Ananthanarayan and Gerken subscribed the effect to central masking.

Friegang et al (1974) studied the influence of white noise on acoustically evoked potentials. A noise level below 50 dB had only little effect on the evoked potentials of the contralateral ear. To learn the significance of these findings white noise to the contralateral ear was applied at 0,30 and 40 dB levels. While constant stimulation of the pisilateral ear with a 1 KHz. tone at 70 dB was applied simultaneously. The results showed a small increase in amplitude during stimulation of the opposite ear with white noise at 30 dB and a reduction in amplitude at 40 dB. The latencies increased in both the cases. These changes can be explained by central mechanisms. For contralateral noise levels exceeding 60 dB or monaural stimulation with white noise and tones, the threshold was displayed by the amount of the masking noise level, and the steepness of the input-output curve was increased.

Kramer and Teas (1988) used a forward masking paradigm. They recorded wave V of the auditory brainstem response and N_1 from the ear canal from normal hearing subjects. Response amplitudes and latencies to 40 dBHL probe clicks presented in quiet and as a function of the time delay following short duration wideband noise maskers were measured. The primary effects were decrease in N_1 amplitude and increase in wave V latency, neither of which were recovered by êt = 100 ms. Wave V amplitude was fully recovered by êt = 25 ms even though N_1 amplitude was significantly reduced. The differential effects of N_1 and wave V suggest at least for some stimulus conditions, that these two responses are to some degree independent of each other.

The method of "derived brainstem responses" was presented and discussed by Parker and Thornton (1978a,1978b,1978c,1978d). and Don and Eggermont (1978). In this method the click with a wideband frequency spectrum is used unfiltered and this wideband stimulation is masked by high-pass filtered noise of different low-frequency limits. If two brainstem responses of different high pass masking cut-off frequencies are recorded and the difference between these two responses is calculated, a so-called "derived response" is obtained considered as representative for the range between the frequency limits of the different masking noises.

Don and Eggermont (1978, 1980) analysed the click evoked brainstem potential in man using high pass noise masking and also studied the effect of click intensity brainstem evoked response to 60 dBSL click in noise high passed at various cut-off frequencies separated by half-octave steps were recorded in normal hearing adult subjects. By applying a derived response technique narrow-band contributions to the brainstem response from specific portions of the basilar membrane were revealed. Latencies and amplitudes of the various waves in the derived brainstem response were recorded. Results indicated that nearly the whole cochlear partition could contribute to the brainstem response. The shifts in latency of waves I, III and V and amplitude changes of waves I and III as a function of center frequency appeared to be fully comparable to those of the action potential. In contrast, the amplitude behaviour of wave V as a function of center frequency was found to be different from waves I and III depending upon the frequency range. The discrepancy in the behaviour of wave V vith respect to the earlier waves has been suggested to be due to some sort of neural reorganization at the level where wave V is generated.

Burkard and Hecox (1983) conducted a series of experiments to investigate the effects of continuous broadband noise (ipsilateral) on wave V of the click evoked brainstem auditory evoked response. In general, a broad band noise masker increases the latency and decreases the amplitude of wave V. Varying both click and noise intensity, it was found that noise levels above about 40 dB SPL increase the latency and decrease the amplitude of wave V regardless of the click intensity. The effect of noise on wave V amplitude was constant across click intensity, whereas the effects of a constant noise level on wave V latency decrease at higher click intensities. Both masking and adaptation increased wave V latency, but theier combined effects are occlusive, rate induced wave V latency shift decreased in the presence of continuous broad band noise.

Burkard and Hecox (1983) also evaluated the effects of broadband noise (ipsilateral) on wave V of the brainstem response elicited by tone bursts or clicks in the presence of high pass masking noise. Experiment 1 used 1000 and 4000 Hz. 60 dB nHL tone bursts in the presence of broadband noise. With increasing noise level, wave V latency shift was greater for the 1000 Hz. tone bursts, while amplitude decrements were smilar for both tone burst frequencies. Experiment 2 varied high pass masker cut off frequency and the level of subtotal masking in the presence of

50 dB nHL clicks. The effects of subtotal masking on wave V (increase in latency and decrease in amplitude) increased with increasing derived band frequency. Experiment 3 covaried high pass masker cut off frequency and subtotal masking level for 1000 and 4000 Hz. tone burst stimuli. The effect of subtotal masking on vave V latency was reduced for both tone burst frequencies. When the response generating region of the cochlear partition vas limited by high pass maskers. The results of these three experiments suggested that most of the wave V latency shift associated with increasing levels of broadband noise is mediated by a place mechanism. When the stimulus is a moderate intensity (60 dB nHL), low frequency (1000 Hz) tone burst. However, the interpretation of latency shifts produced by broadband noise for 4000 Hz. tone burst stimuli was reported to be complex because of multiple technical factors.

There have been only a few reports on the use of band-reject or notch masking noise in clinical ABR studies (Picton et al 1979; Stapells, and Picton 1981; Pratt and Bleich 1982). Both the stimulation and masking strategies employed, and the results obtained have varied considerably. Pratt and Bleich (1982) have reported that wave V latency remained constant when a broad-band click was presented simultaneously with half octave wide notches, irrespective of notch frequency.

The combination of suprathreshold tone bursts with frequency of 0.5,1, or 2 KHz and ipsilateral high pass or notch noise masking has been studied in 52 adults by Laukli (1983). Wave V latency changes were found to be similar for both highpass and notch noise masking and in accordance with cochlear tonotopicity, i.e. greater for the lower stimulus frequencies.

The effects of contralateral masking upon brainstem response in normal subjects was studied by Reid and Thornton (1983). The results showed that contralateral masking had no statistically significant effect upon the brainstem response.

A similar study was conducted by Rajalakshmi (1983). She also reported no statistically significant effect of contralateral broadband masking noise on the brainstem evoked response produced by 2 KHz and 4 KHz logon stimulus.

Rosenhammer and Holmkvist (1983) compared monaurally evoked ABRs to clicks at 70 dB nHL in the presence of contralateral masking by white noise at 60,70,80 and 90 dB nHL with the corresponding ABR's without contralateral masking. They observed that the latency of wave I did not change significantly with contralateral noise at any one of the four levels. The latency of wave III was significantly prolonged only at the noise level of 90 dBHL. The latency of wave V was significantly increased at the noise levels of 80 and 90 dBHL. The average latency prolongation were on the order of 0.05 ms. The findings suggest the latency increments to be attributable to central masking than to acoustic cross over or stapedius reflex elicitation. Contralateral white noise at levels below 80 dBHL did not seem to effect the ABR to clicks above 65 dB nHL.

Reid et al (1984) found the amplitude of wave VI to be reduced significantly in the presence of contralateral masking. Wide band clicks were delivered at 70,80 and 90 dB SL, both with and without 50 dBSL of contralateral masking. Reduction in amplitude for the 90 dBSL stimulus but there was no effect at the lower stimulus levels.

So far, ipsilateral and contralateral masking effects upon brainstem response have been studied by various authors. These studies have shown an increase in latency and decrease in amplitude in the presence of noise. In the present study, an attempt is made to study the effect of binaural noise on latency and amplitude of the brainstem evoked responses and also, the effect of change of sensitivity on brainstem responses.

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METHODOLOGY

Part I:- Effect of binaural noise on brainstem response

Subjects:-

5 subjects (3 females and 2 males) in the age range of 18 to 23 years were selected for the present study. All the subjects had normal hearing (£ 20 dBHL, ANSI 1969).

The subjects were selected based 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. Negative history of epilepsy or other neurological complaints.
3. They should be able to relax and feel comfortable with electrodes on, within 10-15 minutes after their placement.

Equipment:-

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

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 audiotory stimulus and accepts patients' electrical responses from the preamplifier. Signal conditioning and digital averaging extract the patients' brainstem responses from the background noise. Oscillographic display and ink-on-paper recording provide an on-going monitor as well as prominent record of responses.

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

Accessory group used was:

- a binaural air-conduction head set (TDH-39 earphones housed in MX-41/AR ear cushions) with cord set.
- interconnecting cables, chart paper and pens
- sets of electrodes, electrolyte gel and electrode adhesive pad

Controls and their function:-

The TA-1000 is operated with only four knobs and nine push button switches.

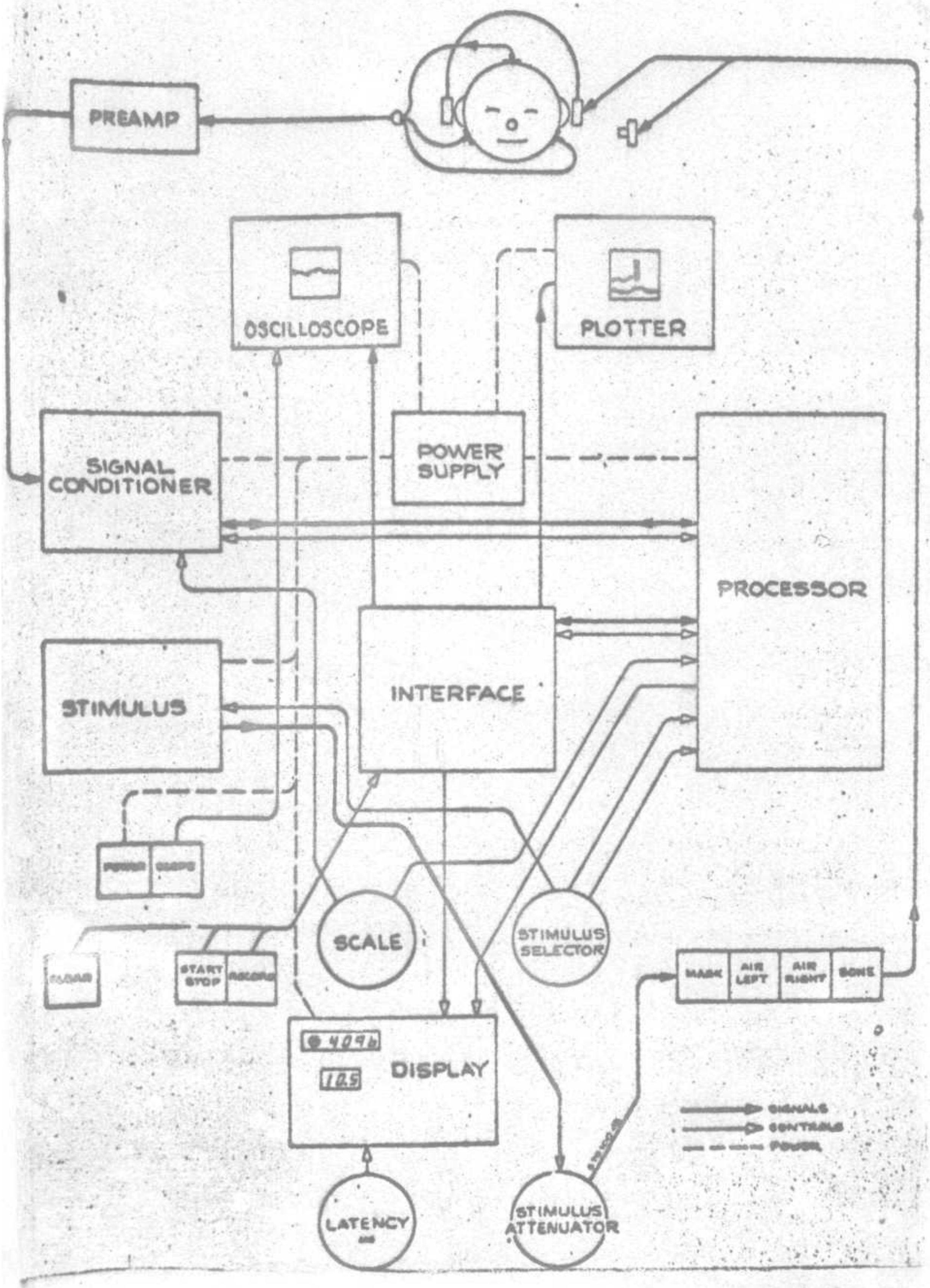
Four knobs:-

1. The stimulus function switch permits selection of 2 KHz, 4KHz, or 6 KHz acoustic logon stimulus equivalent frequencies, at repetition rate of S 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 establish the presentation level, permits selection of acoustic logon stimulus from 0 to 100 dBHL.

3. The scale function switch permits selection of system sensitivity and number of averaged response samples. For 1024 samples 0.5êmV, 1 mV, 2 mV, and 5 mV/division sensitivities are

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



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 mV, 0.5 mV, and 1 mV/division sensitivities are available.

4. The latency control switch provides a cursor mark on the oscilloscope display for precise determination of time delay from stimulus peak to any point on the averaged patient response. Readout of latency, in milliseconds, to 0.1 ms resolution is displayed in digital form directly above this control.

Push button switches:-

1. Power switch energizes the system and indicate the system status.
2. 'Scope' switch controls the oscilloscope display
3. 'Clear' switch clears the microprocessor averaged memory, resets the sample display counter and corrects the microprocessor operating mode to correspond to the current control statu
4. 'Start/Stop' push button indicates the microprocessor average function. The average function is automatically terminated when the selected number of samples has accumulated, or whan any average 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 ear phone.
8. Air right applies the stimulus to the desired ear phone.

9. 'Bone' push button applies the stimulus to the bone vibrator transducer.

Besides these there is i. paper advancer thumb wheel when rotated downward advances the plotter chart paper; ii. the limit indicator in the samples window will light briefly to indicate the presence of excess input to the system. At high sensitivitie i.e. 0.1 mV, 0.2 mV, and 0.5 mV/division, this indicator will be relatively active, depending on the individual patient. Patier responses, occurring when the limit light is on, are rejected from the averaged responses and are neither accumulated nor counted; iii. 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 patient EEG activity, the raw signal from which the averaged response is derived.

Test Environment:-

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

Test Procedure:-

First, pure tone thresholds were established to confirm normal hearing (ANSI, 1969). Then the subjects were explained the nature of the test and were ashed to relax in a sitting position. The subjects were not sedated.

The electrodes and the surface of the skin where electrodes were attached were cleaned with spirit. Then each electrode with the electrolyte gel was attached to the cleaned skin with the help of adhesive tape.

Electrode placement was as follows:-
Red or signal electrode was placed on the vertex (high forehead);
White or reference electrode was placed on the mastoid of the test ear (right);
Black or ground electrode was placed on the mastoid of the non-test ear (left).

After the electrodes were fixed in proper positions they were plugged into the patient's electrode cable (observing the colour code). If after the connection of the electrodes, high input light on the preamplifier flashed continuously, the electrodes were checked for their proper attachments and the subject was again instructed to be relaxed. The preamplifier was located very near to the subject and the subject's electrode cable were pinned to the bedding.

The bone vibrator from TA-1000 was placed on the vertex of the subject to deliver logon stimulus. The earphones from GSI-10 were placed over the ears to deliver the narrow-band noise whose canter frequency was 2 KHz and 4 KHz to both ears simultaneously.

The scale switch was set to 2048 samples and sensitivity value of 0.2 uV/division was selected. A sample time of 5 ms and stimulus repetition rate of 5 per second was chosen for the present study.

For each subject the brainstem evoked response for the following frequencies and intensities ware obtained.

2 KHz - 70 dBHTL - without noise
2 KHz - 70 dBHTL - with binaural noise at 77 dBSPL
2 KHz - 70 dBHTL - with binaural noise at 67 dBSPL

The type of noise used: Narrow-Band Noise whose center frequency is 2 KHz.

4 KHz - 70 dBBTL - without noise
4 KHz - 70 dBHTL - with noise (binaural) at 77 dBSPL

The type of noise used: Narrow-Band Noise whose center frequency is 4 KHz.

To start with, the power switch was pressed. The TWF/RUN/EEG switch was set to 'RUN'. The 'Bone' push button was pressed to deliver the logon stimulus through the bone vibrator. Before pressing the 'Start/Stop' push button, 'Clear' switch was pressed to clear the microprocessor. After the samples were accumulated, the average function would automatically stop. Then, 'Record' push button switch was pressed to get a graphic readout of the brainstem evoked response.

Treatment of the Data:-

Latency Determination:- The TA-1000 has a callibrated latency cursor, which appears on the oscilloscope trace as a function of latency control. The latency of a particular peak was obtained by moving the cursor to the desired peak. The latencies of I,III, and V peaks were determined by positioning the cursor in the peak of the wave.

Amplitude measurement:- To determine the magnitude of the brainstem evoked response in microvolts, the marker amplitude 'M' (1/2/3/4 divisions) and the amplitude of the desired trace feature 'T' vas noted. Then the scale switch amplitude 'S' (either 0.5, 0.1, 0.2 or 1.0 mV/divisions) was noted.

BSER amplitude = $\frac{TS}{M}$ where,

T = The amplitude of the desired trace feature.

S = Sensitivity

M = Marker amplitude

When the system had stopped either manually or automatically before full sample number had been averaged, a correction N/n was applied.

N = number of samples present on the scale

n = number of samples actually computed

BSER amplitude = N/n x TS/M

Absolute amplitude values for peaks I,III and V was obtained using the above formula.

Part II:- Effect of Sensitivity on Brainstem Evoked Response

Subjects:- 10 subjects (5 females and 5 males) in the age range of 18 to 23 years were selected. All the subjects had normal bearing ($\leq$20 dBHL, ANSI 1969).

Equipment:-

Electric Response Audiometer Model TA-1000

I,III and V, both at 2 KHz and 4 KHz obtained in the presence of binaural noise presented at 70 dB SPL and 60 dBSPL. However the effect is found to be more when the noise level is 77 dBSPL.

Tables 6 and 7 show the means and standard deviations of interpeak latency (V-I) obtained at 2 KHz and 4 KHz respectively in the presence and absence of binaural noise for 5 normal hearir subjects. The results show that there is an increase in interpeak latency (V-I) in the presence of binaural noise at both frequencies -i.e. at 2 KHz and 4 KHz.

Part II:- Effect of sensitivity on brainstem evoked response

The aim of the study was to find out the effect of change of sensitivity values on brainstem response in normal hearing subjects.

The data collected were analysed statistically using Wilcoxon matched pairs signed ranks test (Seigel, 1956) to find out if there is any significant effect of change of sensitivity values on the amplitude and latency of brainstem response.

Tables 8 and 9 show the means and standard deviations of absolute latency for peaks I,III and V obtained at 2 KHz and 4 KHz for different sensitivity values in 10 normal hearing subjects. The results show that there is no change in latency value with change in sensitivity values for all the three peaks(I,III&V).

Tables 10 and 11 show the means and standard deviations of absolute amplitude values for peaks I,III and V obtained at 2 KHz and 4 KHz for different sensitivity values. The results show that there is no effect on amplitude values when the sensitivity values are changed.

Tables 12 and 13 show the means and standard deviations of interpeak latency (V-I) obtained at 2 KHz and 4 KHz for different sensitivity values. The results show that there is no change in interpeak latency (V-I) value obtained at different values of sensitivity.

Tables 14 and 15 illustrate the significance of difference between sensitivity values for latencies of waves I,III and V obtained at 2 KHz and 4 KHz at 0.05 and 0.01 level of significance. From the tables, it is clear that there is no significant difference between sensitivity values for latencies of waves I,III and V.

Tables 16 and 17 illustrate the significance of difference between sensitivity values for amplitude values of waves I,III and V obtained at 2 KHz and 4 KHz at 0.05 and 0.01 level of significance. The results show that there is no significant difference between sensitivity values for amplitude values of waves I,III and V.

Tables 18 and 19 illustrate the significance of difference between sensitivity values for interpeak latency (V-I) obtained at 2 KHz and 4 KHz at 0.05 and 0.01 level of significance. The results show that there is no significant difference between sensitivity values for interpeak latency (V-I).

Thus, from the results, it is clear that there is no significant effect on latency and amplitude of the brainstem response with change in the values of sensitivity and hence any sensitivity can be used to measure the brainstem response. However, the morphology of waveform was affected when brainstem response was measured at different sensitivity values.

When brainstem response was measured with a sensitivity value of 0.5 mV and 1.0 mV, the wave form was not smooth i.e. the peaks were not smooth for all the 10 subjects.

At 0.1 mV, the Brainstem responses obtained were better than the responses obtained at other sensitivity values. However; at 0.1 mV, complete averaging of responses was occurring before 2048 samples were presented. In 7 out of 10 subjects averaging took place before 2048 samples were presented. In 2 subjects, the responses at 0.1 mV sensitivity could not be obtained at all.

Discussion:-

Part I:- Effect of binaural noise on BSER

Results of the present study show that the binaural noise (narrow-band noise) brings about an increase in latency and decrease in amplitude of the peaks I,III and V obtained at 2 KHz and 4 KHz. There was an increase in latency of greater than 0.2 ms far peak III and 0.5 ms for peak V. However, the effect was found to be more when the noise level was 77 dBSPL.

The results of the present study are in agreement with the results of the following investigators: Moore and Ananthanarayan (1978); Friegang et al (1974); Prasher and Cohen (1984); Don and Eggermont (1978); Burkard and Hecox (1983) and Rosenhamer and Holmkvist (1983) and Ananthanarayan and Gerken (1983).

Moore and Ananthanarayan (1978)studied the effect of noise on brainstem response under the following conditions:- Brainstem response was elicited with probe frequency of 1000 and 4000 Hz. Subsequent responses were obtained in the presence of wide-band noise; at the center frequency of two narrow bands of noise; or away from the narrow bands of noise. In all these 3 conditions, masking noise was presented simultaneously with probe stimuli. The mode of presentation for the noise was either ipsilateral or contralater, and sounds were presented at a SPL of 75 or 90 dB. The noise sources were a 250-8000 Hz. wide band noise, a 1000 Hz band limited noise or a 4000 Hz. band limited noise.

A clearly identifiable brainstem response was obtained in the unmasked condition. However, when the wide-band noise was introduced, responses tended to decrease in amplitude and latency was prolonged. There was no significant effect on the brainstem response in the presence of 1000 Hz narrowband noise. In contrast the presence of the 4000 Hz narrow band noise diminished the brainstem response amplitude and latency was prolonged particularly at the 90 dB SPL. Ananthanarayan and Gerken(l983) subscribed the effect to central masking.

In the present study, the noise sources were a 2000 Hz narrow band noise and 4000 Hz narrowband noise. Noise was presented at levels of 67 and 77 dB SPL. Thus based on the results of Moore and Ananthanarayan (1978), in the present study, increase in latency and decrease in amplitude of the brainstem response can be ascribed to central masking.

Friegang et al (1974) studied the influence of white noise on brainstem response. They found that a noise level below 50 dB had only little effect on the evoked potentials of the contralateral ear.

The results of the present study showed greater effect on brainstem response at noise levels 77 dB SPL than at 67 dB SPL. when the intensity of the logon stimulus was 70 dBHL.

However, Burkard and Hecox (1983) found that noise levels above about 40 dB SPL increase the latency and decrease the amplitude of wave V regardless of the click intensity. They conducted a series of experiments to investigate the effects of continuous broadband noise (ipsilateral) on wave V of the click evoked brainstem response. The effect of noise on wave V amplitude was constant across click intensity, whereas the effects of a constant noise level on wave V latency decrease at higher click intensities.

In the present study, greater shift in latency and decrease in amplitude was observed for wave V which is in agreement with the above study.

Prasher and Cohen (1984) studied the selective effects of contralater lateral white noise does not influence the brainstem response components but pulsed white noise simaltaneously presented with the clicks produced a central masking effect which was observed as an amplitude reduction confined to wave V and thus they suggest that the area of mediation of the central masking effect is caudal to the site of generation of wave V.

Thus, in the present study, the redaction in amplitude of wave V in the presence of binaural noise whose site of generation is at the level of the inferior colliculus can be attributed to central masking effect.

Rosenhamer and Holmkvist (1983) compared monaurally evoked ABRs to clicks at 70 dBnHL in the presence of contralateral masking by white noise at 60,70,80 and 90 dB nHL with the corresponding ABRs without contralateral masking. Latency of wave I was not affected in the presence of noise. Latency of wave III was significantly prolonged only at the noise level of 90 dB HL. The latency of wave V was significantly increased at the noise levels of 80 and 90 dB HL. The findings suggest the latency increments to be attributable to central masking than to acoustic crossover or stapedius reflex elicitation.

Don and Eggermont (1978,1980) applied derived response technique to study the narrow-band contributions to the brainstem response from specific portions of the Basilar Membrane. Results indicated that nearly the whole cochlear partition could contribute to the brainstem response. The shifts in latency of waves I,III, and V and amplitude changes of waves I and III as a function of centre frequency appeared to be fully comparable to those of the action potential. In contrast, the amplitude behaviour of wave V as a function of center frequency was found to be different from waves I and III depending upon the frequency range. The discrepancy in the behaviour of wave V with respect to the earlier waves has been suggested to be due to some sort of neural neorganization at the level where wave V is generated.

Ananthanarayan and Gerken (1983) in their study, observed two contrasting effects on components of the ABR. One was partial masking of wave III, and the other wss amplitude enhancement of wave V. It is possible that wave V generators receive input via a pathway not reflectedin wave III. The increased latency of wave V could seem to indicate though that the wave V generator(s) are also driven by a sound affected by partial masking, hence the enhancement of wave V would be a central effect.

Part-II: Effect of sensitivity on Brain-stem evoked response

The results of the present study shows that there is no significant effect on latency and amplitude of the brainstem response obtained at different sensitivity values. However, the morphology of the waveform was affected when the sensitivity values were changed.

At 0.5 m.V and 1.0 mV sensitivity value, the waveform obtained was not smooth. at both 2 KHz and 4 KHz. At 0.1 mV, the brainstem responses obtained were better than the responses obtained at other sensitivity values. However, at 0.1 mV, complete averaging of responses was occurring before 2048 samples were presented. In 7 out of 10 subjects averaging took place before 2048 samples were presented. In 2 subjects the responses at 0.1 mV sensitivity could not be obtained at all.

Table - 2: Means and Standard Deviations of absolute latency values for peaks I.III and V obtained at 2 KHz 70 dBHL in the absence and presence of blnaural noise.

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Subjects	Without Blnaural Noise			With Binaural Noise (77 dB SPL)			With Binaural Noise (67 dB SPL)		
	I	III	V	I	III	V	I	III	V
1.	1.6	3.2	5.0	1.7	3.6	5.9	1.7	3.5	5.0
2.	1.3	3.3	5.0	1.5	3.4	5.8	1.6	3.4	5.2
3.	1.7	3.6	5.2	1.6	3.8	5.3	1.6	3.6	5.2
4.	1.0	3.8	5.5	1.0	4.1	6.1	1.0	3.8	5.8
5.	1.5	3.7	5.6	1.3	4.0	6.1	1.3	3.7	5.7
Mean:-	1.42	3.52	5.26	1.42	3.78	5.84	1.44	3.6	5.38
S.D.:-	0.25	0.23	0.25	0.25	0.26	0.29	0.26	0.14	0.31

Table - 3: Means and Standard Deviations of absolute latency values for peaks I,III and V obtained at 4 KHz. 70 dBHL in the absence and presence of binaural noise.

Subjects	Without Binaural noise			With Binaural Noise (77 dB SPL)		
	I	III	V	I	III	V
1.	1.5	3.4	5.0	1.8	3.1	6.3
2.	1.4	3.2	5.1	1.6	3.3	5.6
3.	1.3	3.2	5.2	-	3.4	5.7
4.	1.5	3.8	5.8	1.7	4.2	6.7
5.	1.8	3.6	6.0	2.2	-	6.4
Mean:-	1.5	3.44	5.42	1.83	3.5	6.14
S.D.:-	0.17	0.23	0.40	0.23	0.42	0.42

Table - 4: Means and Standard Deviations of absolute amplitude values for peaks I,III and V obtained at 2 KHz. 70 d in the absence and presence of binaural noise.

Subjects	Without binaural Noise			With Binaural Noise (77 dB SPL)			With Binaural Noise (67 dBSPl		
	I	III	V	I	III	V	I	III	V
1.	0.12	0.32	0.44	0.06	0.06	0.06	0.04	0.2	0.24
2.	0.24	0.12	0.72	0-	0.1	0.16	0.04	0.12	0.42
3.	0.08	0.08	0.04	0.04		0.1	0.08	0.08	0.04
4.	0.02	0.2	0.28		0.1	0.34		0.24	0.48
S.	0.12	-	0.16	0.06	0.06	0.14	0.16	0.05	0.05
Mean:-	0.12	0.18	0.33	0.05	0.08	0.16	0.08	0.14	0.25
S.D.:-	0.07	0.09	0.24	0.03	0.02	0.10	0.05	0.07	0.18

Table-5: Means and Standard Deviations of absolute amplitude values for peaks I,III, and V obtained at 4 KHz. 70 dBHL in the absence and presence or binaural noise.

Subjects	Without Binaural Noise			With Binaural Noise (77 dBSPL		
	I	III-	V	I	III	V
1.	0.02	0.06	0.06	0.01		0.10
2.	0.14	0.08	0.34	0.04	0.02	0.38
3.	0.12	0.08	0.2		0.12	0.02
4.	0.08	0.12	0.44	0.04	0.14	0.2
5.	0.2	0.36	0.72	0.08	0.1	0.1
Mean:-	0.11	0.14	0.35	0.04	0.1Q	0.16
S.D.:-	0.06	0.11	0.22	0.02	0.05	0.12

Table-6: Means and Standard Deviations of Interpeak latency (V-I) obtained at 2 KHz 70 dBHL in the absence and presence of binaural noise.

Subjects	Without Binaural Noise	With Blnaural Noise	
		77 dB SPL	67 dB SPL
	V-I	V-I	V-I
1.	3.4	4.2	3.3
2.	3.7	4.3	3.6
3.	3.5	3.7	3.6
4.	4.5	5.1	4.8
5.	4.1	4.8	4.4
Mean:-	3.84	4.54	3.94
S.D.:-	0.41	0.49	0.56

Table-7: Means and Standard Deviations of Interpeak latency (V-I) obtained at 4 KHz 70 dBHL in the absence and presence of binaural noise.

Subjects	Without Binaural Noise	With Binaural Noise (77 dBSPL)
	V-I	V-I
1.	3.5	4.5
2.	3.7	4.0
3.	3.9	5.7
4.	4.3	5.0
S.	4.2	4.2
Mean:-	3.92	4.68
S.D.:-	0.3	0.61

Table-8: Means and Standard Deviations of absolute latency for peaks I, III and V obtained at 2 KHz 80 dBHL for different sensitivity values (0.2, 0.5, 1.0 & 0.1 mV)

SUBJECTS	0.2 mV			0.5 mV			1.0 mV			0.1 mV		
	I	III	V	I	III	V	I	III	V	I	III	V
1.	1.2	3.6	5.3	1.3	3.5	5.5	-	3.5	5.5	1.2	3.5	2.5
2.	1.4	3.1	4.6	1.4	3.2	4.6	1.5	3.2	4.8	1.4	3.2	4.7
3.	1.2	3.4	5.0	1.3	3.3	5.1	1.5	3.4	5.1	1.3	3.4	5.1
4.	1.5	3.2	5.0	1.4	3.3	4.9	1.5	3.2	4,9	1.4	3.3	5.0
5.	1.4	3.3	5.0	1.2	3.3	5.1	1.3	3.3	5.0	1.2	3.3	5.0
6.	1.2	3.2	4.6	1.2	3.3	4.7	1.2	3.2	4.6	-	-	-
7.	1.4	3.4	5.4	-	3.5	-	1.4	334	5.4	1.5	3.4	5.3
8.	1.2	3.2	4.9	1.1	3.2	5.0	1.2	3.1	4.9	-	-	-
9.	1.4	3.6	5.4	1.4	3.5	2.4	1.3	3.6	5.4	1.4	3.4	5.3
10.	1.1	3.3	4.8	1.3	3.3	4.9	1.3	3.3	4.9	1.3	3.3	4.9
Mean;-	1.3	3.33	5.0	1.29	3.34	5.02	1.36	3.32	5.05	1.34	3.35	5.1
S.D.:-	0.12	0.16	0.28	0.10	0.11	0.28	0.12	0.15	0.28	0.10	0.09	0.24

Table 9: Means and Standard Deviations of absolute latency for peaks I, III and V obtained at 4 KHz 80 dBHL for different sensitivity values (0.2, 0.5, 1.0 & 0.1 mV)

SUBJECTS	0.2 mV			0.5 mV			1.0 mV			0.1 mV		
	I	III	V	I	III	V	I	III	V	I	III	V
1.	1.3	3.5	5.2	1.3	3.6	5.3	1.4	3.6	5.3	1.3	3.5	5.3
2.	1.4	3.1	4.9	1.4	3.2	4.9	1.3	3.2	4.9	1.3	3.2	4.9
3.	1.2	3.5	5.2	1.4	3.5	4.2	1.4	3.5	5.2	1.3	3.4	5.1
4.	1.4	3.3	4.9	1.5	3.3	5.0	1.5	3.2	5.0	1.4	3.3	5.0
5.	1.3	3.3	5.1	1.3	3.3	4.9	1.2	3.3	4.8	1.2	3.3	4.8
6.	1.2	3.2	4.7	1.2	3.3	4.8	1.2	3.2	4.7	-	-	-
7.	1.3	3.6	5.4	1.3	3.3	5.5	1.4	3.5	5.4	1.3	3.5	5.3
8.	1.1	3.2	5.0	1.2	3.3	5.1	1.3	3.2	5.0	-	-	
9.	1.3	3.7	5.5	1.4	3.6	5.6	1.5	3.3	5.5	1.4	3.5	5.5
10.	1.2	3.3	5.0	1.3	3.3	5.0	1.4	3.1	4.9	1.3	3.3	5.0
Meant-	1.27	3.37	5.09	1.33	3.39	5.13	1.36	3.31	5.07	1.31	3.38	5.11
S.D.:-	0.09	0.18	0.23	0.09	0.14	0.25	0.10	0.16	0.25	0.06	0.11	0.22

Table-10: Means and Standard Deviations of absolute amplitude values for peaks I, III, and V obtained at 2 KHz 80 dBHL for different sensitivity values (0.2,0.5,1.0 and 0.1 mV)

SUBJECTS	0.2 mV			0.5 mV			1.0 mV			0.1 mV		
	I	III	V	I	III	V	I	III	V	I	III	V
1.	0.07	0.05	0.35	0.09	0.03	0.19	-	0.13	0.25	0.02	0.05	0.2
2.	0.3	0.28	0.48	0.25	0.2	0.14	0.3	0.13	0.45	0.3	0.2	0.26
3.	0.52	0.25	0.83	0.25	0.53	0.75	0.25	0.35	0.75	0.39	0.31	0.71
4.	0.24	0.24	0.7	0.34	0.28	0.53	0.3	0.33	0.5	0.3	0.23	0.65
5.	0.24	0.3	0.44	0.25	0.28	0.5	0.15	0.3	0.43	0.31	0.3	0.35
6.	0.24	0.36	0.5	0.28	0.25	1.0	0.4	0.38	0.63	-	-	-
7.	0.24	0.1	0.5		0.08	-	0.03	0.13	0.2	0.1	0.08	0.3
8.	0.22	0.3	0.5	0.2	0.35	0.55	0.2	0.3	0.45	-	-	-
9.	0.3	0.16	0.36	0.28	0.13	0.45	0.25	0.03	0.4	0.16	0.08	0.47
10.	0.28	0.16	0.76	0.15	0.15	0.85	0.2	0.15	0.9	0.19	0.26	0.73
Mean:-	0.27	0.22	0.54	0.23	0.23	0.58	0.23	0.22	0.50	0.22	0.19	0.48
S.D.:-	0.11	0.09	0.16	0.07	0.14	0.23	0.10	0.12	0.20	0.11	0.10	0.18

Table-ll: Means and Standard Deviations of absolute amplitude values for peaks I, III and V obtained at 4 KHz 80 dBHL for different sensitivity values (0.2, 0.5, 1.0, & 0.1 mV

SUBJECTS	0.2 mV			0.5 mV			1.0 mV			0.1 mV		
	I	III	V	I	III	V	I	III	V	I	III	V
1.	0.22	0.02	0.25	0.1	0.08	0.23	0.15	0.13	0.2	0.12	0.05	0.31
2.	0.32	0.32	0.56	0.33	0.33	0.63	0.3	0.25	0.55	0.29	0.28	0.55
3.	0.3	0.2	0.5	0.25	0.4	0.75	0.31	0.25	0.75	0.41	0.23	0.76
4.	0.5	0.4	0.9	0.2	0.55	0.7	0.25	0.5	0.75	0.26	0.49	0.73
5.	0.16	0.44	0.34	0.23	0.38	0.38	0.25	0.35	0.33	0.18	0.36	0.33
6.	0.36	0.5	0.62	0.3	0.4	0.45	0.45	0.4	0.45	-	-	-
7.	0.36	0.3	0.68	0.4	0.35	0.75	0.28	0.25	0.63	0.02	0.02	0.03
8.	0.04	0.16	0.56	0.3	0.29	0.53	-	0.5	0.6	-	-	-
9.	0.24	0.08	0.32	0.23	0.1	0.21	0.25	-	0.38	0.16	0.29	0.36
10.	0.36	0.2	0.6	0.13	0.28	0.53	0.18	0.28	0.63	0.19	0.15	0.5
Mean:-	0.31	0.26	0.53	0.25	0.32	0.52	0.27	0.32	0.53	0.20	0.23	0.45
S.D.:-	0.11	0.15	0.18	0.09	0.13	0.19	0.09	0.12	0.19	0.11	0.15	0.23

Table-12: Means and Standard deviations of interpeak latency values (V-I) obtained at 2 KHz 80 dBHL for different sensitivity values (0.2,0.5,1.0 & 0.1 mV)

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Subjects	0.2 mV	0.5 mV	1.0 mV	0.1 mV
	V-I	V-I	V-I	V-I
1.	4.1	4.2	-	4.3
2.	3.2	3.2	3.3	3.3
3.	3.8	3.8	3.6	3.8
4.	3.5	3.5	3.4	3.6
5.	3.6	3.9	3.7	3.8
6.	3.4	3.5	3.4	-
7.	4.0	-	4.0	3.8
8.	3.7	3.9	3.7	-
9.	4.0	4.0	4.2	3.9
10.	3.7	3.6	3.6	3.6
Mean:-	3.7	3.7	3.7	3.8
S.D:-	0.27	0.29	0.28	0.27

Table-13: Means and Standard Deviations of interpeak latency value (V-I) obtained at 4 KHz 80 dBHL for different sensitivity values (0.2,0.5,1.0 & 0.1 mV)

SUBJECTS	0.2 mV	0.5 mV	1.0 mV	0.1 mV
	V-I	V-I	V-I	V-I
1.	3.9	4.0	3.9	4.0
2.	3.6	3.5	3.6	3.6
3.	4.0	3.8	3.8	3.8
4.	3.5	3.5	3.5	3.6
5.	3.8	3.6	3.6	3.6
6.	3.5	3.6	3.5	-
7.	4.1	4.2	4.0	4.0
8.	3.9	3.9	3.7	-
9.	4.2	4.2	4.0	4.1
10.	3.8	3.7	3.5	3.7
Mean:-	3.82	3.8	3.71	3.8
S.D.:-	0.24	0.25	0.19	0.19

Table-14: Significance of Difference (Wilcoxon Signed Ranks Test, Seigel, 1956) between sensitivity values with regard to latency of I, III and V peaks obtained at 2 KHz 80 dBHL

Peaks	0.2 & 0.5 mV	0.2 & 1.0 mV	0.2 & 0.1 mV	0.5 & 1.0 mV	0.5 and 0.1 mV	1.0 & 0.1 mV
I	NS	NS	NS	NS	NS	NS
III	NS	NS	NS	NS	NS	NS
V	NS	NS	NS	NS	NS	NS

Table-15: Significance of Difference (Wilcoxon Signed Ranks Test, Seigel 1956) between sensitivity values with regard to latency of I, III and V peaks obtained at 4 KHz 80 dBHL

Peaks	0.2 & 0.5 mV	0.2 & 1.0 mV	0.2 & 0.1 mV	0.5 & 1.0 mV	0.5 & 1.0 mV	1.0 & 0.1 mV
I	NS	S	NS	NS	NS	NS
III	NS	NS	NS	NS	NS	NS
V	NS	NS	NS	NS	NS	NS

Key: NS - Not Significant at $P<$ .05 level S - Significant at $P\leq$ .05 level

Table-16: Significance of Difference (Wilcoxon Signed Ransk Test,Seigel 1956) between sensitivity values with regard to amplitude values of I,III and V peaks obtained at 2 KHz 80 dBHL

Peaks	0.2 & 0.5 mV	0.2 & 1.0 mV	0.2 & 0.1 mV	0.5 and 1.0 mV	0.5 & 0.1 mV	1.0 & 0.1 mV
I	NS	NS	NS	NS	NS	NS
III	NS	NS	NS	NS	NS	NS
V	NS	NS	NS	NS	NS	NS

Table-17: Significance of Difference (Wilcoxon Signed Ranks Test, Seigel 1956) between sensitivity values with regard to amplitude values of I,III and V peaks obtained at 4 KHz 80 dBHL

Peaks	0.2 & 0.5 mV	0.2 & 1.0 mV	0.2 & 0.1 mV	0.5 & 1.0 mV	0.5 & 0.1 mV	1.0 & 0.1 mV
I	S	NS	NS	NS	NS	NS
III	NS	NS	NS	NS	NS	NS
V	NS	NS	NS	NS	NS	NS

Key: NS - Not Significant at $P \leq 0.05$ level S - Significant at $P \leq 0.05$ level

TabLe-18: Significance of Difference (Wilcoxon Signed Ranks Test, Seigel 1956) between sensitivity values with regard to interpeak latency (V-I) obtained at 2 KHz 80 dBHL

Inter-peak	0.2 & 0.5 mV	0.2 & 1.0 mV	0.2 & 0.1 mV	0.5 & 1.0 mV	0.5 & 0.1 mV	1.0 & 0.1 mV
V-I	NS	NS	NS	NS	NS	NS

Table-19; Significance of Difference (Wilcoxon Signed Ranks Test, Seigel 1966) between sensitivity values with regard to interpeak latency (V-I) obtained at 4 KHz 80 dBHL

Inter-peak	0.2 & 0.5 mV	0.2 & 1.0 mV	0.2 & 0.1 mV	0.5 & 1.0 mV	0.5 & 0.1 mV	1.0 & 0.1 mV
V-I	NS	S	NS	S	NS	NS

Key: NS - Not Significant at $P \leq 0.05$ level

S - Significant at $P = \leq 0.05$ level

SUMMARY AND CONCLUSIONS

The present study was aimed at investigating whether there is any effect of binaural noise on the latency and amplitude of brainstem response. The study was also aimed at finding out the effect on latency and amplitude of brainstem response at different values of sensitivity.

The Electric Response Audiometer Model TA-1000 was used for the study. The study was divided into two parts. In part I, 5 subjects (3 females and 2 males) with normal hearing in the age range of 18 to 23 years were selected. Logon stimuli were presented through the bone vibrator at 70 dBHL for 2048 samples at the rate of 5 stimuli/second in the absence and presence of the noise respectively. Narrowband noise was presented binaurally through the earphones. Latency and amplitude of the brainstem response were measured. Stimulus frequencies employed were 2 KHz and 4 KHz at 70 dBHL. The noise levels selected were 77 dBSPL and 67 dBSPL at 2 KHz and 77 dBSPL at 4 KHz. The response latency and amplitude of I,III and V peaks of brainstem response were noted for all the subjects. Data were analysed so as to obtain the means and standard deviations.

In part II, 10 subjects with normal hearing (5 males and 5 females) in the age range of 18 to 23 years were selected. At different sensitivity values (0.2 mV, 0.5 mV, 1.0 mV, and 0.1 mV brainstem evoked responses for the logon stimuli were noted (Logon stimuli were presented to the right ear). The latency and amplitude of waves I,III, and V were noted down for all the subjects. The stimulus frequencies employed were 2 KHz and

4 KHz at 80 dBHL. The data obtained vere analysed statistically using Wilcoxon matched pairs signed rank test (Seigel 1956) to find out if there is any significant effect on latency and amplitude of the brainstem response at different sensitivity values.

The following conclusions can be drawn from the results obtained:

1. There was increase in latency for peaks III and V obtained at 2 KHz in the presence of binaural noise (Noise level 77 dB SPL)
2. There was increase in latency only for peak V obtained at 2 KHz in the presence of binaural noise (Noise level 67 dBSPL)
3. There was increase in latency for peaks I and V obtained at 4 KHz in the presence of binaural noise (Noise level 77 dBSPL).
4. There was a decrease in amplitude for peaks I,III and V obtained at 2 KHz in the presence of binaural noise at 77 dB SPL and 67 dBSPL respectively.
5. There was a decrease in amplitude for peaks I,III and V obtained at 4 KHz in the presence of binaural noise (Noise level 77 dB SPL)
6. There was an increase in interpeak latency (V-I) obtained at 2 KHz in the presence of binaural noise (Noise level 77 dB SPL AND 67 dBSPL).
7. There was an increase in interpeak latency (V-I) obtained at 4 KHz in the presence of binaural noise (Noise level 77 dB SPL).

8. The change in sensitivity values has no significant effect on latency and amplitude of the peaks I,III and V obtained at 2 KHz and 4 KHz.
9. The change in sensitivity value has no significant effect on interpeak latency (V-I) obtained at 2 KHz and 4 KHz.
10. There was a change in the morphology of the waveform obtained at different sensitivity values (0.2 mV, 0.5 mV, 1.0 mV & 0.1 mV

Limitations of the Study:-

1. Less number of subjects were used for the study.
2. The effect of binaural noise was studied at only two frequencies and at only one intensity level (70 dBHL - logon stimulus)
3. The effect of sensitivity was studied at only one intensity level (80 dBHL - logon stimulus).

Recommendations:-

1. To carry out the study on a larger population.
2. To study the effect of binaural noise at different intensity levels.
3. To study the effect of sensitivity at different intensities.

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