EFFECT OF RATE OF PRESENTATION OF STIMULUS ON BRAIN-STEM EVOKED RESPONSE

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TO MY PARENTS

C E R T I F I C A T E

This is to certify that the Independent Project entitled "EFFECT OF RATE OF PRESENTATION OF STIMULUS ON BRAIN-STEM EVOKED RESPONSE" is the bonafide work on part fulfillment for the Degree of Master of Science (Speech and Hearing) of the student with Register No. 8401

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CERTIFICATE

This is to certify that this Independent Project entitled "EFFECT OF RATE OF PRESENTATION OF STIMULUS ON BRAIN-STEM EVOKED RESPONSE" has been prepared under my supervision and guidance.

GUIDE

DECLARATION

I hereby declare that this Independent Project entitled "EFFECT OF RATE OF PRESENTATION OF STIMULUS ON BRAIN-STEM EVOKED RESPONSE" is the result of my own study under the guidance of Dr.M.N.Vyasamurthy, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other diploma or degree.

Mysore | Reg.No. 8401
Dated: May 1985

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INTRODUCTION

INTRODUCTION

The clinical utilization of the electrophysiology of the auditory function has opened a new era in our ability to diagnose receptive auditory impairment. During the last three decades there has been a substantial emerge of activity in Electric Response Audiometry, due, no doubt, to the development in computer technology and to enhanced insights into auditory physiology particularly at the level of the sense organ and the brainstem.

Brain-Stem Electric Response Audiometry (BSERA) differs from conventional pure-tone audiometry in that it is an entirely objective procedure, the subject's response is totally involuntary, even to the extent that normal responses are obtained from sedated, unconscious or comatose subjects whose auditory function is intact. BSER finds clinical application in the evaluation of hearing abnormalities involving that portion of the auditory pathway between the cochlea, where the acoustic stimulus is first converted to an electrical signal, and the brainstem, where this signal initiates the coordinated neuron discharge subsequently recognized as sound. "The responses are obtained from surface electrodes by a completely safe and nontraumatic technique which may be performed without the necessity for medical training". (Gibson, 1978).

('The response consists of a series of 7 waves during the first 10 ms following stimulus onset and is presumed to derive from the progressive activation of tracts and nuclei in the auditory brainstem pathways.

Although certain pathological conditions are associated with changes in BSER patterns, factors unrelated to pathology can also influence the normal response parameters. The nature of the stimulus recording procedure, and subjects evaluated all have associated effects on the response.

Pertinent stimulus characteristics include intensity, repetition rate, polarity, envelope (rise-fall time and duration), and presentation mode (monaural vs binaural). (Fria, 1980).

A parameter of stimulation that is very important for ERA is the stimulus presentation repetition rate. It is the number of stimuli delivered, usually per second. By increasing the repetition rate i.e. the rate of stimulus presentation, BSER recording time can be markedly reduced.

Some subjects, typically young children and babies only yield small BSER. Due to minute voltages involved, many individual BSER epochs have to be summed and averaged before the responses can be clearly identified from the background fluctuations. When intensities are used that are only slightly above the psychophysical hearing threshold, upto 8000 stimulations may be required to obtain an identifiable response Hence most workers try to minimise the time taken to obtain each BSER by using a fast stimulus repetition rate. For instance at a stimulus repetition rate of 5/sec it takes around 26' 42" to record the BSER to 8000 stimulus presentation while with increasing the rate to 20/sec it takes only 6' 42" which is nearly 1/4 of time required with rate of 5/sec.

Increasing the repetition rate can cause adaptation however leading to a drop in response amplitude and a rise in response latency. For threshold determination the largest response and most generally advocated is the ($N_4P_4N_5$ complex) V peak. Hence the influence of rate on the components of their complex regarding amplitude information whether they vary with a fast/slow rate is vital in threshold determination. For neurootological diagnosis, all the waves are important. Changes in latencies are used as a diagnostic criterion, eg. for acoustic tumours (Selters and Brackmann, 1977) and multiple sclerosis (Robinson and Rudge, 1977), it is therefore important to know the influence of the repetition rate on latency, and the level in the auditory pathway at which changes in latency develop.

" Several investigators (Jewett and Williston, 1971? Pratt and Sohmer, 1976? Zollner et al, 1976? Don et al, 1977) have already studied this issue, but their results are not consistent". (Van Olphen et al, 1979).

These reports do not give a clear answer to the question of whether there is a decrease in amplitude and an increase in latency of the successive potentials with increasing rate. Most of them have employed the click stimulus and influence of logon stimuli is not known.

Hence, there is a need to investigate the influence of the stimulus rate on the amplitudes and latencies of brainstem evoked potentials in man using logon stimuli.

The purpose of the present investigation is to compare and evaluate the effect of 2 different rates of presentation of stimulus in BSER using logon stimuli.

has been
The following null hypothesis/proposea:

Main Hypothesis:

- There is no significant difference in the brainstem responses between the two rates of presentation of the stimuli(5stimuli/ sec and 20 stimuli/sec) at 2 KHz,4 KHz and 6 KHz (logon stimuli).

REVIEW OF LITERATURE

Auditory brainstem responses are the far-field reflections of electrical activity originating in the auditory pathway in its course from the cochlea to the cortex which can be recorded from scalp electrodes using computer averaging.

2.1 History and Development of Brainstem Evoked Response(BER):

As early as 1875, the presence of electrical potentials in the brain was first noted by (aton who recorded electrical changes in the exposed brain of rabbits and monkeys. It however remained for Jewett and Williston (1971) to give a description of the brainstem electrical responses in human subjects. They showed that acoustically generated "early" potentials could be detected from a wide area of the skull. Hecox and Galambos (1974) applied them to audiometry of infants and adults.

Most of the earlier forms of electrical response audiometry had low reliability because the results changed during sleep, under sedation, or under general anesthesia. Jewett et al, (1970) were among the first to record earlier 1.0 to 10 ms brainstem response unaffected by sleep or sedation.

The history of these responses really began in 1967 when Sohmer and Feinmesser in Jerusalem, succeeded in recording the

8th nerve action potential (AP) from an active electrode placed on the ear lobe. Jewett et al (1970) confirmed the validity of the responses and their paper provided a more detailed definitive description of ABR properties.

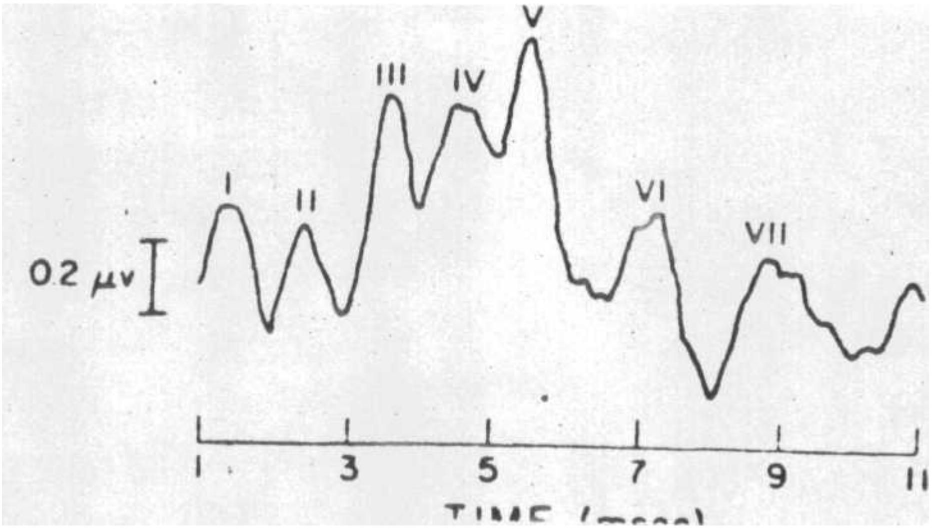
Further studies in humans by Romano and Williston, Hecox, Galambos (1974) and associates,, Starr and Achor (1977) and others have shown that these responses are reliable clinical indicators of both normal and pathological conditions in the peripheral auditory system.

The early literature on brainstem electrical responses(BER) tends to confuse the reader as different research groups in the past used different terms to describe the same events. Perhaps the most precise name would be 'auditory nerve' and brainstem evoked responses since both type of responses are recorded in the same average trace. Nevertheless, in congruence with the International ERA study group (Davis, 1971) and Gibson (1978). the term "brainstem electrical response" (BER) is the most appropriate term and is the commonest in recent literature.

2.2 **Anatomical Source of the response:**

The general form of BSER (Fig.l) includes a series of five to seven positive waves approximately 1 msec, apart. These are presumed to represent successive activation of the brainstem auditory nuclei and it has considerable evidence.

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



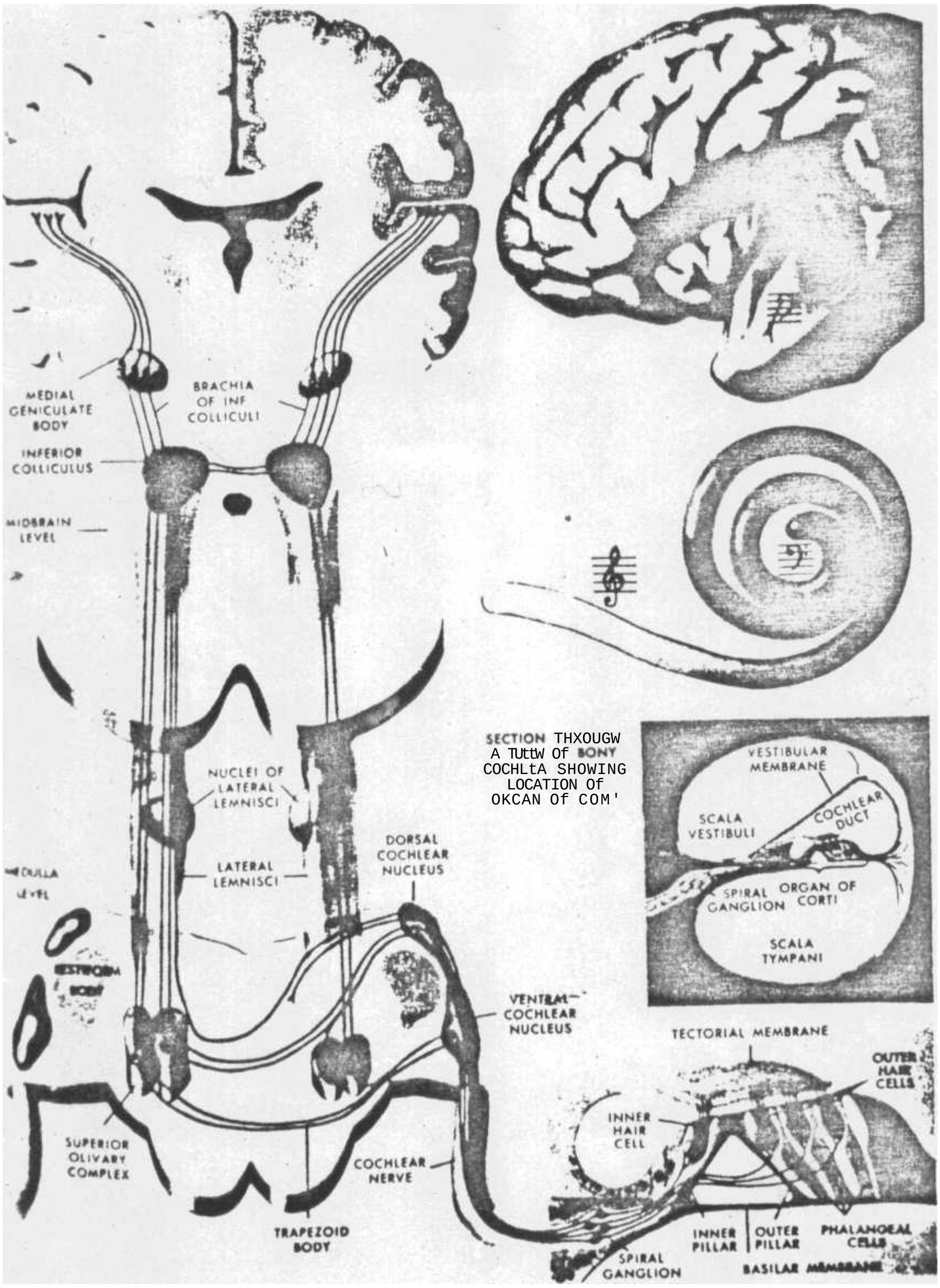
(Adapted from Skinner, P.H., 1978)

Classically, the "relay stations" between cochlea and cerebral cortex are, in ascending order - auditory nerve, cochlear nuclei (CN), superior olivary complex (SOC), nuclei of lateral lemniscus, inferior colliculus (IC) and medial geniculate body (MGB) from where the fibres travel in the auditory raditions to primary auditory cortex i.e. the Heschl's gyri deep in the temporal lobe (Dobie,R.A 1980), Fig.2 gives the auditory pathway.

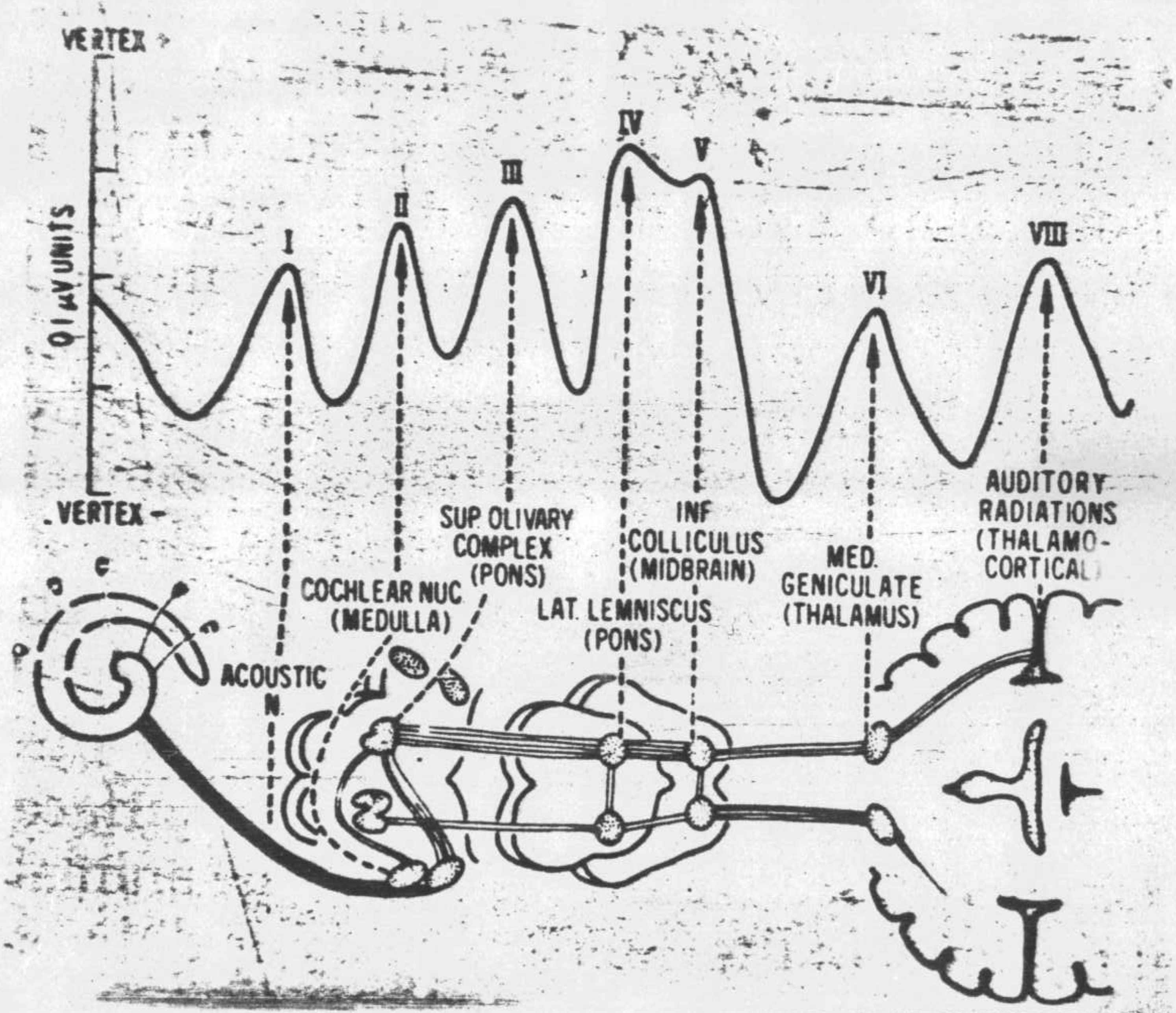
Evidence from animal experiments (Jewett, 1970; Lev and Sohmer, 1972; Buchwald and Huang, 1975; Starr and Achor, 1977; 1978), human studies of topographical analysis of scalp distributions (Sohmer and Feinmesser, 1973; Martin and Coats, 1973; Martin and Moore, 1977; Picton et al, 1974) and from pathological correlations in humans (Sohmer et al, 1974? Starr and Achor, 1978) have demonstrated that each component wave of the BER can be associated with a specific neural generator in the auditory pathway.

A diagrammatic representation of this correspondence between BER component waves and anatomical structures in the primary ascending auditory pathway is shown in Fig.3. A correspondence is observed between Wave-I and the first order fibres of the eighth cranial (auditory) nerve; Wave-II and the CN.Wave-Ill and the SOC (by contralateral activation); Wave-IV and the ventral

Fig:2:- Diagram of the Auditory Pathway.



(Adapted from Ciba, 1970)



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

nucleus of LL and preolivary region (crossed and uncrossed activation); Wave-V and the IC (crossed projections); Wave-VI and MGB and Wave-VII and primary auditory cortex.

Nevertheless caution must be exercised in assuming that each wave has only a single generator. Such an association, especially for Waves-II through V, must be considered hypothetical for at least 2 reasons. (Fria, 1980).

1. The brainstem lesions of patients in human studies were often extensive and diffuse, making a one to one correspondence between given waves and neurologic structures difficult to conceive.

2. It has been shown that each surface recorded BER component wave probably reflects the composite activity of several neural generators (Jewett, 1970; Picton et al, 1974; Starr and Achor, 1978). Fria (1980) states that II-V waves reflect the generalized lemniscal activity of the brainstem auditory system. .

All in all, the evidence for a neural origin for each wave of the BER is strong and has been accepted by most workers.

Thus, BER;have great neurological **S significance as they demonstrate the course of the auditory response through the . brainstem areas and they are presumed to reveal the site of any pathology which disrupts this passage. t^ ^

2.3 Classification of Auditory Electrical Response:

The auditory electrical responses can be divided into categories on the basis of placement of electrodes, latency, different properties and presumably different anatomical sources.

On the basis of latency ie. the time elapsed between the stimulus and response, the auditory electrical/evoked response can be currently divided into 4 categories. Fig.4 shows the schematic representation of the four class of auditory evoked potentials (electrical responses). It includes:

Early response - 4 to 8 ms

Middle response - 8 to 50 ms

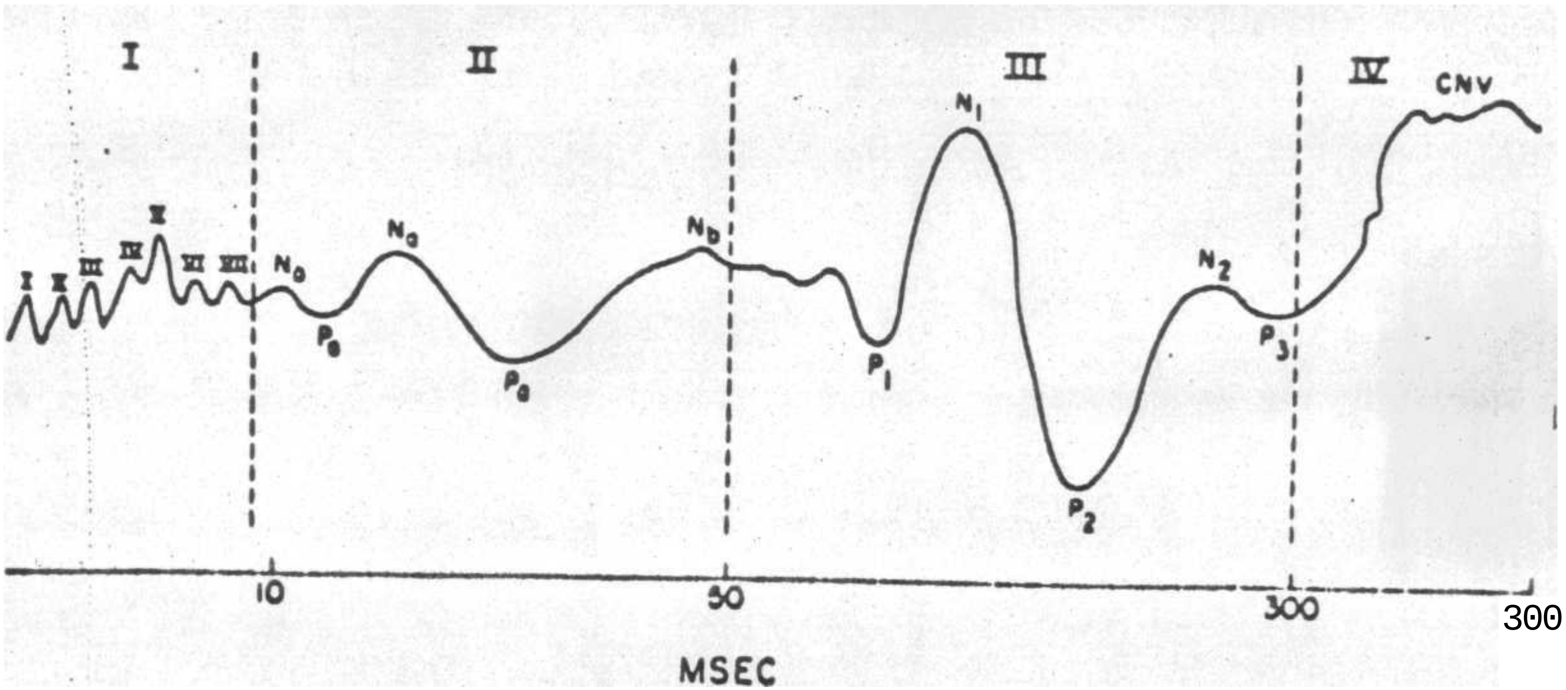
Late response - 50 to 300 ms

Very late response - 300 ms to several seconds,

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

The early response is comprised of a series of "very fast waves" (100 to 2000Hz) which presumably arise from the brainstem (Jewett and Williston, 1971; Lev and Sohmer, 1972). The middle response is comprised of a series of "fast waves" (5-100 Hz) which presumably arise from the primary cortical projection areas

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



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

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

2.4 Normal Response Parameters: (in BER):

The use of the auditory brainstem responses (ABR) for clinical purposes obviously involves the recognition of abnormal results. Such recognition depends on a knowledge of normal ABR characteristics. Those parameters considered include - morphology, latency and amplitude of the obtained response.

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

The visual appearance of the ABR in different studies may vary. Although most investigators display positive waves at the vertex as upward deflections, some display the same waves as downward deflections. Attention to this seemingly minor point can avoid confusion when comparing published wave forms in the literature.

Chiappa et al (1979) described 6 variant forms in normal young adults (Fig.5).

The variants include:

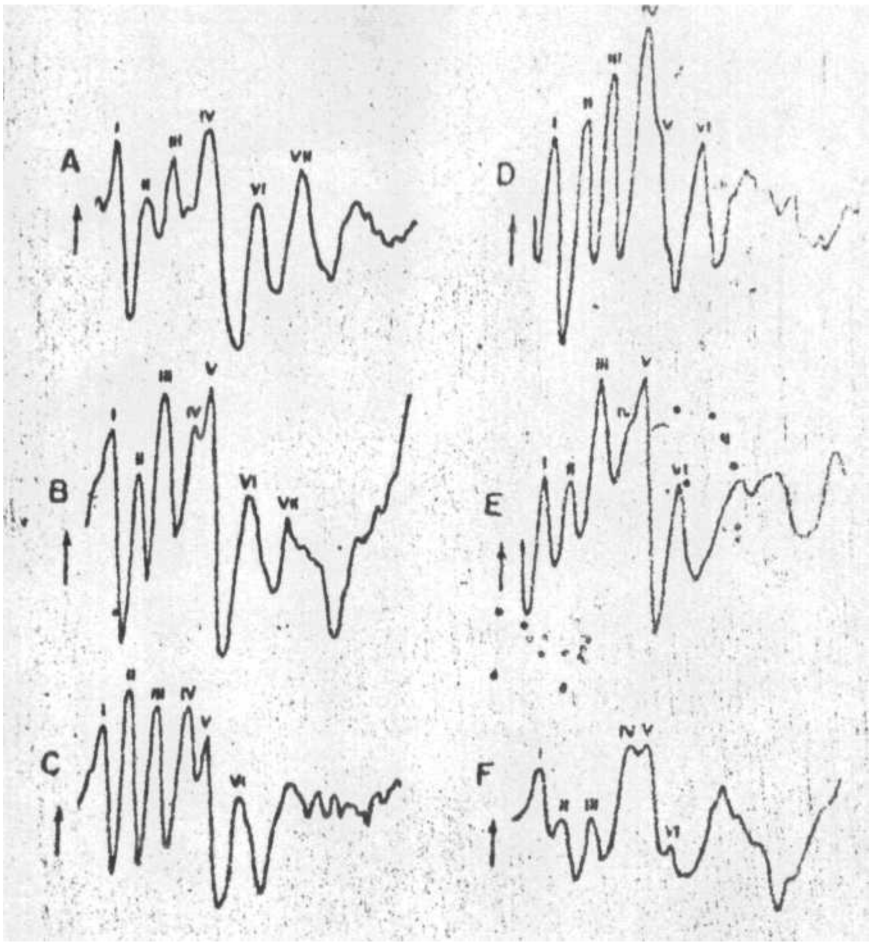
A) a single peak with no separation of waves-IV and V.
B) separate IV and V waves with V of greater height than IV.
C) separate waves with IV of greater height than V.
D) wave V appearing as an inflection on IV.
E) Wave-IV appearing as an inflection on V.
F) separate waves of the same height.

In normal adult subjects wave-V is the most frequently observed component of the ABR and waves II and IV are often poorly defined responses. Wave-III has also been found to be a prominent feature in the literature. Hence in this study wave-1, II and V would be considered in analysis.

- **Response Latency**: The time relationship between any response and the stimulus eliciting that response is commonly called 'latency'. While studying the brainstem electrical response (BER) this parameter is designated as absolute latency and interwave latency. Fig.6 shows the distinction between absolute and interwave latency for component waves of the brainstem electrical response (BER).

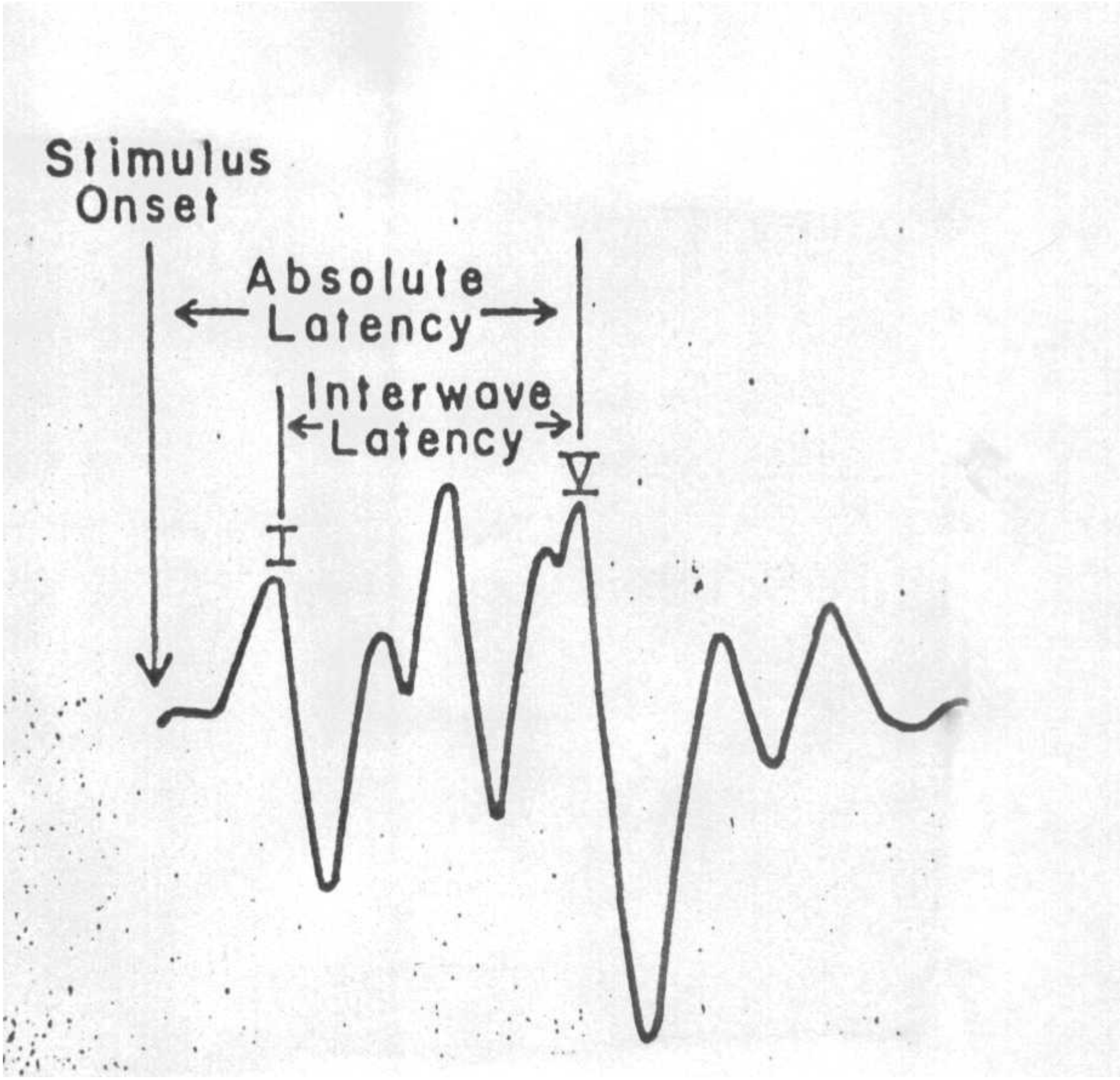
Absolute latency conforms to the traditional definition, i.e. the time relationship between stimulus onset and associated

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



(As reported by Chiappa et al (1979)

Fig-6: Diagram showing the distinction between absolute and interwave latency for component waves of the brainstem electrical response (BER)



(Adapted from Fria, T., 1980)

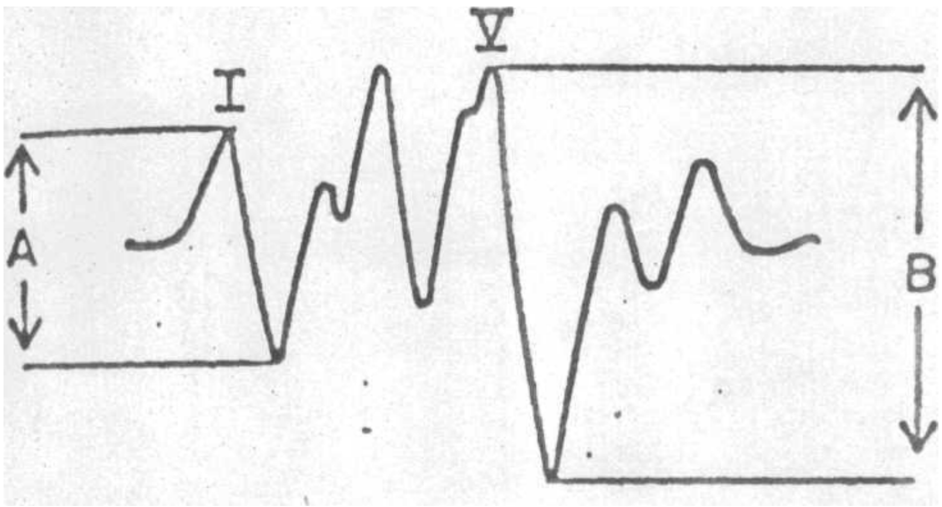
response. Interwave latency, however, refers to the time difference between two component waves, eg. the I-V interwave latency. Both absolute and interwave latency values are typically specified in milliseconds (ms).

In relation to this parameter of response latency it can be stated that the latency of each of the BER peaks, using similar stimuli, is remarkably constant amongst adults subjects.

Response Amplitude: It 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 (assuming that vertex positive waves are displayed as upward deflections). This measurement is sometimes called "absolute amplitude ". It can also be expressed in relation to one another, and these measurements are commonly called "relative amplitude". (The distinction between absolute amplitude and relative amplitude is represented in Fig.7) Relative amplitude is the ratio of the absolute amplitudes for 2 ABR waves. In this Figure relative amplitude = B/A.

Absolute amplitude measures show wide variation between and within subjects. Relative measures are more consistent and are better indices for comparing amplitude phenomena between subjects and within the some subject on different occasions (Starr and Achor, 1975).

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



(Adapted from Fria, T., 1980)

2.5 **Factors Affecting Normal Response Parameters**:

Although certain pathological conditions are associated with changes in ABR properties normal response parameters can be influenced by factors unrelated to pathology. The nature of the stimulus, recording procedure, and subjects evaluated all have associated effects on the response. Diagnostic errors can be minimized by knowing the effect that technical and subject related factors can have on normal response parameters. The factors affecting this could be classified as:

I Stimulus effects

II Procedure effects

III Subject effects.

(Fria, T.J 1980).

I. Stimulus effects: include

- a) Stimulus intensity
- b) Stimulus repetition rate
- c) Stimulus envelope (rise-fall time and duration)
- d) Stimulus polarity
- e) Mode of presentation (monaural vs binaural)

II. Procedure effects: include

- a) Position of electrodes
- b) Use of filters (bandwidth)
- c) Choice of response reference points for the computation of latency and amplitude.

- 6) Difference in stimulus transducer

- e) The effect of masking and/or ambient noise levels.

III. <u>Subject effects</u>: include

- a) State of the subject.(awake, asleep, sedated/anesthetizec
- b) Effect of the temperature.
- c) Sex differences.
- d) Effect of age.

In this section, only the stimulus effects would be dealt with, in brief and with particular emphasis on effect stimulus repetition rate.

I(a) <u>Stimulus Intensity:</u>

The stimulus parameter exerting greatest influence on the response waveform is intensity. In general it is observed that as the stimulus intensity is reduced the response amplitude of the auditory electrical responses decrease and the response latency of the characteristic peaks is increased or prolonged.

Although all BER component waves usually, are observed in response to high intensity stimuli, the likelihood of observing all waves is reduced with each intensity decrement as threshold is approached. At intensities below approximately 40 dBnHL (threshold of a panel of normal hearing young adults), 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). When wave-V is fused into an indistinguisheable IV-V complex, its resolution is improved at lower stimulus intensities (Rowe, 1978? Stockard et al, 1978b).

In general a decrease in stimulus intensity is associated with an increase in component wave latencies and the mean latency for NV in normal adults increases from approximately 5.5 ms at 80 dBnHL to slightly greater than 8.0 ms at 10 dBnHL (Hecox and Galambos, 1974? Starr and Achor, 1975; Yamada et al. 1975).

The general reduction in BER amplitude with decreasing stimulus intensity has been recognized (Stockard et al, 1979b? Starr and Achor, 1975). With increasing stimulus intensity the amplitude of the first wave increases. The amplitude of the later waves from the brainstem nuclei increases little with increasing stimulus intensity and at high intensities (above 70 dB 150) the amplitude occasionally is decreased. (Picton et al 1970).

b) Stimulus envelope (Rise-fall time and duration):

A critical stimulus parameter affecting the nature of the auditory electrical response is the rise time and duration of the stimulation sound.

Hecox et al,(1970) examined the influence of stimulus envelope on wave-V latency and amplitude, and observed that stimulus rise time had the greatest effect in wave-V latency, increasing rise time from 0 to 10 ms was associated with more than a 2.0 ms increase dn wave-V latency. Variations in stimulus off time was observed to have minimal influence on wave-V latency. Hecox et al, (1976) concluded that the BER was an 'onset' response, i.e. its properties were largely dependent on stimulus onset characteristics.

" Tone pips and bursts have larger rise times than clicks and hence one would expect related effects on BER latency. Responses to tone pips and bursts of various frequencies have been studied by a numbers of investigators (Brama and Sohmer, 1977; Coats et al, 1979; Picton, et al 1979). In general they have observed that wave-V latency in response to a given Stimulus intensity, is inversely related to the frequency of the stimulus. One might expect that this effect is due primarily to the increase in rise time as frequency is lowered.

Response morphology and amplitude are also influenced by stimulus envelope characteristics. Responses to low frequency (250, 500 or 1000 Hz) tone pips or bursts are significantly smaller and less clearly defined than responses to unfiltered clicks. This relates to the observation that the increased rise time associated with these stimuli is less effective in producing a synchronous firing of neuronal groups necessary for clear response definition.

c) Stimulus Polarity :

Reversing stimulus polarity from rarefaction (R) to condensation (C) has been reported to influence BER response morphology (Gibson, 1978; Coats and Jerger, 1980; Fria, 1980) and not any other responses.

The condensation (C) phase of the stimulus polarity refers to the first acoustical wave applying positive pressure to the tympanic membrane whereas the rarefaction (R) phase refers to the first acoustical wave applying negative pressure to the tympanic membrane.

Changing click polarity from R to C has been reported to have an influence on the morphology of the IV-V complex and the use of alternating click polarity can affect the morphology of , wave-I due to the possible cancellation of out-of-phase components when responses to the separate polarities are summed (Stockard.et al, 1978b, 1979a).

There are differences in the literature on the reported effect of stimulus polarity on latency parameter. Some reports no difference between mean latency while others found no significant difference with changing polarity.

d) Mode of Presentation:

An additional stimulus related characteristic that has been demonstrated to have an effect on normal response parameters is the mode of presentation, i.e. monaural vs binaural stimulation.

The amplitude of response is enhanced (about 20% larger) if the stimulus is presented to both ears simultaneously (Davis, 1976; Gibson, 1974; Jewett and Williston, 1971; Starr and Achor, 1975; Stockard et al 1978b).

This finding correlates well with the psychoacoustical finding of an apparent increase in loudness on binaural stimulation.

e) Stimulus repetition rate:

A parameter of stimulation that is very important for ERA is the stimulus presentation/repetition rate or the inter-stimulus interval(ISI). The ISI is a measure of the time elapsing between the end of one stimulus and the beginning of the next. The stimulus rate is the number of stimuli delivered, usually per second. One can relate the ISI and stimulus rate if one knows the length of the stimulus - for eg: ISI 200 ms, stimulus length 50 ms is equivalent ta stimulus rate of 4/sec.

Recording brainstem responses is a time consuming procedure, especially when a large number of recordings are required as in the case for threshold determination. The recording time can be shortened considerably by presenting the stimuli at a higher repetition rate. Hence its important to know the influence of the repetition rate on latency and amplitude, and the level at which changes develop. Several investigators have already studied this issue, but their results are not consistent.

Eggermont and Spoor (1973a) found that decreasing the interstimulus interval (ISI) (i.e. with increased stimulus rate) altered the amplitude.latency and waveform of the action potential (AP), but had no noticeable effect on the cochlear microphonic (CM) and summating potential (SP). These effects are due to the fact that the AP depends on the firing of individual nerve fibres and that each nerve fibre requires a short period after each firing (refractory period) before another neural impulse may be initiated. The equilibrium value for any of the functions at a given ISI is generally reached after 5 stimuli, and after this period the pattern of firing of individual fibres reaches a steady state. The findings of Eggemount and Spoor (1973a) are as follows:-

1. The amplitude of the AP remains at approximately 100% of its value for rates upto 7/sec (ISI approximately 140 ms) and

only alters fractionally at rates upto 14/sec. (ISI 70 ms). A general reduction in amplitude of the N^ component of AP at faster LSI/rates is noticed.

2. The latency of the N^ component of the AP increases with shorter ISI (rapid rate).

3. The width of N_1 component of AP increases.

According to Pratt and Sohmer (1976); increasing the stimulus rate causes a decrease in the amplitudes and an increase in the latencies of N_1-N_5 The decrease in amplitude of N_1 is most prominent. In general, the later the wave the smaller the decrease in the amplitude, however the amplitude of N_4 is leasnt affected. The stimulus rate has no effect on the latency of N_1, but the latencies of the later waves increase with increasing rate, the effect being greater on the later waves (cumulative effect).

Zollner et al (1976) found a decrease in amplitude and an increase in latency for all the wave? N_1-N_5 The latency shift was Larger for the later waves.

Jewett and Williston (1971) were the first to 'Observe morphological changes in the BER as stimulus repetition rate was increased from 2.5 to 25 clicks/sec. The increase in stimulus rate significantly resulted in loss of definition of the earlcomponent i.e. I through IV. This wave form degradation was slight at 10 click/sec but quite noticeable at rates of 20/sec. The N_5 component was found to be little affected. In fact, they repotted an increase in the amplitude of N_5 at higher stimulus rates. They did not observe a change in latency for N_5 as a consequence of higher stimulus rates. However the N_5 mentioned by Jewett and Williston has a latency of 4.6 - 5.1 ms, which is almost 2 ms shorter than the latency reported by Pratt and Sohmer (1976) and Zollner et al (1976).

Rowe (1978) reported that early wave definition was main- -

tained at rates as high as 30/sec, but Stockard et al (1978b) and Chiappa et al (1979) found reduced definition at higher rates of 70 to 80 clicks/sec.

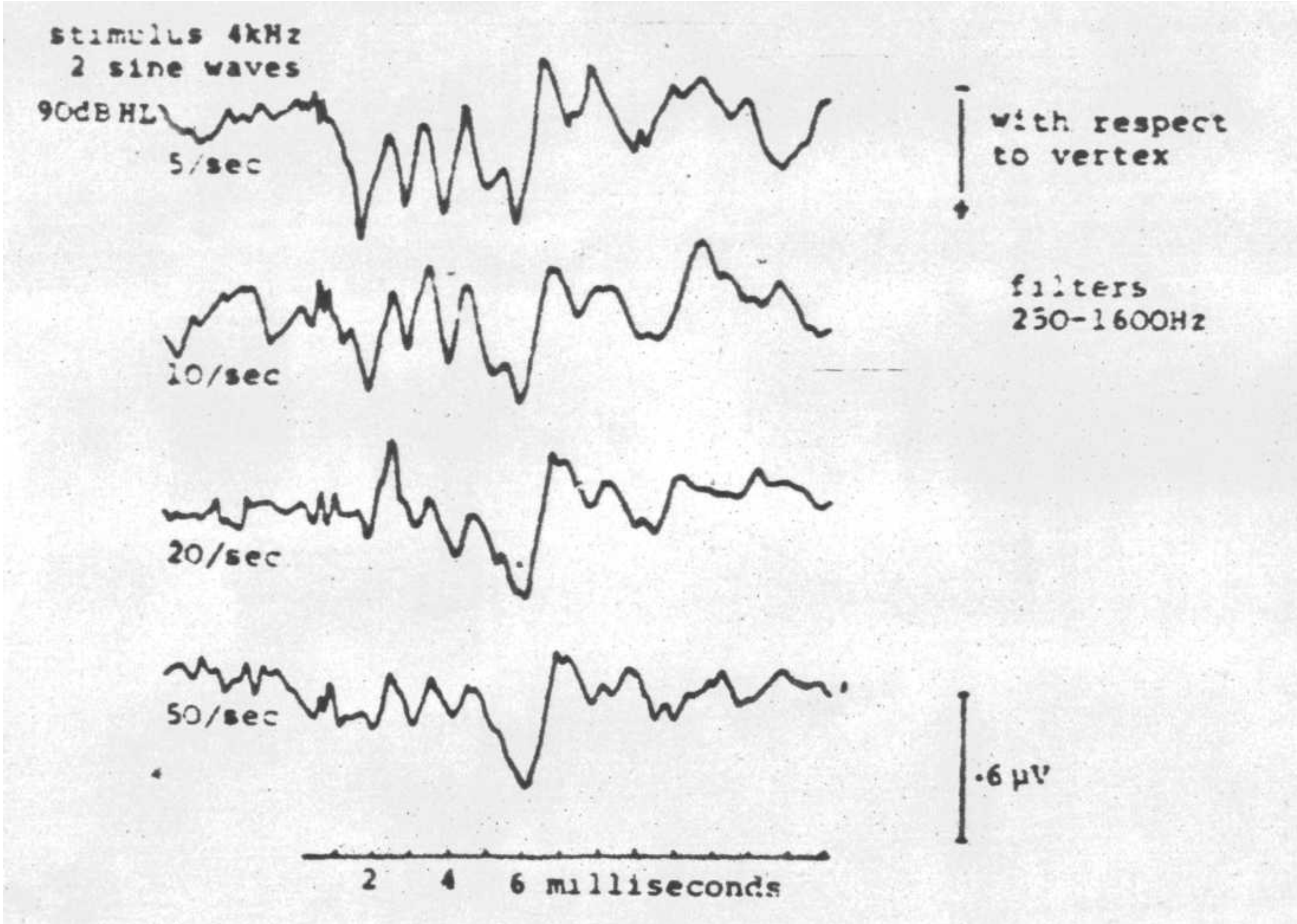
Olphen et al (1979) found that the amplitudes of N_2-N_4 diminish uniformly with increasing stimulus rate. The repetition rate was found to have little or no influence on the amplitude of N_5, however increase in latencies of N_2-N_5 was noticed,

Wave-V dominance appears to be resistant to rate effects (Chiappa et al 1979; Jewett and williston, 1971? Rowe, 1978; Stockard et al, 1978a; Pratt and Sohmer, 1975? Terkildsen et al, 1976) but Gibson (1978) notes that NIV and NV tend to merge at faster rates. This property of the later waves is useful as it allows to collect a large number of epochs within a reasonable period when threshold estimations are being sought. However, Stockard et al (1978b) found that decreasing waveform resolution associated with rapid stimulus rate (i.e. 80 clicks/sec) could render the BER uninterpretable.

Fig.8 shows the effect of varying the stimulus presentation rate on the BER waveform. In general an increase in absolute latency of all BER component waves is associated with an increase in stimulus repetition rate (Chiappa et al, 1979; Don et al, 1977; Acton et al 1977; Rosenhamer et al 1978; Stockard et al, 1978b; Weber and Fujkawa, 1977). For eg. an increase in click rate from 10 to 100 click/sec can increase wave V latency by slightly more than 0.60 ms.

The physiological basis for the effect found on varying the stimulus presentation rate on BER waveform could possibly explained through this - sensory systems require a finite period of time following an adequate stimulus to fully recover their responsiveness. If subsequent stimuli occur before recovery is complete, the systems response will be altered (attenuated or prolonged /in latency). Don et al 1977 consider the shift of latency of the brainstem response components with rapid stimulation rates as a manifest of incomplete recovery. Its more likely that a change in receptor function known as adaptation or fatigue is the cause for the latency shift induced by rapid stimulation. Both are presumed to be due to metabolic alterations of receptor elements consequent on their activation.

Fig.8: Effect of varying the stimulus presentation rate on the BER waveform



(Adapted from Gibson, WPR, 1978)

The review of literature shows considerable variability in the results. Moreover most of the investigators have employed the click stimulus. Rarely do we find any study regarding the effect of rate of presentation of logon stimuli on the brainstem responses. Hence at attempt has been made to study the effect of stimulus repetition rate on BER using the logon stimuli.

METHODOLOGY

METHODOLOGY

3.1 Subjects:

10 subjects (5 males and 5 females) in the age range of 17 to 23 years were selected for the present experimental study. Only one ear i.e. right was tested in all these subjects.

The selection of the subject's was based onthe following criteria:

i) They should have had audiometrically and otologically normal ears.

ii) Negative history of epilepsy or other neurological complaints.

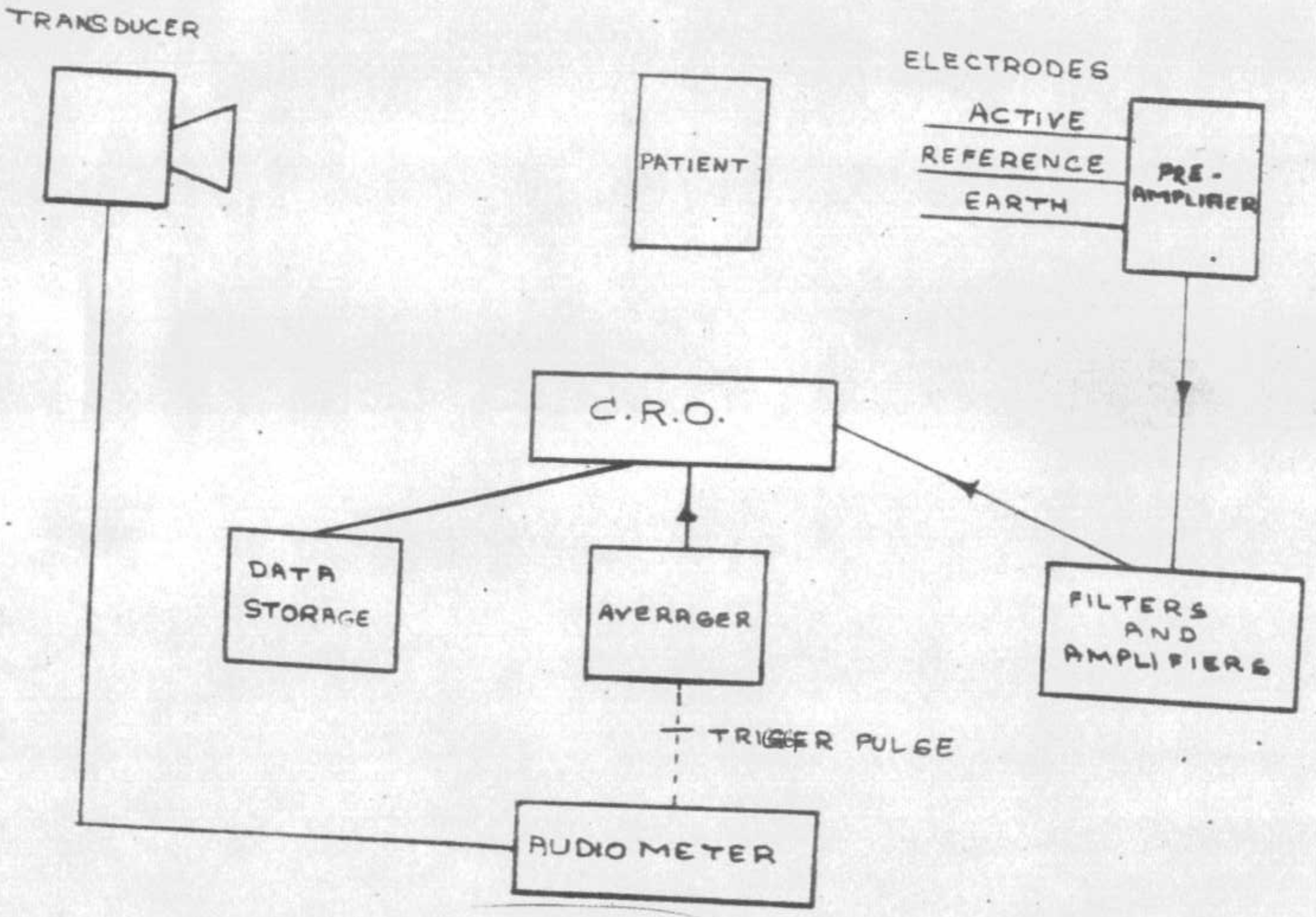
iii) They were required to relax and feel comfortable with electrodes on, within 10-15 minutes after their placement.

3.2 Equipment:

Electric Response Audiometer Model TA-1000 was used to test the subjects. A schematic block diagram of the system is shown in fig.9 and the picture of the instrument is shown in fig.10.

Basically the equipment consists of a stimulating system, which provides the necessary sound stimuli to evoke the response (a stimulus generator which feeds the stimuli to a transducer - earphone or a bone conductor) and a recording system. (The recording apparatus consists of electrodes, amplifiers, filters, averager and display) together with some device for obtaining a permanent record.

Figure-9: Schematic diagram of ERA equipment



(adapted from Gibson, WPR; 1978)

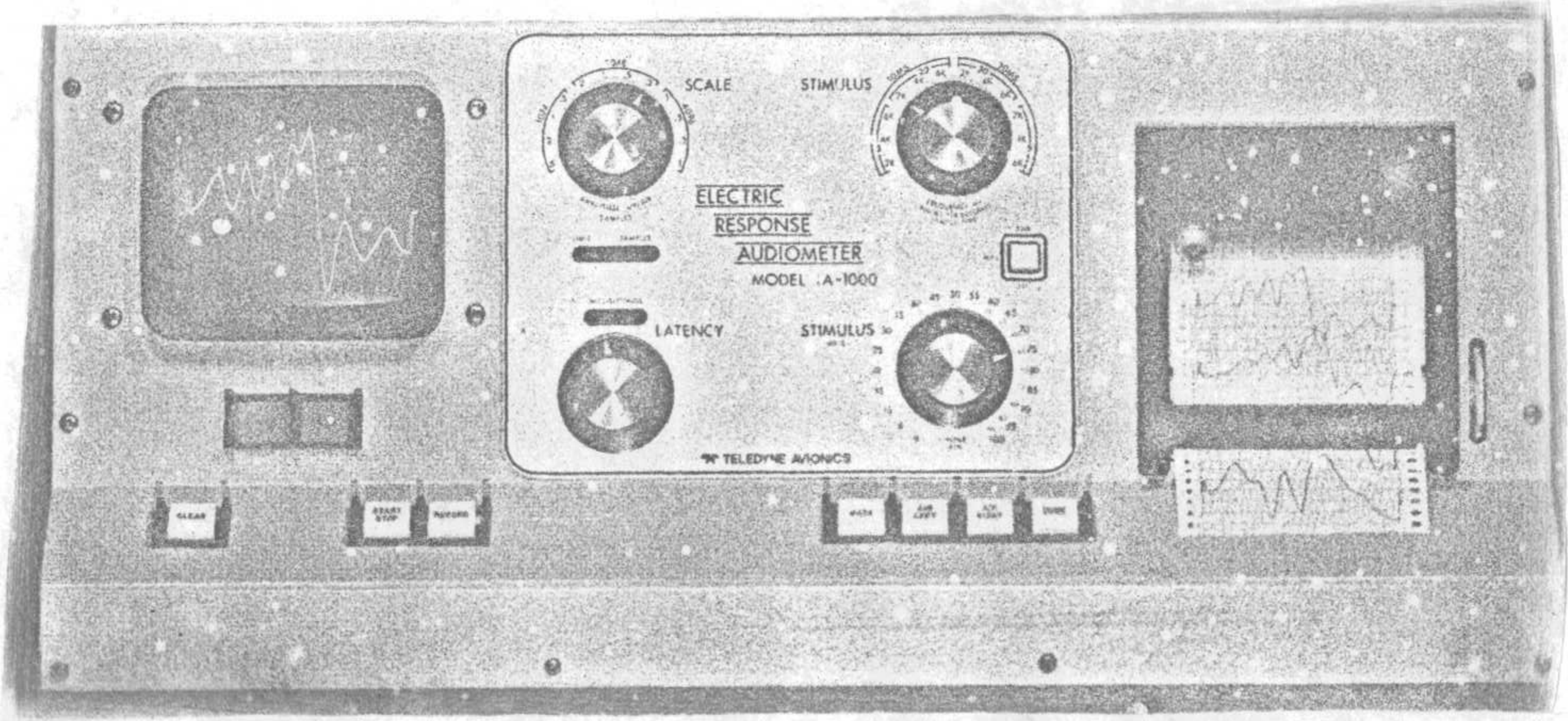


Fig 10- Electric Response Audiometer. Model-TA1000
(used in this present study)

The stimulus generator unit produces first an electrical waveform which is amplified and then passed to a device (an attenuator) which decreases the output by known increments so that the stimulus intensity can be varied in 5-10 dB steps. Finally the amplified, attenuated signal is fed to the transducer (earphone or bone vibrator) which changes the electrical waveform into its corresponding acoustic waveform. The number of stimuli required and the rate of the presentations is determined by the rate of triggering so that each presentation is synchronized with the sweeps of the averager to allow averaging. The patient's electrical response is detected by the electrodes and because the evoked response is minute, measuring only a few millionths of a volt, the signal is amplified by the preamplifier and mainamplifier at all the frequencies in the physiological spectrum without distortion. The filter excludes all the other frequencies which are not adding to the response but form only a source of artefactual contamination and only those within which the energy lies are passed to the averager. The averager cancels the random activity and summatesthe selected number of responses. The resulting electrical activity is displayed on the oscilloscope and the data obtained can be stored for later analyses through permanent recording devices.

Brief description of the Instrument:

Fig. 0 The TA-1000 system consists of the SLZ 9793 desk-top console, the SLZ 9794 preamplifier and an accessory group.

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

The SLZ 9794 preamplifier is an isolated EEG preamplifier with frequency response and gain specifically designed for ERA. Patient's electrical response that is sensed by the set of 3 electrodes, is conducted to the consols by an interconnecting cable.

The Accessory group used was:

a) A binaural air-conduction head-set (TDH-39 earphones housed in MX-41/AR ear cushions) with cord set.

b) Interconnecting cables, chart paper and pens.

c) Sets of electrodes, electrolyte gel and electrode adhesive pad.

- Controls and their function:

The TA-1000 is operated with only (i) four knobs and (ii) nine push button switches. All knobs are clearly marked to indicate their functions. All push-buttons indicate, by means of internal lamps, the active state of the selected function.

i) Four knobs:

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

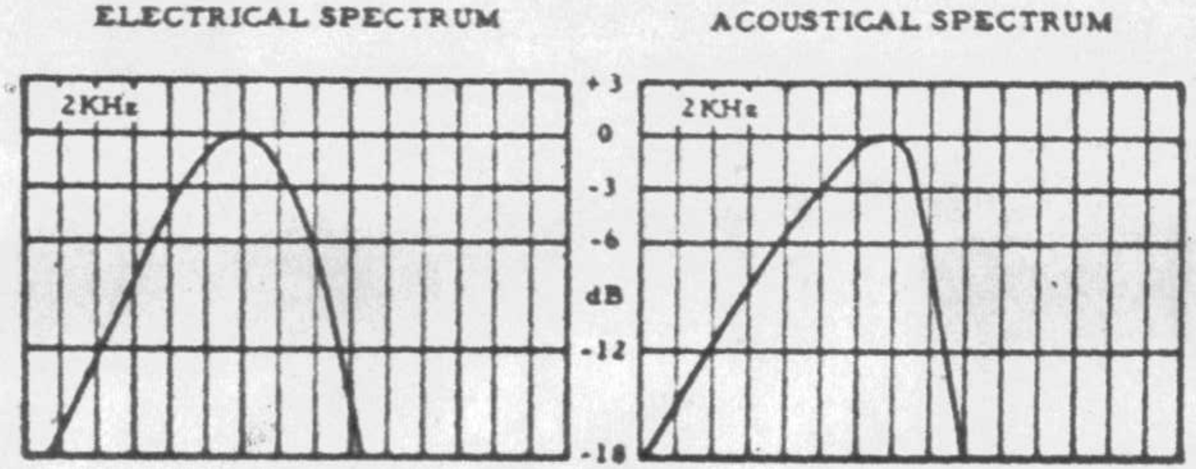
   The TA-1000 stimulus logon is characterized by 3 peaks in a 50% -ve, 100% +ve, 50%-ve sequence followed by a 50% +ve, 100%-ve, 50% +ve sequence reversing on each successive stimulus (Fig.1l).

2) The stimulus attenuator establishes the presentation level, permits selection of 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, 0.5 1μV, 2μV and 5μV/division sensitivities are available.

4) The latency control positions 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 ns resolution is displayed in digital form directly above this control.

Figure-11:-Electrical and Acoustical Spectrum of 2 KHz Logon Stimuli



ii) Push Button Switches:

1) Power switch energizes the system and indicates the system status.
2) Score switch controls the oscilloscope display.
3) Clear push button clears the microprocessor averager, memory, resets the sample display counter and corrects the microprocessor operating mode to correspond to the current control status.
4) Start/Stop push button initiates the microprocessor average function. As the number of samples accumulates, the averager can be stopped to evaluate intermediate results and restarted without disturbing the averager action. The averager function is automatically terminated when the selected number of samples has accumulated, or when any averager memory channel is full? automatic termination requires a clear, to permit restart.
5) Record push-button indicates the plotter readout of the averager is not active.
6) Mask push button applies broad-band noise masking to the contralateral ear only when either air left or air right stimulus is active.
7) Air left applies the stimulus to the desired earphone.
8) Air right applies the stimulus to the desired earphone.
9) Bone push button applies the stimulus to the bone vibrator 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 sensitivities i.e. 0.1 μV, 0.2 μV and 0.5μV/division, this indicator will be relatively active, depending on the individual patient. Patient responses, . occuring when the limit light is on, are rejected from the averaged responses and are neither accumulated nor counted, (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 EE3 position, after a clear, the oscilloscope will display the ongoing patient EEC activity, the raw signal from whiciythe averaged response is derived.

3.3 Test Environment:

The experiment was carried out in a sound treated room situation which was dimly lit. Factors considered include:

a) Power source: The main A.C. current was channelized to I.T.L. Model SVS - 200L stabilizer with input 170-270 volts and output of 230 volts, which was stepped down by Kardio S.No.101 to 110 volts which is the requirement of the instrument to function properly.

b) Location of the instrument: The instrument was placed inside a larger sound treated room where:

- Humidity was neither too high or low to the point where either the subject or clinician were uncomfortable.
- It was away from noisy environment or excessive vibration area.
- It was away from electrically noisy area i.e. large motors, copying machine etc.
- Curtains were drawn to control direct sunlight in the room and the room was dimly lit.

3.4 Test Procedure:

After determining the pure tone thresholds, the subject was asked to relax on a couch with a pillow under the neck to encourage the neck muscles to relax.

Surface electrodes were used in this study. Before attaching each electrode the skin was cleaned with alcohol and then a drop of electroconductive jelly was placed on the centre of the surface electrode so as to ensure optimum electrical contact between the electrode and the skin.

Electrode placement was as follows:-

Active/Signal electrode(Red) - Vertex (high forehead)

Reference electrode(white) - Mastoid process of the test ear(right).

Earth/Ground electrode(Black) - Mastoid of the non test ear(Left). .

The electrodes were held in position with adhesive plaster. Each electrode was plugged into the correspondingly coloured receptacle on the patient electrode cable from the preamplifier. The test was not started until the limit light both in the pre-amplifier and beside the sample contour disappeared.

The scale switch was set to 2048 samples and 2μV/division. A sample time of 10 ms was chosen since early responses of brain-stem were required. For each subject the ABR for the following frequencies and intensities at 2 different rates (5 pulses/second and 20 pulses/second) were recorded for right ear:

1. 2 KHz - 80 dBHTL - 5 pulses/second
2. 2 KHz - 80 dBHTL - 20 pulses/second
3. 2 KHz - 100 dBHTL - 5 pulses/second
4. 2 KHz - 100 dBHTL - 20 pulses/second
5. 4 KHz - 80 dBHTL - 5 pulses/second
6. 4 KHz - 80 dBHTL - 20 pulses/second
7. 4 KHz - 100 dBHTL - 5 pulses/second
8. 4 KHz - 100 dBHTL - 20 pulses/second
9. 6 KHz - 80 dBHTL - 5 pulses/second
10. 6 KHz - 80 dBHTL - 20 pulses/second
11. 6 KHz -100 dBHTL - 5 pulses/second
12. 6 KHz - 100 dBHTL -20 pulses/second

Subjects were tested in a single session lasting for about 1-1 1/2 hour. For a few subjects the test data were collected on 2 different occasions.

The test data was rejected when:

1) the counter stopped before reaching 2048 samples.
2) the limit light flickered too often during the testing.

When adequate samples were observed, the final recording was done by pressing Record button (the oscilloscope trace, representative of the patient's BSER for test parameter was recorded on the plotter.

3.5 Treatment of the data:

a) Latency determination: The latencies of the peaks of waves I, III and V were measured by positioning the cursor on the peak of the 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 as the respective latency for each peak.

b) Amplitude measurement: To determine the magnitude of the BSER in microvolts, the marker amplitude 'M' (1/2/3/4 divisions) and the amplitude of the desired trace feature 'T' was noted. Then the scale switch amplitude 'S'(2μV/division) was noted.

Thus BSER = TS/M.

The following measures were computed:

1) Absolute latency values for I, III and V peaks at the 2 rates ('5' and '20' pulses/second).
2) Absolute amplitude values for I, III and V peaks at the 2 rates (5 and 20 pulses/second).
3) The absolute latency difference between the/2 rates of presentation.
4) The absolute amplitude difference between the 2 rates of presentation.

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The aim of the study was to note the effect of rate of presentation of stimulus on brainstem response in normal hearing subjects.

The absolute latency difference and amplitude difference with the 2 rates (5 stimuli/second and 20 stimuli/second) for I, III and V peaks were considered. Tables 1 and 2 give the absolute latency values and amplitude values respectively under the 2 rates of stimulus presentation for 80 and 100 dBHL stimulus at 2 KHz, 4 KHz and * KHz.

The data collected were analysed so as to obtain the means and the standard deviations at the 2 rates.

Tables 3 and 4 show the means and Standard Deviations of 'absolute latency' and 'absolute amplitude' respectively for each peak (I, III and V) obtained at different rates of presentation of the stimulus in 10 normal hearing subjects.

The Wilcoxon matched pairs signed ranks test (Siegel, 1956) was employed to find whether or not there exists significant difference between the 2 rates at .05 and .01 levels of significance.

Table-3 shows the mean latencies, for peaks I and III increase when the rate of presentation is increased (i.e. from 5 stimuli/second to 20 stimuli/second).

Table-4 shows that in general the amplitude values of peaks I and III decrease when the rate of presentation is increased/ However, with wave-V, the results of the present study show an increase in the amplitude of wave-V and very little change in latency of wave-V with increase in rate of presentation.

Table-5 and 6 illustratecthe significance of difference between the rates, for latency and amplitude respectively.

Discussion:

The results of the present study clearly reveal that the rate of presentation of the stimulus has significant effect on the latency or peaks I and III. The rate - 20 stimuli/second produces increase in the latency of peaks I and III.

According to the results of the present study the rate of presentation has no significant effect on the effect of latency of peak-V.

From Table-6 it is obvious, there is no consistent pattern regarding the effect of rate of presentation on the amplitudes of peaks I, III and V. However, the results show that generally the rate of presentation has no effect on the amplitudes of peaks III and V.

Regarding the Peak I amplitude, the rate of presentation seems to have significant effect. The results show that the amplitude of peak I decrease with increase in the rate of presentation.

This finding corroborates the results reported by Pratt and Sohmer (1976) who state "increasing the stimulus rate causes a decrease in the amplitudes and the decrease in amplitude of N_1 is most prominent".

Although the present study show significant difference in the latency of peak III with increase in rate of presentation, no significant difference in amplitude of peak III has been observed.

This finding is also in agreement with the many studies which report that the absolute amplitude values are not reliable (Starr and Achor, 1975) and are highly variable.

The finding that peak V latency and amplitude showed no significant differences on varying the rate conforms the findings of the other investigators (Chiappa et al 1979; Jewett and Willistc 1971; Rove, 1978; Stockard et al 1978a; Pratt and Schmer, 1975; Terkildsen et al 1976) who report that wave V dominance appears to be resistant to rate effects. However Weber and Fujkawa (1977) report that rate of stimulus presentation markedly influence wave V latency.

Table-l(a)

Absolute latency values under different rates for - Peak-I

Sl. No.	Intensity	2K		4K		6K	
		5/sec	20/sec	5/sec	20/sec	5/sec	20/sec
1	80 dB	1.0	1.3	1.1	1.1	1.1	1.2
	100 dB	0.8	0.9	0.9	0.9	0.9	1.0
2	CC dB	1.1	1.2	1.1	1.2	1.1	1.2
	100 dB	0.8	0.9	0.9	1.0	0.9	1.1
3	80 dB	1.3	l.5	1.5	1.5	1.3	1.5
	100 dB	0.7	1.0	0.8	1.0	0.9	1.2
4	80 dB	3.2	1.3	1.3	1.4	1.3	1.5
	100 dB	1.0	1.0	1.1	1.1	1.0	1.2
5	80 dB	1.4	1.5	1.3	1.4	1.3	1.4
	100 dB	1.0	1.2	1.1	1.3	1.1	1.2
6	80 dB	1.2	1.3	1.3	1.3	1.2	1.5
	100 dB	1.0	1.2	1.0	1.1	1.1	1.1
7	80 dB	1.4	1.4	1.3	1.3	1.3	1.5
	100 dB	0.8	0.9	0.8	1.1	0.8	1.0
8	80 dB	1.0	1.0	1.1	1.1	1.1	1.2
	100 dB	0.7	0.9	0.8	1.0	0.9	1.0
9	00 dB	1.3	1.5	1.2	1.3	1.1	1.2
	100 dB	0.8	0.9	0.9	1.0	1.0	1.1
LO	80 dB	1.0	1.2	0.9	1.1	1.0	1.1
	100 dB	0.7	0.9	0.8	0.9	0.8	0.9

Table-l(b) : Absolute latency values under different rates for - Peak III

SI NO	Intensity	2 K		4K		6K	
		5/sec	20/sec	5/sec	20/sec	5/sec	20/sec.
1	80 dB	3.2	3.3	3.3	3.4	3.3	3.5
	100 dB	3.0	3.2	3.1	3.3	3.2	3.3
2	80 dB	3.1	3.1	3.0	3.1	3.0	3.2
	100 dB	2.8	2.9	2.9	3.0	2.9	3.0
3	80 dB	3.2	3.3	3.2	3.3	3.2	3.4
	100 dB	2.8	3.0	3.0	3.1	3.0	3.1
4	80 dB	3.3	3.4	3.5	3.7	3.6	3.8
	100 dB	3.2	3.3	3.3	3.4	3.3	3.5
5	80 dB	3.4	3.5	3.3	3.3	3.3	3.5
	100 dB	3.0	3.2	3.1	3.2	3.1	3.2
6	80 dB	3.1	3.2	3.2	3.3	3.2	3.4
	100 dB	2.9	3.0	3.1	3.2	3.0	3.2
7	80 dB	3.3	3.3	3.2	3.3	3.3	3.4
	100 dB	2.9	3.0	3.0	3.2	2.8	3.0
8	80 dB	2.9	2.9	3.0	3.1	3.1	3.1
	100 dB	2.8	2.8	2.9	2.9	2.3	3.0
9	30 dB	3.3	3.5	3.4	3.5	3.4	3.6
	100 dB	2.8	2.9	3.0	3.1	3.0	3.2
10	80 dB	2.9	3.1	2.9	3.1	3.0	3.1
	100 dB	2.75	2.8	2.9	3.0	2.9	3.0

Table-l(c): Absolute latency values under different rates for - Peak-V

Sl. No.	Intensity	2K 5/sec	2K 20/sec	4K 5/sec	4K 20/sec	6K 5/sec	6K 20/sec
1	80 dB	5.3	5.3	5.4	5.3	5.5	5.5
	100 dB	5.3	5.2	5+3	5.3	5.3	5.3
2	80 dB	4.9	4.9	5.1	4.9	4.9	5.1
	100 dB	4.7	4.8	4.9	4.7	4.9	5.0
3	80 dB	4.9	4.9	4.8	5.0	5.0	4.9
	100 dB	4.5	4.6	4.7	4.8	4.9	4.9
4	80 dB	5.1	5.3	5.3	5.3	5.3	5.5
	100 dB	4.8	5.1	5.1	5.2	5.0	5.2
5	80 dB	5.2	5.3	5.2	5.2	5.3	5.3
	100 dB	4.8	4.9	5.0	5.0	5.1	5.1
6	80 dB	4.7	4.8	4.8	4.9	5.1	5.1
	100 dB	4.7	4.8	4.8	4.8	4.6	4.0
7	CO dB	4.7	4.9	4.7	4.9	5.1	5.2
	100 dB	4.8	4.8	4.9	4.8	4.5	4.5
8	80 dB	5.0	4.9	4.0	4.0	5.0	4.9
	100 dB	4.6	4.7	4.7	4.7	4.9	4.5
9	80 dB	5.1	5.2	5.4	5.4	5.5	5.5
	100 dB	4.7	4.7	4.9	4.9	5.0	5.0
10	80 dB	4.7	4.7	4.9	4.6	4.9	4.8
	100 dB	4.5	4.5	4.8	4.8	4.0	4.5

Table-2a : Absolute amplitude values under different rates for - Peak I

Sl. No.	Intensity	2 K		4 K		6 K	
		5/sec	20/sec	5/sec	20/sec	5/sec	20/sec
1	80 dB	0.29	0.05	0.20	0.15	0.16	0.10
	100 dB	0.25	0.15	0.25	0.24	0.20	0.10
2	80 dB	0.22	0.22	0.41	0.29	0.32	0.28
	100 dB	0.48	0.35	0.42	0.35	0.42	0.30
3	80 dB	0.15	0.25	0.15	0.16	0.30	0.18
	100 dB	0.42	0.35	0.12	0.12	0.13	0.32
4	80 dB	0.22	0.17	0.27	0.15	0.21	0.06
	100 dB	0.30	0.23	0.32	0.22	0.40	0.15
	80 dB	0.20	0.10	0.22	0.15	0.35	0.20
	100 dB	0.4	0.2	0.50	0.25	0.4	0.35
6	80 dB	0.27	0.23	0.24	0.20	0.14	0.07
	100 dB	0.27	0.24	0.35	0.20	0.27	0.22
7	80 dB	0.24	0.25	0.21	0.20	0.21	0.10
	100 dB	0.28	0.22	0.42	0.30	0.44	0.28
a	80 dB	0.20	0.22	0.25	0.28	0.35	0.25
	100 dB	0.36	0.25	0.32	0.22	0.42	0.26
9	80 dB	0.33	0.27	0.33	0.25	0.22	0.12
	100 dB	0.25	0.16	0.30	0.30	0.40	0.36
10	80 dB	0.36	0.34	0.48	0.37	0.50	0.30
	100 dB	0.60	0.35	0.59	0.44	0.70	0.44

Table-2b: Absolute amplitude values under different rates for - Peak-III

Sl. No.	Intensity	2 K		4K		6K	
		5^sec	20/sec	5/sec	20/sec	5/sec	20/sec
1	80 dB	0.27	0.36	0.36	0.3	0.3	0.24
	100 dB	0.3	0.2	0.4	0.3	0.35	0.35
2	80 dB	0.1	0.16	0.12	0.12	0.09	0.15
	100 dB	0.09	0.15	0.2	0.12	0.22	0.15
3	80 dB	0.3	0.3	0.38	0.35	0.27	0.25
	100 dB	0.36	0.38	0.58	0.4	0.45	0.42
4	80 dB	0.12	0.16	0.17	0.11	0.16	0.15
	100 dB	0.14	0.16	0.22	0.23	0.25	0.18
5	80 dB	0.2	0.10	0.25	0.20	0.10	0.06
	100 dB	0.30	0.20	0.30	0.24	0.16	0.18
6	80 dB	0.16	0.15	0.22	0.18	0.22	0.15
	100 dB	0.18	0.3	0.35	0.22	0.3	0.31
7	80 dB	0.65	0.6	0.4	0.5	0.37	0.34
	100 dB	0.5	0.4	0.56	0.5	0.54	0.50
8	80 dB	0.38	0.4	0.5	0.4	0.35	0.5
	100 dB	0.4	0.36	0.6	0.44	0.55	0.35
9	80 dB	0.45	0.5	0.55	0.56	0.38	0.45
	100 dB	0.56	0.6	0.4	0.55	0.6	0.56
10	80 dB	0.58	0.5	0.6	0.58	0.56	0.58
	100 dB	0.62	0.68	0.92	0.9	0.88	0.76

Table-2c: Absolute amplitude values under different rates for - Peak-V

Sl. No.	Intensity	2K		4K		6K	
		5/sec	20/sec	5/sec	20/sec	5/sec	20/sec
1	80 dB	0.28	0.56	0.4	0.48	0.42	0.40
	100 dB	0.60	0.62	0.56	0.58	0.45	0.42
2	80 dB	0.3	0.45	0.16	0.20	0.26	0.30
	100 dB	0.37	0.4	0.3	0.3	0.27	0.30
3	80 dB	0.65	0.6	0.55	0.50	0.35	0.35
	100 dB	0.6	0.5	0.5	0.4	0.35	0.6
4	80 dB	0.42	0.4	0.35	0.3	0.27	0.27
	100 dB	0.3	0.35	0.25	0.32	0.2	0.4
5	80 dB	0.8	0.42	0.35	0.6	0.58	0.48
	100 dB	0.52	0.58	0.56	0.58	0.48	0.50
6	80 dB	0.32	0.4	0.3	0.37	0.24	0.32
	100 dB	0.45	0.35	0.37	0.40	0.40	0.55
7	80 dB	0.7	0.8	0.57	0.65	0.47	0.6
	100 dB	0.4	0.6	C.35	0.6		
8	80 dB	0.2	0.4	0.2	0.3	0.2	0.25
	100 dB	0.35	0.35	0.4	0.6	0.25	0.4
9	80 dB	0.47	0.55	0.36	0.56	0.42	0.52
	100 dB	0.6	0.6	0.3	0.6	0.42	0.42
10	80 dB		0.56	0.52	0.42	0.4	0.4
	100 dB	0.62	0.56	0.58	0.76	0.52	0.7

Table-3: Mean and S.D. for absolute latency

Peak	Intensity		2 K 5/sec	2 K 20/sec	4K 5/sec	4K 20/sec	6K 5/sec	6K 20/sec
I	80 dB	Mean	1.19	1.32	1.21	1.27	1.18	2.33
		S.D	0.15	0.15	0.15	0.13	0.10	0.15
	100 dB	Mean	0.83	0.98	0.91	1.04	0.94	1.08
		S.D	0.12	0.12	0.11	0.11	0.10	0.10
III	80 dB	Mean	3.17	3.26	3.2	3.31	3.24	3.4
		S.D	0.16	0.18	0.18	0.18	0.17	0.21
	100 dB	Mean	2.89	3.01	3.03	3.14	3.0	3.15
		S.D	0.13	0.16	0.13	0.14	0.15	0.16
V	60dB	Mean	4.96	5.02	5.04	5.03	5.16	5.18
		S.D	0.20	0.22	0.26	0.24	0.21	0.25
	100 dB	Mean	4.74	4.84	4.91	4.87	4.9	4.88
		S.D	0.21	0.20	0.17	0.24	0.22	0.28

Table-4: Mean and S.D. for absolute amplitude.

Peak	Intensity		2K 5/sec	2K 20/sec	4 K 5/sec	4 K 20/sec	6K 5/sec	6K 20/sec
I	80 dB	Mean	0.25	0.21	0.28	0.22	0.28	0.17
		S.D.	0.06	0.08	0.10	0.07	0.10	0.08
	100 dB	Mean	0.36	0.25	0.36	0.26	0.38	0.28
		S.D.	0.11	0.072	0.12	0.08	0.15	0.10
II	80 dB	Mean	0.32	0.32	0.36	0.33	0.28	0.29
		S.D.	0.18	0.17	0.15	0.17	0.14	0.16
	100 dB	Mean	0.34	0.32	0.45	0.39	0.43	0.38
		S.D.	0.17	0.17	0.21	0.21	0.21	0.18
III	80 dB	Mean	0.46	0.51	0.38	0.44	0.36	0.39
		S.D.	0.20	0.12	0.13	0.14	0.11	0.11
	100 dB	Mean	0.48	0.49	0.42	0.51	0.37	0.48
		S.D.	0.11	0.11	0.12	0.14	0.10	0.11

Table-5: Significance of latency difference between the 2 rates (5 stimuli/sec and 20 stimuli/sec)

Intensity	Peak I Frequency.			Peak III Frequency.			Peak V Frequency		
	2K	4K	6K	2K	4K	6K	2K	4K	6K
80 dBHL	*	*	*	*	*	*	NS	NS	NS
100 dBHL	*	*	*	*	*	*	NS	NS	NS

Table-6: Significance of amplitude difference between the 2 rates (5 stimuli/sec and 20 stimuli/sec).

Intensity	Peak I Frequency			Peak III Frequency			Peak V Frequency		
	2K	4K	6K	2K	4K	6K	2K	4K	6K
80 dBHL	NS	* (.02)	*	NS	NS	NS	NS	NS	NS
100 dBHL	*	*	* (.05)	NS	NS	* (.02)	NS	NS	* (.05)

Key:- * Significant at P .01 level

NS Not significant at P .05 level

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

This study aimed at investigating the effects of rate of presentation of stimulus on brainstem response.

10 subjects with normal hearing in the age range of 17 to 23 years were selected for the study. Logon stimuli at 2 different rates - 5/second and 20/second were presented to right ear and latency and amplitude of the brainstem response were measured. The stimulus frequencies employed were 2 KHz, 4 KHz and 6 KHz at 80 dBHL and 100 dBHL. The brainstem response were recorded through disc electrodes and the response to 2048 stimuli was summed up. The response latency and amplitude of I, III and V peaks of BSER with each rate of presentation were noted. The effects of each rate on amplitude and latency were compared to see if significant difference existed.

The following conclusions can be drawn from the results obtained:

- Increasing the rate of stimulation (from 5/secondf to 20/second) produces increase in latency but decreses the magnitude (amplitude) of the BSER waves.

- The rate of presentation has a significant effect on the latency and amplitude of peak-1.

Peak III shows significant difference in the latency but not in amplitude as rate is varied.

Peak V shows no significant differences in both latency and amplitude on varying the rate of presentation of stimuli. This is in agreement with many other studies (Chiappa et al, 1979; Jewett and Williston, 1971; Rowe, 1978; Stockard et al, 1978a; Pratt and Sohmer, 1975? Terkildsen et al 1976).

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