A STUDY OF INTSITY AMPLITUDE FUNCTION OF BRAINSTEM EVOKED RESPONSE WITH AND WITHOUT CONTRALATERAL MASKING IN NORMAL HEARING SUBJECTS

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AN INDEPENDENT PROJECT SUBMITTED IN PART FULFILMENT FOR THE DEGREE OF
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To My Beloved Parents

CERTIFICATE

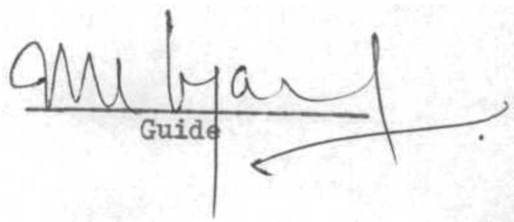
This is to certify that the Independent Project entitled "A Study of Intensity-Amplitude Function of Brainstem Evoked Response with and without Contralateral Masking in Normal Hearing Subjects" is the bona fide work in part fulfilment for the Degree of Master of Science in Speech & Hearing with Register No.

N. Rathna

Director,
All India Institute of
Speech & Hearing,
Mysore 6.

CERTIFICATE

This is to certify that this Independent Project has been prepared under my supervision and guidance.



DECLARATION

This Independent Project is the result of my own study undertaken under the guidance of Mr. M.N. Vyasamurthy, Lecturer in Audiology, All India Institute of Speech & Hearing, and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore
Date: Register No.

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The cooperation of the subjects, many of whom spent a considerable amount of time in unpalatable experimental conditions, was unfailing and I am especially grateful to them all.

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CHAPTER I

INTRODUCTION

> "It is not too much to say that the history of paediatric audiology has been laboriously searching for a better technique to measure hearing of difficult-to-test patients. Assessment of hearing of the difficult-to-test is crucial, challenging and rewarding".
>
> (Hiroshi Shimuzu, 1982)

It is for this reason many investigators have devoted themselves to develop a method that requires no cooperation from the patients. The evoked response audiometry with the help of computer has been attempted as an objective way of assessment for the past two decades as a clinically useful procedure.

The ideal requirements of an objective audiometry are:

1) No patients cooperation
2) No subjective judgement of the examiner
3) Results are highly reproducible
4) The response threshold can be obtained within 20 dB SL
5) Frequency specificity of the response allows for audiogram prediction
6) There is no risk in the procedure - and
7) Instrument is simple enough for daily clinical use

Although BSERA satisfies most of the ideal requirements of objective audiometry, there are many drawbacks, viz.,

1) Puretones cannot be used
2) Maximum intensities of clicks and tone-pips are limited to around 85 to 90 dB on HL
3) Information regarding hearing threshold with clicks is limited to high frequencies
4) ABR thresholds to clicks do not necessarily agree with the behavioral thresholds to clicks
5) The sensitivity and frequency-specificity of ABR to low frequency tone-pips still remain to be seen - and
6) Results may be affected by neurological disorders in the VIII nerve or brain stem.

Nature of the auditory Encephalic Response

Auditory electroencephalic response is arbitrarily divided into 4 classes of responses, on the bases of latency, different properties and anatomical sources.

4 classes of response have been identified from latency. They are:

'early response' - "4 to 8 msec."
'middle response' - "8 to 50 msec."
'late response' - "50 to 300 msec."
'very late response' "300 msecs. to several seconds"

Classification	Origin	Waveform	Latency in Msec.	Amplitude
Early	Brain Stem	Fast (100-2000Hz)	4-8	-1/MV
Middle	Primary cortical projection area	Fast (5-100 Hz)	8-50	.7-3Mv
Late	Primary cortical projection areas and Secondary Association areas	Slow (2-10 Hz)	50-300	8-20MV
Very late Expectancy wave	Secondary association areas	Slow	230-360	10-20Mv
Contingent negative variation CNV	Prefrontal cortex and Secondary association areas	DC	300 plus	io-30Mv

In the brain stem evoked response we are interested in the early response. The early or brain stem response can be observed as a series of fast waves described by Jewett (1970), Jewett and Williston (1971), Sohtner and Feinmester (1970).

Auditory brain stem 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. There are seven components in the initial 10 msecs. following a click signal.

Sanders et al (1979). Sohmer et al (1976), Stockard et al (1978a) have found that natural sleep has no effect on ABR amplitude or latency. But in the sedated condition, they found that the absolute and interwave latencies tended to be shorter. It is also reported that during anaesthetic condition, there was no effect on latency, but amplitude was reduced by 15%.

The difference between ABR properties for male and female subjects have been studied by Beagley and Sheldrake (1978), Jerger and Hall (1980), McClelland and McCrea (1979), Rosenhamer et al (1980), Stockard et al (1978b, 1979). These studies showed that the wave 7 and III latency was significantly earlier in females and interwave latencies were longer in male subjects.

Ontogenic studies have shown that subjects' age has a significant influence on the response. This is evidenced by following studies: Hecox and Galambos (1974), Salamy and McKean (1976), Salamy et al (1975), Starr et al (1977), Starr et al (1979). These studies conclude that the mean latency changes with age and that the change is greater for wave V.

Starr et al (1977) and Stockard et al (1978b) have reported changes in amplitude with maturation and they conclude that the absolute response amplitude is greater in children.

BSERA has wide clinical applications. Audiologic applications of

BSERA include the estimation of -

1) hearing in paediatric patients
2) type of hearing loss
3) configuration of hearing loss - and
4) early identification of hearing loss

Neurologic applications of BSERA are possible through ILD (inter-aural Latency Difference) and the interwave latency.

Need for the Study

Considerable emphasis has been placed on the use of BSERA as objective audiometry and on its neurological and otological applications in the recent years. While testing unilateral hearing loss cases using BSERA, the non-test ear is required to be masked. It is not known how the contralateral noise affects the amplitude and latency in normal hearing subjects. Thus there is a need for finding out the effect of noise on amplitude and latency of BSER in normal hearing subjects.

The problem was to study the effect of contralateral noise on BSER amplitude and latency in normal hearing subjects.

Hypotheses

1) There is no significant differe obtained
at 2 KHz with and without contralateral noise.

2) There is no significant difference between latencies (Wave V) obtained at 4 KHz with and without contralateral noise.

3) There is no significant difference between absolute amplitudes obtained at 2 KHz with and without contralateral noise.

4) There is no significant difference between absolute amplitudes obtained at 4 KHz with and without contralateral noise.

5) There is no significant difference between interwave latencies (I-V) obtained at 2 KHz with and without contralateral noise.

6) There is no significant difference between interwave latencies (I-V) obtained at 4 KHz with and without contralateral noise.

Methods and Results

Ten normal hearing subjects (5 males and 5 females) were used for the study. The brain stem response was measured using Teledyne Avionics (TA 1000) Electric Response Audiometer in a sound treated room. Results were analyzed to see their statistical significance.

Limitation of the Study

The study was restricted to 10 subjects as limited time was available for testing.

Implications of the Study

…

The results of the present study would be useful while interpreting the brain stem response (obtained with contralateral noise).

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 e.g. I-V latency.

Response Amplitude: Refers to the height of a given wave component 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".

CHAPTER II

REVIEW OF LITERATURE

The chronology of man's efforts to evaluate the human sensory system is certainly not of recent origin. In the recent days the technical advancement has provided for more sophisticated assessment of human sensory functions. The professionals in the field are trying to evolve electrophysiologic procedures which would yield objective clinical information regarding the status of human sensory system.

Although there are many procedures, none of them have universal acceptance. One such procedure is psychogalvunic skin response audiometry which failed to provide solution to objective measurement. From 1960 onwards interest has been focussed on contributions from cortical evoked responses to tonal and other acoustic stimuli. This is gaining importance with significant increase in instrument sophistication.

Within the wider field of electric response audiometry (ERA) the technique known as brain stem evoked response audiometry (BERA) has been found to be particularly useful in recent years.

In 1967, Feinmesser and Sohmer of Jerusalem recorded the 8th nerve action potential (AP) from an electrode placed on earlobe. A response was evoked by a click of 115 dB SPL. Jewett (1970) conducted experiments in cats and showed that the responses thus obtained were the results of potentials generated by several levels of auditory pathway.

Comparative studies in animals and man were done in 1971 by Jewett and Williston. The results of their study have indicated that first of these potentials (N_1) is generated at coohlear nerve. Lev and Sohmer (1972) reached the conclusion that the wave sequence was produced by the cochlear nerve (N_1), cochlear nucleus (N_2) and the superior olivary complex (N_3) and the inferior colliculus.

Since then brain stem evoked response audiometry has gained importance and it has been widely used with young infants, difficult-to-test patients and has great clinical applications:

1) estimating hearing acuity - and
2) neuro-otological diagnosis.

ERA came into existance during 1962 with systematic clinically oriented studies of auditory evoked potentials in children. Two audiologic goals were defined. One was to make 'audiometry' as 'objective' as possible and the second goal was to develop a method to teat the integrity of at least the peripheral auditory system in uncooperative, hyperactive or otherwise'difficult-to-test' children.

Two events important for ERA occured about in 1969. The first was the formation of International Evoked Response Audiometry Club. The second event was the introduction of a commercial clinical instrument by Princeton Applied Research Crop. (Evoked Response Audiometer Model 140).

Anatomical Origins of Response Components

From the very beginning, various investigators have speculated about the origin of ABR component waves. The literature in this area can be divided into two categories - those investigating neural generators in animals and investigations aimed at obtaining human data.

Animal Studies

In most of the studies cat was used. Jewett (1970), Lev and Sohmer (1972), Buchwald and Huang (1975), Starr and Achor (1978), and Allen and Starr (1978) in different animals found that waves I and V reflected activity from unilateral generators; waves II and III originated in bilateral generators; and wave IV appeared to have its origin in either a midline or bilateral generators. The above studies concluded that the composite activity of as many as six brain stem generators were reflected in ABR.

Human Studies

Lev and Sohmer (1972) speculated the similarity between the cat and human ABR generators.

Subsequent to this, Sohmer et al (1974), Starr and Achor (1978), Starr and Hamilton (1978), Stockard and Rossiter (1977) examined alterations of the ABR in patients. Martin and Coats (1973), Martin and Moore (1977), Picton et al (1974) made topographical analysis of scalp distribution of human ABR's and found that wave I was restricted

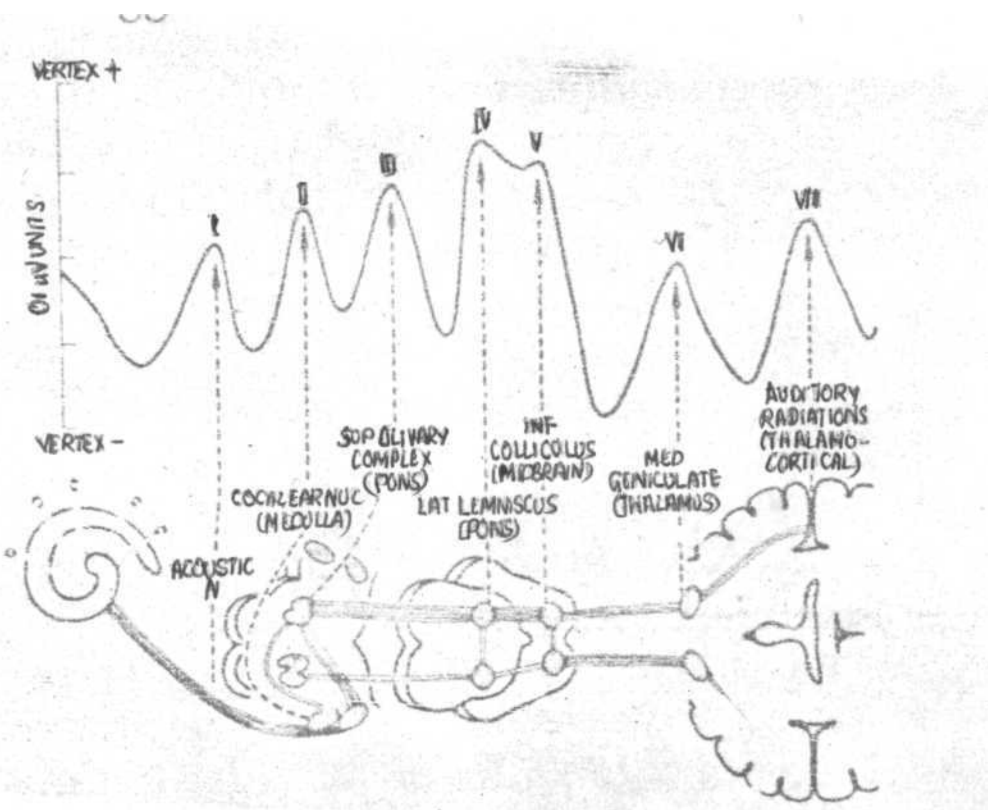

VERTEX +
VERTEX -
I
II
III
IV
V
VI
VII
ACOUSTIC N
COCHLEAR NUC (MEDULLA)
SUP OLIVARY COMPLEX (PONS)
LAT LEMNISCUS (PONS)
INF COLLICULUS (MIDBRAIN)
MED GENICULATE (THALAMUS)
AUDITORY RADIATIONS (THALAMO-CORTICAL)

Fig. 2.

To the ipsilateral mastoid (w.r.t. stimulated ear) and was similar to the N_1 potential recorded with a transtympanic needle electrode proof for the wave I origin (auditory nerve).

Picton et al (1974) concluded that we waves I thru IV represented the activity of the auditory nerve and brain stem auditory nuclei.

Goff et al (1977) after investigating ABR in normal young adults in pre and post anaesthetic conditions indicated a sub-cortical lemniscal origin for the ABR wave components.

A composite impression of the reviewed above has motivated several investigators to assign a specific correspondance between given ABR component waves specific neural generators represented diagrammatically in figure. 2.

The middle ear muscles are probably active at high level stimulation with clicks with moderate repetition rate.

INFLUENCE 0F INNER EAR.

An oscillation is seen on the basilar membrane of monophasic click stimulation is used.

Neural Bases of ABR:

Nerve cell bodies in the relays of the auditory pathways are the generators of ABR. Following physiological properties of auditory pathways may be emphasized:

1) Click stimulation gets transformed to a transient oscillation on the basilar membrane;

2) A volley of action potentials are generated and the leading front being generated at the high frequency region, sets up a field potential (N_1); and

3) Multiple local field potentials are caused when groups of synchronized units + (ve) with some delay. This happens in brain stem relays. These oscillating potentials summate vectorially to form the surface recirded far-field potential (ABR).

Physiological Mechanisms in Auditory Brain Stem Evoked Response

The interpretation of ABR in physiological or anatomical terms is hazardous because of the complex structure and connections of the auditory pathway and inhomogenous electric properties of surrounding electric properties of the volume conductor.

Recording of far-field potentials - volume conductor

The ABR is generated in the deep brain structures and transmitted

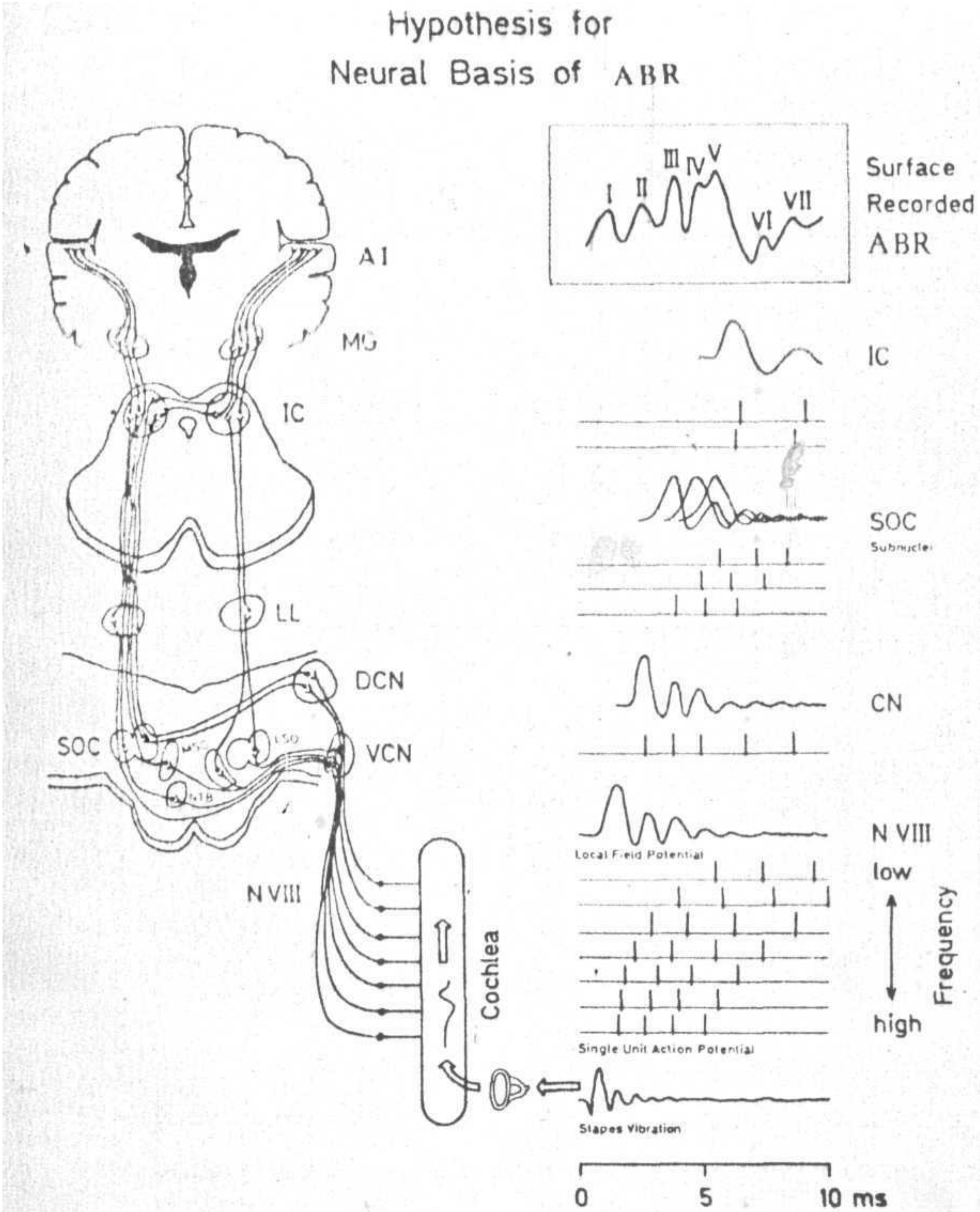


Figure 3. Outline of the auditory pathway, local field potentials and single unit action potentials recorded from main relay stations in the auditory pathway. To the right : principal pattern of nerve activity in different relays and the local field potentials. Above is the ABR Vector sum of field components in volume conductor.

through a volume (brainstem extracellar fluid) of electrically conducting medium as far-field potentials.

Recent evidence indicates that the generators of such potentials by surface recording are in the relay stations of afferent auditory pathway rather than in tracts. The source for such generation is the depolarization of the nerve cell bodies.

The ideal stimulus would produce a synchronized activation of neurons from a limited segment of the cochlea and allow for a test throughout the length of B.M. Short-tone pips or narrow-band filtered sine waves give a more frequency selective information than the wide band clicks. The acoustic signal generated by the earphones is not identical with the signal activating the receptor cells in the inner ear. It is shaped by sound transmission system and inner ear mechanics.

Influence of Sound Transmission System

The open ear canal resembles to a broad band passfilter with a resonance frequency around 3 KHz)Shaw, 1974)* The middle ear system has a low passcharacter and impulse response of middle ear is highly damped oscillatory (Bekesy, 1961; Holier, 1974).

Normal Response Parameters and Factors Affecting Response Paramaters

The use of ABR for clinical purposes is dependent on the abnormal results recognition, which in turn, is dependent on the knowledge of the normal ABR characteristics. The clinician must be aware of the variability of normal characteristics between and within subjects and variability due to nonpathologic factors, as nature of the stimulus, recording procedure, and subjects. The following discussion is about the review of normal values for ABR parameters - morphology, latency and amplitude.

Response Morphology

In this context, morphology refers to the visual appearance or waveform. As it cannot be specified in measurable units as millisecond or microvolts, it is a subjective parameter unlike the latency or the amplitude.

Different authors use different visual appearance. Some display positive waves at the vertex as upward deflections and some display the same as the downward deflections.

Several investigators have observed that waves IV and V often are fused together into what has been called the "IV-V Complex". Variations in the waveform of the IV-V complex, based on the relative height and separation of the two waves, have received attention in recent literature Chiappa et al (1979) described six variant forma in normal young adults.

Fig. 1

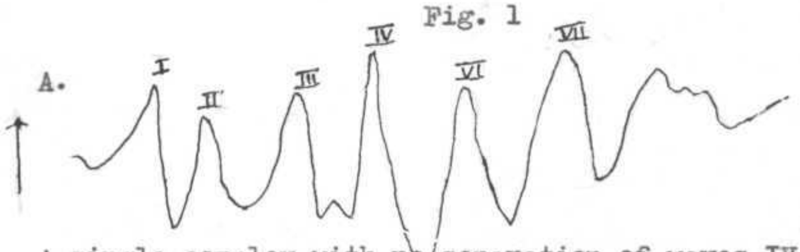
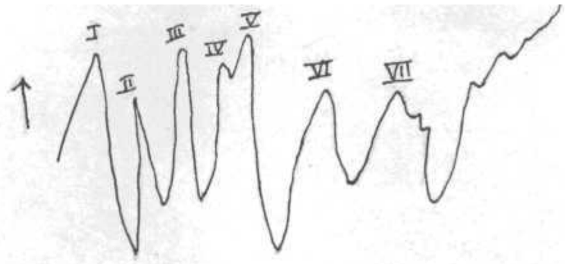


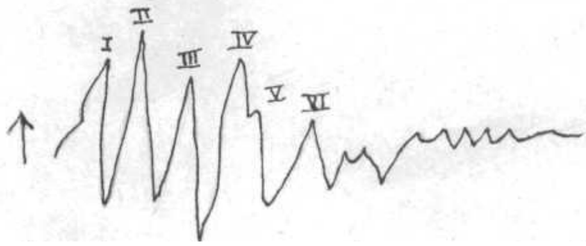
Fig-4. A single complex with no/separation of waves IV & V

B.



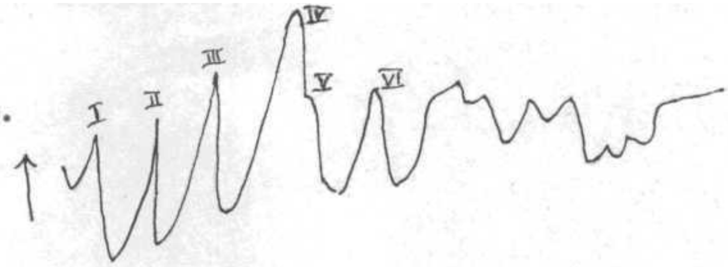
Separate waves with V of greater height than IV

C.



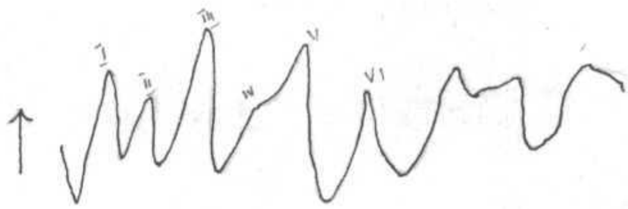
Separate waves with IV of greater height than V

D.

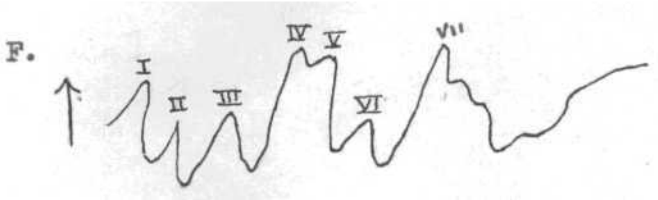


Wave V appearing as an inflection on IV

E.



Wave IV appearing as an inflection on V



Separate waves of the same height.

" Chiappa et al (1979) found that 58% of 52 normal adult subjects had the same IV-V complex waveform in both ears.

Rowe (1973) observed in normal young adult subjects, at high intensity clicks, wave V to be frequently occuring and at least frequency waves II and V. Thomas J. Fria (1981) found wave III to be prominent feature of normal human ABR.

Response Latency

It is generally agreed that the latencies of different ABR components yield important measures for clinical use. Two types of latencies are measured, absolute and interwave latencies. Apart from these, interaural wave V latency difference is of great clinical significance.

The absolute latency of ABR component waves, in response to high intensity clicks, is approximated by the Roman numeral designating the wave (Beagley and Sheldrake, 1978). Wave I latency falls between 1.0 and 2.0 msec, wave II between 2.0 and 3.0 msec, and so on. The following table shows the mean absolute latency values reported by

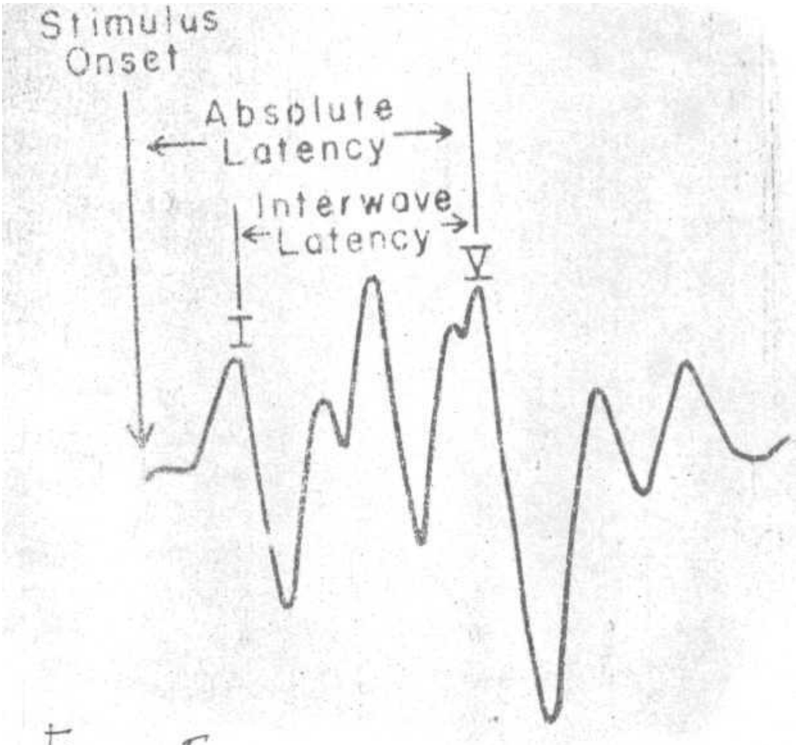


Fig. 5a.

different authors for normal young adults. .

Investigation	Click Intensity in dB	Absolute Latency in msec.					
		I	II	III	IV	V	VI
Jewett & Williston (1971)	60.75	1.5	2.6	3.5	4.3	5.1	6.5
Lev and Sohmer (1972)	65	1.5	2.5	3.5	-	5.0	6.7
Ama deo & Shagass (1973)	60	1.6	2.8	3.7	-	5.6	-
Picton et al (1974)	60	1.5	2.6	3.3	5.0	5.8	7.4
Starr and Achor (1975)	65	1.6	2.8	3.8	4.8	5.5	7.1
Stockard & Rossiter (1977)	60	1.9	3.0	4.1	5.2	5.9	7.6
Rosenhamer et al (1978)	60	1.7	2.9	3.9	5.2	5.9	7.6
Rowe (1976)	60	1.9	2.9	3.8	5.1	5.8	7.4
Stockard et al (1978)	60	1.8	2.9	3.9	5.2	5.8	-
Chiappa et al (1979)	60	1.7	2.8	3.9	5.1	5.7	7.3
Bergholtz (1981)	65	1.8	2.9	4.0	5.2	5.9	-

Normal interwave latency values have been reported for several combinations of ABR component waves. It is increasing focus on the I-III, III-V and I.V interwave latencies. The I-III value estimates transmission time thrice the ponto.medullary junction and lower pons, and the III.V values estimate transmission time from caOdal pons to caBAal midbrain levels. The I.V latency estimates the time needed for impulses to travel the entire system, and is sometimes called "central" or "brainstem" transmission time. The studies reporting normal interwave latency values with standard deviation are presented in the following table. ^

Investigation	Interwave Latency		
	I - III	III-V	I-V
Stockard and Rossiter (1977)	2.1 (0.2)	1.9 (0.2)	4.0 (0.2)
Rowe (1978)	1.97 (C16)	1.97 (0.2)	3.94 (0.22)
Gilroy and Iynn (1978)	2.05 (0.15)	-	3.83 (0.13)
Chiappa et al (1979)	2.1 (0.15)	1.9 (0.16)	4.0 (0.23)
Rosenhamer et al (1979)	2.26 (0.15)	2.0 (0.2)	4.27 (0.22)
Bergholtz (1981)	2.21 (0.25)	1.85 (0.15)	4.09 (0.26)

Response Amplitude

The peak.to.peak amplitudes of the ABR rarely exceed 1 uV and show wide variation between and within subjects. Because of the great variability of absolute amplitude measures some investigators have used relative amplitude and studied the amplitude ratio between different peaks.

Measuring peak-to-peak amplitude, Starr and Achor (1975) found that the ratio of V/I amplitude always exceeded 1-0 in response to click intensities below 65 dB. Similarly, Stockard et al (1973b) and Rosenhamer et al (1978) and Chiappa (1979) found a mean V/I ratio of 2.53 in response to click stimulation in 100 normal ears.

The variation in normal values for ABR wave component amplitudes has been observed to be substantial by a number of investigators (Amadeo and Shagass, 1975; Chiappa et al, 1979; Starr and Achor, 1975). Stockard et al (1978b) reported the mean amplitude in response to high intensity clicks to be 0.15 and 0.33 uV for waves I and V respectively.

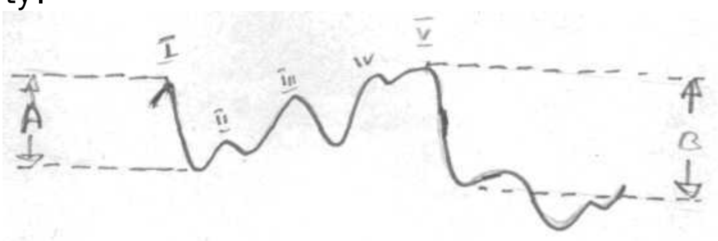


Fig. 5b.

A & B ABSOLUTE AMPLITUDE

Relative amplitude of wave V to Wave I =B/A

I Stimulation

There are some important stimulus characteristics that need consideration because they influence normal response parameters.

Pertinent stimulus characteristics include intensity, repetition rate, polarity, envelope (rise-fall time and duration) and mode of presentation (ascending-descending, monaural Vs binaural). It is possible tnat there may be an interactive influence of stimulus factors (Stockard et al, 1979).

A. The Choice of the stimulus

Studies of evoked auditory potentials have used several types of acoustic stimuli, viz., clicks of short duration, square waves (Perl, Galambos and Glorig, 1953; and Rapin et al, 1966); damped sinusoidal waves (Lowell and his colleagues, 1961); and pulses made up of the positive half of a pure tone (Cody and his colleagues, 1964; Williams and Graham, 1963).

It has been observed that it is easier to evoke a response to clicks than to pure tones. Appleby et al (1963), Perl et al (1953) and Williams et al (1963) hypothesize that the rise time of a click is shorter than rise time of a pure tone and cortical activity evoked by click is more diffuse than with a pure tone. Davis (1965) used tone pips. McCandler and Best (1966) state that when an averaging computer is used, evoked response can be easily evoked with pure tones as with the clicks.

B. Effect of Stimulus Repetition Rate

In general, an increase in absolute latency of ABR component waves is associated with an increase in stimulus repetition rate (Chiappa et al, 1979; Don et al, 1977; Picton et al, 1974, 1977, Rosenhamer et al, 1978, 1979; and Weber and Fujikawa, 1977). Every 20 per second increase in rate above 10 per second is associated with 0*2 msec, increase in wave V latency (Fria, 1980). An increase in rate by 10 to 100 clicks per second generally raises the wave V latency by 0.6 msec, or more.

Chiappa et al (1979) and Stockard et al (1978b, 1979) found that this increase in stimulus rate brought about greater latency for wave V than for wave I. It can be stated consequently that I-V interwave latency increased with stimulus repetition rate. Stockard et al (1978b) reported that each 20 per second increase in rate was related to a 0.1 msec, increase in I-V interwave latency, the average increase being 0.45 m.sec, when stimulus rate was increased from 10 to 80 per second. Also this rate related increase in latency was more pronounced for responses to higher intensity clicks (70 dB SL) than for responses to moderate intensity clicks (50 dB SL).

C. Effect of Change in Click-Polarity

It has been found by many authors that the wave IV-V morphology could be altered by reversing the polarity from rarefaction to condensation. Stockard et al (1979) found that wave IV was more prominent than V in 70 percent of subjects' responses to rarefaction clicks. (This may account for certain IV-V variants reported by Chiappa et al (1979) shown in Fig. C).

Also morphology of wave I can be altered with change in polarity due to possible cancellation of out.of.phase components when responses to separate polarities are summed (stockard et al, 1978b, 1979). Coats and Martin (1977) have also reported significant differences in latencies for rarefaction and condensation clicks (difference $p < 0.01$)

Contradicting the above studies Terkildsen et al (1973) and Rosenhamer et al (1973) reported no significant differences in ABR component wave latencies for rarefaction and condensation clicks.

Stockard et al (1979) found that reversing click polaiity could change the I.III interwave latency (within subjects) by more than 1 standard deviation and by as much as 0.48 m.sec. in one-third of normal adults. Relative amplitude measurements, within subjects, varied as much as 50 per cent by reversing click polarity. Greater shifts in I-III and I-V interwave latency were observed for rarefactior clicks than for condensation clicks, since wave I latency was unchanged in response to rarefaction clicks of 80 per second, while wave I latency with condensation clicks was always increased by increased rate.

Ornitz and Walter (1975) cited animal studies to support the suggestion that polarity related changes in ABR latency may depend upon the frequency composition of the acoustic stimulus.

Thus there are obvious differences in the literature on the reported effeot of stimulus polarity on ABR parameters. Some authors have reported essentially no difference and some others have found significant individual variation within groups (Ornitz and Walter, 1975 Peters and Worthington, 1979; Stockard et al, 1978b, 1979). Consequently, the relationship between click polarity and ABR parameters is complex and involves a great deal of variation.

Stockard et al (1978b) have discouraged the reversal of polarity for successive stimuli in routine ABR tests even though this practice is sometimes necessary to eliminate electromagnetic stimulus artefact.

D. Stimulus Envelope Characteristics and ABR

A good neural synchronization is essential for a reproducible ABR complex. The unfiltered click meets this demand and at suprathresholds evokes a reproducible ABR containing all the components and is suitable in neurological diagnosis. Several authors have studied ABR latency shifts using filtered clicks and tone bursts (Coats et al, 1979: Davis 1976; Mair et al, 1980; Picton et al, 1979; Rosenhamer et al, 1978; and Terkildsen et al, 1975). Comparing response latencies after stimulation with clicks and tone bursts yields shorter latencies for clicks evoked responses depending upon the high frequency content of the click (Weber and Folsom, 1977).

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, relating to the observation that the increased rise time with these stimuli is less effective in producing a synchronous fixing of neural groups necessary for clear response definition. Response amplitude is reduced by cancelling of out-of-phase responses in the averaging process which is facilitated by asynchronous firing.

E. Mode of Presentation and AHR Parameters

Mode of presentation is an additional stimulus related characteristic having effect on ABR parameters (i.e. monaural versus binaural stimulation). In neurologically normal subjects with the same hearing in both ears, binaural stimulation usually leads to a summation and a response of increased amplitude (Bleguad, 1975; Jewett and Williston, 1971; Starr and Achor, 1975; Stockard et al, 1978b). When binaural stimulation is used, wave V increases in amplitude particularly. Blegvad (1975) found, while testing 14 normal subjects, that the Wave V amplitude increase for binaural stimulation averaged 60 per cent. The binaural advantage was observed in response to stimulus intensities of 90 to 100 dB SL. On the average, binaural amplitude corresponded to the monaural amplitude associated with about a 20 dB increase in stimulus intensity.

Stockard et al (1978b) reported that binaural stimulation increases wave III-V amplitude, but not the amplitudes of waves I and II.

Other atimulus related factors like intensity, frequency and masking, will be discussed elsewhere.

F. Rise Time

It is well known that early brainstem responses can be elicited only by signals with a very fast rise time. Tone pips or bursts with rise times slower than 2.5 m.sec. do not elicit the early response (Cobb, Skinner and Burns, 1977).

Skinner and Antinoro (1970b) studied the effects of signal rise time on the middle response using fast rise times (about 10 usec. - 0.5, 2.5, 5, 10 and 25 m.sec. rise times). These data indicate that one must rely on the use of very fast signal rise times in order to elicit clear and stable, early and middle response waveforms.

Skinner and Jones (1968), Onishi and Davis (1968), have reported similar results. They say an optimal rise time of 25 to 30 m.sec, since it is gradual enough to produce a pure tone and sufficiently abrupt to evoke a clear AER.

G. Stimulus Duration

It is well known that stimulus duration is related to perceived loudness of an auditory signal. Zwislocki (1960) has shown that threshold at 1000 Hz improves 10 dB for a 10-fold increase in duration upto about 200 m.sec. Grimer and Feldman (1971) in a study to determine behavioral threshold and evoked response threshold found that in evoked response measurements threshold sensitivity was greatest with a stimulus duration of 200 m.sec. and it was not frequency dependent.

II Procedure Effects

Variations in recording technique can influence the parameters of obtained AER's. For example, the choice of reference electrode locatio can affect the response. Ordinarily 3 electrodes are used for ABR tests. One in the vertex of the skull, one on the ipsilateral (stimulated ear) and contralateral mostoid processes. Vertex and mastoid electrodes are called the "active" and "reference" electrodes respectively.

The factors affecting are electrode positions, ipsilateral and contralateral recording and filter sellings.

A. Electrode Positions

Most investigators place the negative electrode on the vertex or immediately below the hairline, tne positive electrode on or near the ipsilateral mastoid process and the ground electrode on the contra-lateral mastoid process.

A number of investigators (Jewett and Williston, 1971; Martin and

Moore, 1977; Picton et al, 1974; Plaritz, 1974; Stockard et al, 1978b) demonstrated electrode locations for stimulus related neurogenic activity.

Terkildsen et al (1974) and Chiappa et al (1979) found out that the non-eaphalic (inactive sites) reference locations pose problems related to increased to myogenic interference, inferior signal-to-noise ratio due to the increased distance from the active electrode.

Stockard et al (1978b) state that if the positive electrode is placed on the ear lobe instead of the mastoids process, wave I amplitude can be increased. Stockard et al (1973b) also found significant changes in ABR parameters in contralateral recordings. Condition where waves I and III decreased in amplitude, wave II became prominent, waves IV and V clearly separated and wave V latency increased. Similar findings were reported by Thornton (1978b) for contralateral referenced recordings.

Coats and Martin (1977) and Durrant (1977) state that by placing the negative electrode in the ear canal, a better and reliable recording of wave I can be got.

B. <u>Contralateral Recording</u>

Irrespective of the source of recording (ipsilateral or contra-lateral, ear lobe or mastoid process) many investigators have reported variations in ABR (Stockard et al, 1978b; Terkildsen et al, 1973; and Thornton, 1975). With the contralateral recording waves I and III decrease in amplitude and are usually absent. On the other hand, wave II is often large.

C. Filter Settings

As the response is embedded inherently in myogenic and neurogenic noise (unwanted activity) a favourable signal-to-noise ratio is a requirement for successful ABR recordings. Though computer overcomes this, certain degree of reduction prior to averaging can contribute. To reduce noise prior to computer averaging filters eliminating low/high frequency information are essential.

The selection of band pass filters has a great influence on ABR parameters. Jewett and Williston (1971) used filter cut off points of 10 Hz and 10,000 Hz, Sohmer and Feirmesser (1970, 1973) have used 250 Hz and 5000 Hz and others (Starr and Achor, 1975; Stockard and Rossiter, 1977; and Stockard et al, 1978a) have used 100 Hz and 3000 Hz. Wave V is less prominent on the Sohmer and Feinmesser (1973) than in the responses reported by Jewett and Williston (1971) and Starr and Achor (1978).

Stockard et al (1978b) 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. By reducing high frequency cut-off point from 3000 Hz to 300 Hz, poor resolution of component waves was observed.

Different investigators use different filter settings, but in clinical work 100 Hz to 3000 Hz band pass filter is often used.

Studies also differ in the choice of response reference for the computation of latency. Some use peak of the wave and some others use beginning of the negative slope.

A difference in stimulus transducer can also account for varied reports of normal ABR parameters. A number of studies have used TDH-49 with novel transducers, while others used TDH-39 earphone with MX41/AR cushions. A problem arises due to difference in resonance characters of earphones.

III Subject Effects

Kany investigators have compared ABR parameters in awake and asleep human subjects (Amadeo and Shagaas, 1973; Coff et al, 1977; Sanders et al, 1979; Sohmer et al, 1978; and Stockard et al, 1978a). Although in the related condition, absolute and interwave latency tends to be shorter, no significant latency differences were observed.

Goff et al, recorded the ABR in patients prior to and during anaesthesia and found response latency was unchanged, though anaesthesia tended to reduce amplitude by 15%.

Stockard et al (1978a) found that a decrease in brain temperature was associated with an increase in the I-III, III-V, and I-V interwave latency.

The difference between ABR properties for male and female subjects has been investigated by many investigators (Beagley and Sheldrake, 1973i Jerger and Hall, 1980; McClelland and McCrea, 1979; Rosenhamer et al, 1980; and Stockard et al, 1978b, 1979). The results of these studies indicate that the absolute latency of wave I was essentially the same for male and female subjects; but waves III and V latencies were significantly earlier in females; the III-V and I-V interwave latencies were longer in males. McClelland and McCrea (1979) studied both adults and pre-adolescent subjects and found no sex related differences in the younger age group. Stockard et al (1978b) suggested that separate response norms for male and female subjects should be generated in order to avoid diagnostic errors that, in reality, could be attributed to sex differences.

Results of several antogenic studies have demonstrated that subjects age has a significant role on influencing the response parameters. Jewett and Romano (1972) took recordings in rat pups and kitten that from 13th day of life the latency of component waves decreased.

Studies of ABR in premature and full-term new-boms conducted by Starr et al (1977), Schulman-Galambos and Galambos (1975) demonstrated that wave V latency decreased by 0*3 to 0.5 m.sec. with each week of gestational age.

Studies by Hecox and Galambos (1974), Salamy and McKean (1976) and Salamy et al (1975) reported a decrease in absolute latency with increased age has also been observed through the second year of life.

Starr et al (1979) found that the I-V interwave latency decreased with maturation.

Studies of new-bom and infant responses have also revealed age related changes in morphology and amplitude (Lei-berman et al, 1973. and Salamy et al, 1978).

Starr et al (1977) also reported that wave V amplitude increased with maturation, consistent with the findings of Stockard et al (1978b) who reported that V:I relative amplitude ratio decreased in the perinatal period.

Rowe (1978) compared responses of old (mean age 61 years) and young (mean age 25 years) adults and found about a 0.2 m.sec. increase in the I-III interwave latency with increased age. Small increases in interwave latency with advanced age also have been reported by Beagley and Sheldrake (1978) and Stockard et al (1978b).

2.4 Studies on Effect of Frequency on ABR

The abrupt signal rise times which are required to elicit the brainstem evoked response produce wide energy disperson across frequency. Thus, it is necessary to use tone pips or filtered clicks to limit energy disperson and gain information on the frequency response or "audiometric curve" of the hearing mechanism. The problem is confounded further since evidence exists that the BSER, like the action potential CN_1, arises from stimulation of the basal end of the cochlea coincident with the travelling wave regardless of the frequency. Davis (1976) states that "moreover information obtained by the frequency following response is limited in the same manner". Other investigators have studied this problem by using high pass band masking and indicate in contradiction that characteristic BSER's do reflect changes in stimulus frequency and thus place stimulation along basilar membrane (Terkildsen, Osterhammel and Huis in't Veld, 1975). This requires further studies for clarification. Antinoro, Skinner and Jones (1969) found that when sensation level was increased from 20 dB to 100 dB, at the lower frequencies the voltage range was 7 uV and at the higher frequencies it was 2 uV. When phone level was increased from 20 to 100 phons, the lower frequency voltage range was 4.5 uV and at the higher frequencies it was 1.5 uV. This indicates that a significant interaction occured between amplitude of AER and signal frequency, particularly at the high frequencies. Rothman (1970) study is in accordance with this.

Antinoro and Skinner (1968) reported on continued decline in AER amplitude from 250 to 8000 Hz at 30 and 60 dB SL. They reported further that this decline in amplitude was not the result of loudness differences at different frequencies, since similar results were obtained at 30 and 60 dB equal loudness level. Thus the data obtained in these studies suggest a strong relationship between an increase in stimulus intensity and a* an increase in peak amplitude of auditory evoked response for frequencies 2000 Hz and below. This relation breaks down at higher frequencies, indicated by consistent decline in AER amplitude which was 20% per octave from 1000 to 8000 Hz at equal SLs.

There was relatively little difference in amplitude of the AER at 250, 500, 1000 and 2000 Hz.

Beagley and knight (1967) found that stimuli at 500, 2000 and 4000 Hz collectively produced significantly smaller amplitudes than did the stimuli at 1000 Hz when the intensity was at 10 and 20 dB HL. In addition, the stimuli at 500, 2000 and 4000 Hz produced longer latencies than did the stimuli at 1000 Hz when intensity exceeded 30 dB

Evans and Deatherage (1969) observed a progressive decline in evoked response amplitude as frequency increased and they speculate that this relationship may be present because the lower the frequency the longer the area of disturbance along the basilar membrane. Rothman (1970) has pointed out that the sloping of the input-output function decreasing as frequency increases has a specific implication for clinical audiometry.

Jerger and Jerger (1970) compared amplitude of AER to intensity and frequency change with the behavioral performance in two subjects (one with normal hearing and the other with SN hearing loss) and found that the behavioral differences in both intensity and frequency resolution were parallel in the AER amplitude. Testing was carried out 500, 1000 and 4000 Hz and SL of the signal being 20 dB and increment duration was 200 m.sec. Results of this study indicates that latencies of the principal components of the AER were somewhat greater for increments than for isolated tone bursts at comparable intensity levels. John Cobb et al (1973) in a study using tone pips of 250, 500, 1000, 2000, 4000 and 8000 Hz at 40 dB SL and with . different rise times (10 u sec, 0.5, 1.0, 2.5 and 5.0 m.sec. at a centre frequency of 1000 Hz) found that as rise time was increased, response amplitude and detactability decreased and response latency increased.

McCandles and Rose (1970) examined the evoked response to frequency change for 1000 and 2000 Hz and 1000 and 1010 Hz when the tones of each pair were matched for loudness. The amplitude of the response to the smaller changes in frequency was smaller and the peak latencies increased. However, the direction of frequency change did not affect the form of tne evoked response.

2.5 Studies on Effect of Intensity on ABR

In the content of ABR measurements, stimulus intensity is designated as either a given number of decibels above an individual's threshold for that stimulus (dB SL) or above the threshold of a panel of normal hearing young adults (dB HL). Most studies in the literature operationally define the stimulus intensities employed. Confusion arises when certain authors operationally define intensity in accordance with dB HL, but label intensity as dB SL. To avoid this confusion, certain investigators have suggested designating intensity as dB HL whenever levels are referred to individual's threshold for that stimulus, tne designation dB SL is preferred. This important for the discussion of stimulus effects.

The relationship between signal intensity and amplitude of early and middle components is not definitive. Although all ABR 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 40 dB HL, 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, response amplitude increases monotonically at least at low intensity levels, but components may vary in amplitude with increased intensity at moderate and higher intensity levels.

The relationship is confounded among the early components by the relative influence on the emergence and growth of various wavelets. Rosenhamer et al (1978) state that at stimulus intensities below 60 dB SL the replicability of waves other than the V complex is very uncertain.

Beagley and Knight (1967) found that the amplitude of the N_1-P_2 component generally decreased with intensity reduction of the pure tone pulse.

Beagley and Kellong,(1970) from their study state that the amplitude of the evoked response grow linearly with intensity upto about 50 dB and after 60 dB the growth curve is flat when short inter-stimulus interval is employed. Intensity, interval, frequency occasion are all factors which influence the amplitude according to this study.

However, Glatike (1975) indicate that there was no consistent relationship between the response amplitude of consistent peak wavelet V and the stimulus intensity.

McCandles and Best (1964) presented subjects with tones varying in frequency and intensity, the relationship between amplitude of the response and intensity of the stimulus was clear for some subjects and not so for others, which they contributed to the differences in psychophysiological states.

Moore and Rose (1969) examined the amplitude of N_1-P_2 components relative to intensity increments. It was found out that the response amplitude increased with intensity about 70 dB, where amplitude appeared to reach a maximum and amplitude of P_2-N_2 component did not increase significantly with increase in intensity.

Picton et al (1970) found out that there was increase in response amplitude with increasing intensity of auditory stimulation. At intensities above 70 dB ISO, however, there was a decline in the relationship.

Rapin (1966) observed that as the intensity of the clicks was reduced, the amplitude of both early and late components decreased.

Starr and Achor (1975) found that the V:I relative amplitude ratio increased with decreasing stimulus intensity.

Stockard et al (1978b) observed that a 50 dB reduction in stimulus intensity was associated with a 33 per cent decrease in amplitude of the IV-V complex, while the same reduction in intensity was associated with a 90 per cent decrease in wave I amplitude.

Suzuki and Taguehi (1965) plotted the amplitude of the N_1-P_2 component against the decibels above subjective threshold, they observed a linear function.

Wolfe et al (1978) investigated the relation of peak amplitude and latency to signal intensity for the brainstem auditory evoked response. Responses were obtained to clicks presented at sensation levels of 15, 20, 30, 40, 50, 60 and 70 dB and latency and amplitude for various wavelets were plotted against signal intensity. A consistent trend of decreased peak latency was seen with increasing intensity. Also, contrary to previous reports the amplitude of wavelet V showed a linear growth with increased signal intensity.

Zerlin and Davis (1967) examined the amplitude of single unaveraged responses and found that the amplitude of single responses was longer for higher intensities. The authors conclude that the amplitude is

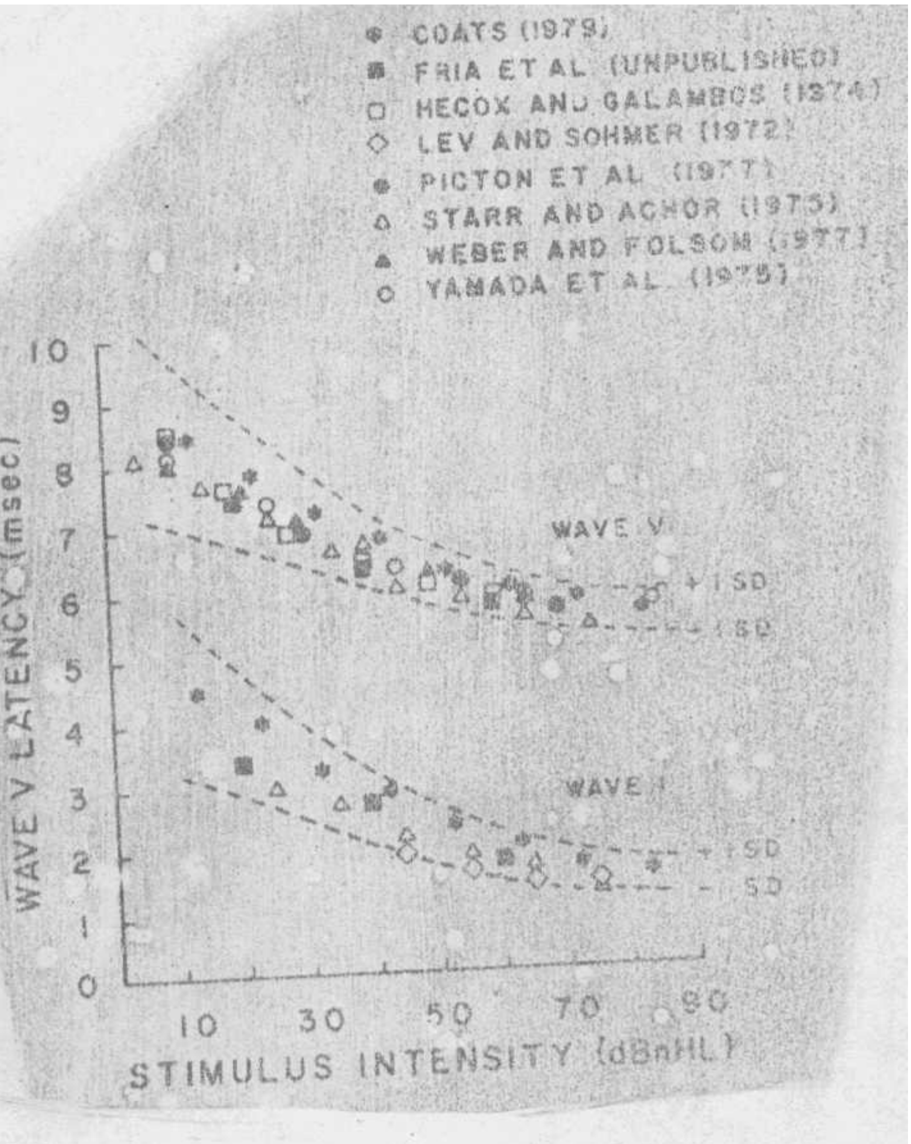


Fig. (6) Latency - Intensity function.

determined by a random process which interacts with such parameters as stimulusintensity and interstimulus interval.

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 of the ABR wave can be displayed on a graph known as "Latency-Intensity Function". Fig. 6.

From the above graph, it can be seen that each 10 dB decrease in click intensity results in a measurable increase in absolute latency. Note that the mean latency for wave 7 in normal adults increases from approximately 5.5 m.sec. at 80 dB HL to slightly greater than 8.0 m.sec. at 10 dB HL (Chiappa et al, 1979; Hecox and Galambos, 1974; Starr and Achor, 1975; and Yamada et al, 1975).

The latency-intensity functions for waves I and V are essentially parallel and separated throughout the intensity range by approximately 4.0 m.sec. This suggests that 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. Stockard et al (1978a) reported one subject who showed a 0.07 m.sec. increase in the I-V interwave latency when responses to 10 and 20 dB SL clicks were compared.

In a later study, Stockard et al (1979) reported that the wave I latency increased more than waves III and V when stimulus intensity was decreased. Consequently, interwave latency values involving wave I (that is, I-III and I-V) were shorter at lower stimulus intensities. The average decrease was in I-III latency was 0.19 m.sec. and for I-V it was 0-34 m.sec. For one subject the I-V latency decreased 0.73 m.sec. when responses to 70 and 30 dB SL clicks were compared. For most of the subjects, the decrease in interwave latency(ies) was most prominent for responses to 40 or 60 dB SL clicks.

Studies on Masking and ABR

There are very few studies indicating the relationship between masking and changes in the ABR parameters.

Investigators have studied, using both white noise and narrow band noise, as monaural stimuli, the human cortical evoked potential in different intensities with such stimuli, the N_1 peak of the response was prolonged in comparison to the response to the onset of a puretone.

Chuden (1972) studied the effect of simultaneously stimulating one ear with a burst of puretone and the other with noise such as might be used for masking the contralateral ear was also studied. In this situation the N_1 peak in response to the tone usually showed the amplitude that was to be expected if only the puretones had been given without contralateral masking. The response to puretones of various

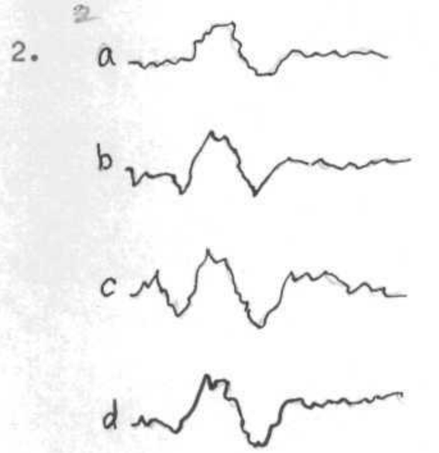
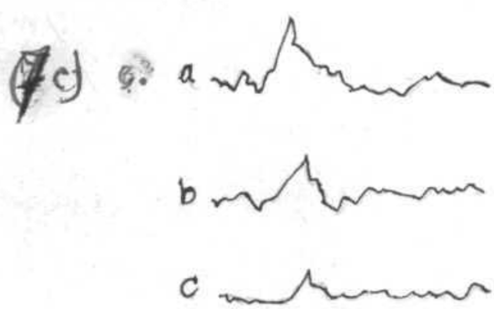


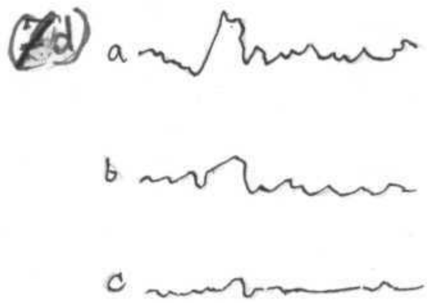
Fig 7

(a) Evoked response in the human testing a normal ear. a) 1000 Hz, 80 dB SL
b) 1000 Hz, 60 dB SL
c) 1000 Hz, 40 dB SL

In all tracings the polarity will be negative up. The computer sweep time will be 500 m.sec. The onset of the tone is at the start of the sweep. The tone duration is 500 m.sec. The number of tone or noise impulses is 60.

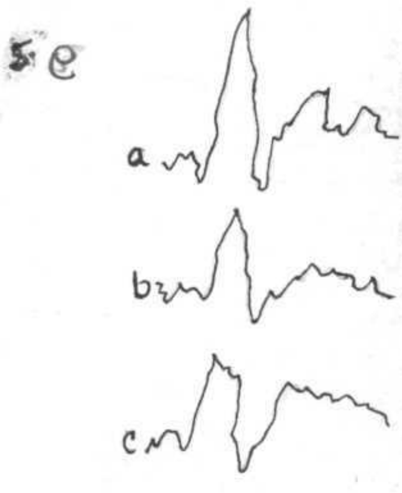
(7b) Evoked response in the human, monaural and binaural stimuli
a) 40 dB, white noise
b) 40 dB, 1000 Hz
c) 80 dB, 1000 Hz
d) 80 dB, white noise

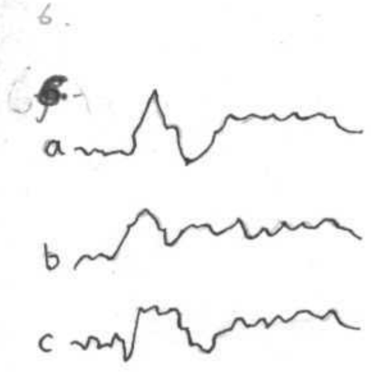




Evoked response in human, stimulation with bursts of narrow-band noise, monaural
a) 80 dB NB, 1000 Hz
b) 60 dB, NB 1000 Hz
c) 40 dB, NB 1000 Hz

Evoked response in human, stimulating one ear with a tone burst and the other with a masking noise, a)right:1000 Hz, 90 dB, tone burst; left: NB, 80 dB, noise; b) right:1000 Hz, 70 dB, tone burst; left: NB, 80 dB, noise; c) right:1000 Hz 50 dB, tone burst, left: NB, 80 dB noise





7(e) Evoked response in human, stimulating one ear with a tone burst and the other with a masking noise. Note the difference in dB of the tone and the noise in (c) in comparison to (a) and the large amplitude.

a) Right:1000 Hz, 70 dB tone
Left: NB, 70 dB, noise

b) Right:1000 Hz, 50 dB tone
Left:NB, 70 dB, noise

c) Right:1000 Hz, 50 dB tone
Left:NB, 90 dB, noise

7(f) Evoked response in the human, stimulating one ear with a tone burst and the other ear with a burst of noise.

a) Right:1000 Hz, 70 dB, tone
b) Right: 70 dB, white noise
c) Right:1000 Hz, 70 dB, tone
left:30 dB, white noise

intensity in the presence of contralateral noiae at a steady intensity was also measured. The following figure gives the response with noise and at steady intensity. (Fig 7)

The results indicate that with binaural stimulation, the brain responds only to the distinct clearest stimulus more or less ignoring the steady state masking noise, even at a higher intensity level. Continuous masking noise will be effective centrally but seems to have no influence upon the summation of human cortical evoked potential.

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.

Don and Eggermont (1978) studied the brainstem electrical responses (BSER) to 60 dB SL click in noise high passed at various cut-off frequencies separated by ^ octave steps were recorded in normal hearing adult subjects. By applying a derived response technique narrow band contributions to the BSER from specific portion of the basilar membrane were revealed. Latencies and amplitudes of the various waves in the derived BSER were recorded. Results indicate that nearly the whole cochlear partition can 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 CF appear to be fully comparable to those of the A.P. In contrast, the amplitude behavior of wave V as a function of CF is different from waves I and III depending upon the frequency range. The discrepancy in the behavior of wave V with respect to the earlier waves suggests some sort of neural reorganization at the level where wave V is generated. The fact that there are contributions to the brainstem response from apical portions of the cochlea opens the possibility for extending the brainstem technique in assessing the higher cochlear turn functions.

In a recent study, Don and Eggermont (1980) studied the effect of click intensity on brainstem evoked potentials using high pass noise masking. Derived narrow band brainstem responses were obtained for. click levels of 10-60 dB SL in normal hearing subjects. The high pass masking noise and the click stimulus were electrically mixed and noise was presented in a constant signal-to-noise ratio in relation to the click. Complete electrophysiological masking of BSER was obtained in the wide band masking condition. The amplitudes and-latencies of the wave I, wave III and wave V components in the derived BSER were studied as a function of click intensity. Characteristic differences were found between the input-output behavior of waves I and III on the one hand and wave V on the other hand, especially for the low frequency narrow bands (centre frequencies of 0.5 and 1 KHz) while the wave I and wave III (peak-to-succeeding trough) amplitude showed a small (20-30 dB) unmasked BSER although the mechanism seems to be different. The major contribution to the BSER which determines its latencies, originates at 60 dB SL from the 8 KHz region but at low SL (10 20 dB) from the 2 KHz region. At tnese low intensity levels the contribution from the apical part of the cochlea, however, is still of the same size as that from high frequency end.

Freigang et al (1974) studied the influence of white noise on acoustically evoked potentials. In evoked response audiometry, the rules of masking in common use in subjective audiometry must be applied and should be used in ERA to eliminate cross-hearing. Bone conduction produces an evoked potential from the opposite ear even for 0-5 dB. A noise level below 50 dB had only little effect on the evoked potentials of the contralateral ear.

For contralateral noise levels exceeding 60 dB or monaural stimulation with white noise and tones, the threshold was displaced by the amount of the masking noise level and the steepness of the input-output curve was increased. In 16 patients with inner ear deafness, this masking effect showed a different behavior. Thus, an additional diagnosis of an inner ear deafness is possible in ERA.

Picton et al (1970) in a study to find out the relationship between amplitude and intensity, observed a definite decline in the amplitude-intensity curve above 70 dB ISO. While investigating possible reasons for this effect, they talk of contralateral masking. A tone of high intensity presented to one ear will also be heard in the contralateral ear with an interaural attenuation of 40 and 70 dB. It was thought possible that this "cross hearing" might result in a response of decreased amplitude. The decline in the amplitude of the evoked response at high intensity, persists with contralateral masking sufficient to eliminate cross-hearing. Decreasing amplitude of response with increased contralateral masking is probably due to central masking mechanism.

Thummler et al (1972) have tried to investigate brainstem responses with wide band and high-pass filtered noise at lower frequency limits of 2600 Hz, 1250 Hz and 850 Hz. The brainstem evoked potential was recorded from a vertex/ear lobe electrode position using a recording band width of 70-2800 Hz, stimulus repetition rate of 20/s and a number of 2000 stimuli and the results are as follows.

a) Disappearance of the click-evoked brainstem response caused by the increasing level of the white noise. The response evoked by a 60 dB HL click can best be detected at 80 dB HL noise, whereas full masking of 60 dB HL click evoked response requires as WB masking level of 85 dB HL. Thus full masking of 60 dB HL click evoked response requires as WB masking level of 85 dB HL.

b) At frequency limit of 1250 Hz wave V shifted by 3.6-4.0 m.sec. at high-pass noise levels of 85 and 90 dB. If the click is masked by high-pass noise at 2600 Hz with a level of 85 dB the brainstem response can always be identified with clear waves III and V. Latency shift varied over a wide range for wave III 1.0-1.8 m.sec. and for wave V 1.2-2.0 m.sec. Using high-pass masking noise at 850 Hz and levels of 85 and 90 dB no clear brainstem responses became discernible. In 40% of all subjects authors recorded a weak wave V at noise level of 85 dB.

c) It became obvious that wave V disappears with a slight latency shift in the case of an increasing noise intensity. But subsequently the wave 7 an additional wave occurs which remains stable even in the event of high noise intensities;noise level was kept constant at 65 dB in order to record both wave V and the additional wave. Additional wave appears in case of high pass noise at 1800 Hz and lower frequency limits and can be observed clearly at 1250 Hz down to 600 Hz.

Test-Retest Reliability

It is essential to mention a word about test-retest reliability. Rosenhamer et al (1973) and Thornton (1975) tested six subjects each on two different occasions and found statistically significant test-retest reliability. The obtained standard deviations of the amplitude were much longer tnan those of latency values. Thornton (1975) opines that this may be due to variance of the background noise.

CHAPTER III

METHODOLOGY

Subjects

Ten subjects (5 males and 5 females) in the age range of 18-23 years were included in the study. All the subjects had normal hearing ($\leq$ 15 dBHTL ANSI 1969).

Instrumentation

Electric Response Audiometer Model TA-1000 was used for the study (See Fig.8).

Stimulus

a) Logon - The stimulus used was the logon stimulus. The logon as an acoustic stimulus, requires a brief explanation. In conventional puretone audiometry, the stimulus presentation time is at least 200 m.sec, yielding a high degree of frequency specificity. To additionally enhance the puretone character of the stimulus the rise and decay times are kept relatively long, seldom less than 20 m.sec, thereby reducing the side-band which results from more rapid modulation of the puretone envelope. For BSER, the temporal integration times are short, typically 0-5 m.sec. or less, quite similar to the cyclical period of exciting stimuli in the upper and mid speech frequency range.

The implication is that each individual waveform is an individual stimulus and that the multiple responses to the multistimulus content of a puretone would intermodulate to such an extent to preclude the extraction of useful information.

Theoritically the optimum compromise between an abrupt waveform and a puretone is the elementary signal or "logon" described by D.Gabor. The electrical logon used as a stimulus in the TA-1000 is of 1.5 cycles duration with the first and third half cycle of the same polarity and 6 dB lower in the amplitude than the second half cycle which is of opposite polarity. Each stimulus is phase inverted with respect to the previous one to help suppress cochlear and other microphone artefacts in the averaged response. The cost of the second half cycle /the peak of the stimulus is the reference time for latency determination.

The electrical logon used to drive either the earphone or bone vibrator is generated by a series of shaping and filtering circuits.

b) <u>Masking</u> - The masking source uses a current-starved zener diode noise source and active filtering to obtain an overall noise band width of 1.6 kHz to 7.8 kHz at the -3 dB points. Effective masking level for the logon stimulus was determined by laboratory tests, applying both the logon stimulus and the masking noise simultaneously to the same earphone. Masking level is determined by the setting of stimulus attenuator and available only when monaural air conduction testing is selected. The noise used is a wide band masking noise.

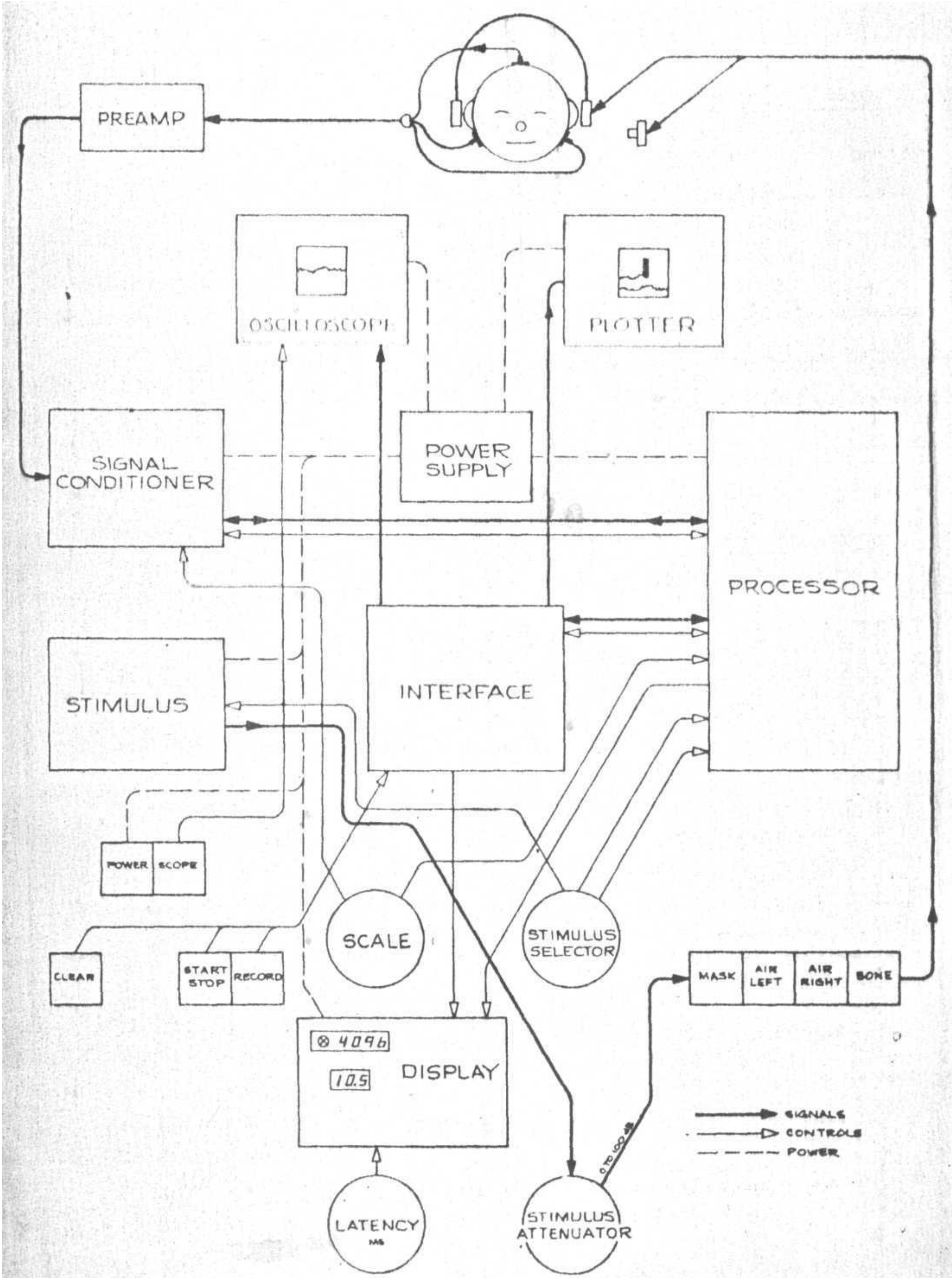


Figure 9: Flow chart of ERA: TA-1000 used in the present study.

Procedure

1. power Source - The guidelines suggested in the manual regarding power supply were followed.

2. Location and System Interconnection - The TA-1000 was located in a sound treated room and the cables were routed in a safe convenient manner. The interconnecting cables were colour coded for easy identification and the plugs were inserted into receptacles bearing the same colour code.

3. Plotter Preparation - Chart paper was loaded by opening the black metal frame and the white plastic platen and dropping the paper into the paperbin. (The main power switch was put on before opening the wnite plastic platen in order to cause the pen to clear the opening platen). The black frame was released by pulling two latch pins and swinging the platen down. The roll of paper was placed in the paper bin. A pen was inserted into the tubular pen holder.

4. Instructions - The subjects were instructed to be in a relaxed comfortable state and they were made to sleep on an examination table which was covered by a cushion bed. The subjects were not sedated. The experiment was carried out in a dimly lit room. Tne subjects were explained about the nature of the test.

5. Preamplifier and Patient Electrodes - The preamplifier was located very near to the subject and the subject's electrode cable was

pinned to the bedding. The electrodes were attached to the subject in a conventional manner, using adhesive pads and electrolyte gel. High forehead placement of the vertex electrode, white electrode placement on the right low mastoid area (stimulated ear side) and the black electrode placement on the left low mastoid area (nonstimulated side) were selected for the study. 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 other variables, viz., excessive muscular activity- Swallowing were also checked to avoid high input light on the preamplifier. After checking all these, the earphones were placed on the subject's ears to deliver the acoustic signal.

6) Selection of Test Parameters - The parameters involved the selection of the stimulus to be presented to the subject and the processing of the subjects' electrical response to obtain meaningful data. The stimulus switch permitted the selection of 2k, 4k or 6 kHz acoustic logon stimuli at repetition rates of 5 or 20 per second. For the present study, the sample time was 10 m.secs., the frequencies tested were 2k and 4kHz, with a p repetition rate of 5 per second.

Stimulus attenuator permitted selection of acoustic logon stimuli from 0 to 100 dB HL (through air conduction). The intensites tested were, 100 dB, 90 dB, 80 dB and 70 dB (air conduction). The RIGHT ear push button was pressed.

The mask button permitted the presentation of masking noise to the non-test ear. Masking level was determined by the setting of the stimulus attenuator. The scale switch permitted selection of readout amplitudes from 0-05 to 20uv/Div. for 1024, 2048 or 4096 samples per test. In the present study, the data were collected using 2048 samples at a sensitivity setting of 0-2 uv/Div.

7. Test Sequence - The instructions given in the manual were followed for recording the responses. The accumulation of valid samples was indicated by the samples display. Limit light flashed, stopping momentarily, the samples indicating that a sample was rejected from the averaged. The TA-1000 would stop automatically when the preset number of sample has reached. The system could also be stopped in midway of a test by pressing START/STOP button.

With the starting of the test, a 4-division marker was observed at the left side of the oscilloscope indicating the value of the amplitude division. Concurrent with this 4-divisions marker the oscilloscope trace amplitude had increased four-fold. B As the test progressed, the trace reached full oscilloscope amplitude and gradually the amplitude decreased and finally a 1-division resulted with corresponding reduction in trace amplitude. Maximum oscilloscopic trace amplitude was maintained by automatic gain switching consistent with the averaged subject's response.

When the test was complete, averaging of responses stopped automatically. The oscilloscopic trace, representative of subject's BSER for the test parameters, was observed. A permanent record of the response was obtained by pressing the RECORD button.

8. Latency Determination - The TA-1000 has a calibrated latency cursor, wnich appears on tne 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 exact latency in milliseconds was displayed. Latency was the time from the instant the acoustic logon arrived at the tympanic membrane until the vertex electrical response was detected. All time delays due to filters, sound velocity, processing time, etc., are compensated for. The arrival time of the acoustic logon has been determined by direct measurement of a 50 ohm Telex 1470A earphones on a B & K 2203 sound Level Meter with a 9A 6 cc Coupler, using the electrical logon of a TA-1000 as the source.

9. Interpreting BSER Amplitudes - Both the oscilloscope and plotter display an amplitude marker at the left side of the data format. Full scale deflection of both the oscilloscope and the plotter is $\pm$ 4 divisions. To determine the magnitude of the BSER, in micro-volts, the following procedure is followed:

Marker amplitude M (either 1, 2 or 4)

Amplitude of the desired trace feature T (maximum value 4 divisions)

Scale switch amplitude S (either 0.05, 0.1, or 0.2)
0.5, 1 or 2 uv/Div. microvolts per division were noted.

BSER = TS/M 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 preset on the scale

n . Number of samples actually counted

Then, BSER = (N/n) (TS/M)

CHAPTER IV

RESULTS AND DISCUSSION

In this study, brainstem response measurements were made. Amplitude and Latency of the brainstern response with and without contralateral noise were measured and analyzed.

Results

The data was collected from all the ten subjects. Brainstem responses were obtained at different intensity levels for the right ear in both the conditions (with and without contralateral noise). The results are tabulated in the data sheet. The tables 1 to 8 show the raw data for the ten subjects and tables 9 to 12 show average and standard deviations of all the ten subjects.

The Raw Data

Tables 1 to 8 give the values for absolute latency (in milliseconds), absolute amplitude (in microvolts), interwave-latency (in milliseconds) and relative amplitude for different intensities and frequencies with and without contralateral noise.

Analysis

Results of the present study were analyzed to obtain mean, standard deviation and to test the differences between means whether significant

70 Without Noise			70 With Noise			80 Without Noise			80 With Noise			90 Without Noise			90 With Noise			100 Without Noise			100 With No	
I	III	V		III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III
1.4	3.3	5.5	1.4	3.4	5.5	1.3	3.3	5.2	1.2	3.3	5.3	1.1	3.0	5.2	1.1	3.0	5.2	0.8	2.8	5.1	0.8	2.8
1.4	3.4	5.3	1.5	3.5	5.2	1.2	3.3	4.9	1.2	3.4	5.0	1.1	3.2	4.8	1.2	3.2	4.7	1.0	3.0	4.7	1.0	3.0
1.5	3.3	4.8	1.5	3.3	4.9	1.2	3.1	4.3	1.2	3.1	4.3	1.0	2.9	4.1	1.0	2.9	4.1	0.8	2.8	4.1	0.8	2.8
1.3	3.2	4.9	1.4	3.2	5.0	1.1	2.9	4.6	1.1	3.0	4.6	0.9,	2.8	4.5	0.9	2.8	4.5	0.9	2.8	4.4	0.9	2.8
1.5	3.2	4.7	1.5	3.2	4.6	1.2	3.0	4.4	1.2	3.0	4.5	1.0	2.8	4.4	1.0	2.9	4.5	0.8	2.5	4.4	0.8	2.6
1.9	3.9	4.9	1.5	3.2	4.9	1.3	3.2	4.7	1.3	3.0	4.5	1.0	2.9	4.5	1.0	2.9	4.5	0.9	2.7	4.3	0.9	2.8
1.3	3.4	5.2	1.3	3.3	5.2	1.3	3.2	5.1	1.3	3.3	5.1	0.9	2.9	4.8	0.9	2.8	4.8	0.8	2.8	4.6	0.8	2.9
1.7	3.9	5.0	1.8	3.0	5.7	1.4	3.4	5.2	1.3	3.4	5.2	1.1	3.2	5.0	0.9	3.2	5.0	1.2	3.2	4.9	0.9	3.1
1.5	3.4	5.2	1.6	3.4	5.4	1.4	3.3	5.1	1.3	3.3	5.1	1.2	3.2	5.3	1.1	3.2	5.0	1.0	3.0	4.9	1.0	3.0
1.7	3.6	5.5	1.7	3.6	5.5	1.3	3.3	5.1	1.0	3.2	5.1	1.0	3.2	4.9	1.0	3.2	4.9	0.8	3.0	4.7	0.8	3.0

Table I. Showing the raw data for 2 KHz at 70, 80, 90 and 100 dBHLfor the absolute Latency (in Msecs) for, waves I, III & V (in the right ear) with & without centralateral noise.

70 Without Noise			70 With Noise			80 Without Noise			80 With Noise			90 Without Noise			90 With Noise			100 Without Noise			10C With Nc	
I	III	V	I	III	V	I	III	V	I		V	I	III	V	I	III	V	I	III	V	I	III
1.3	3.5	5.5	1.2	3.5	5.5	1.3	3.3	5.4	1.3	3.3	5.4	1.1	3.1	5.3	1.1	3.1	5.2	1.1	3.1	5.4	1.1	3.1
1.4	3.5	5.2	1.4	3.4	5.2	1.3	3.5	5.1	1.3	3.4	5.1	$.2	3.3	5.1	1.2	3.3	5.1	1.0	3.0	4.6	1.0	3.1
1.2	3.2	4.5	1.3	3.2	4.5	1.1	3.0	4.3	1.1	3.1	4.3	1.2	3.2	5.0	1.0	3.2	5.0	0.9	2.9	4.2	1.0	3.0
1.4	3.2	4.8	1.4	3.2	4.8	1.1	3.0	4.7	1.1	3.0	4.7	1.0	3.0	4.2	1.0	3.0	4.2	0.9	2.9	4.6	0.9	2.9
1.4	3.1	4.9	1.6	3.2	4.9	1.2	3.1	4.7	1.2	3.0	4.7	1.0	2.9	4.7	1.0	2.9	4.7	1.0	2.8	4,4	0.9	3.0
1.5	3.3	5.0	1.5	3.2	5.1	1.4	3.1	4.7	1.3	3.2	4.8	1.1	2.9	4.6	1.0	2.8	4.6	1.0	2.9	4.4	1.0	2.9
1.4	3.2	5.1	1.4	3.2	5.1	1.1	3.1	5.0	1.1	3.1	5.0	1.1	2.9	4.5	1.1	3.0	4.6	0.9	3.0	4.9	0.9	3.0
.5	3.4	5.4	1.4	3.4	5.4	1.4	3.3	5.2	1.3	3.2	5.3	1.1	3.1	5.0	1.1	3.1	4.9	1.0	3.0	5.0	1.0	3.3
.3	3.3	5.3	1.3	3.4	5.3	1.2	3.3	5.2	1.2	3.2	5.2	1.2	3.2	5.2	1.3	3.3	5.2	1.0	3.0	5.1	1.1	3.0
.7	3.6	5.5	1.6	3.6	5.5	1.5	3.5	5.1	1.5	3.4	5.1	1.2	3.2	5.1	1.1	3.2	5.1	1.0	3.2	5.0	1.0	3.2

TABLE : 2. Showing raw data for 4 KHz at 70, 80, 90 & 100 dBHL for the absolute Latency (in Msecs) for waves I, III & V (in the right ear) with & without centralateral noise.

70 without Noise			70 With Noise			80 Without Noise			80 With Noise			90 Without Noise			90 With Noise			100 Without Noise			100 With Nc	
I	III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III
0.46	0.46	0.74	0.48	0.52	0.64	0.26	0.24	0.40	0.32	3.30	0.52	0.36	0.33	0.34	0.34	0.22	0.48	0.36	0.14	0.60	0.28	0.18
0.10	0.14	0.56	0.16	0.26	0.28	0.28	0.34	0.53	0.30	3.06	0.16	0.44	0.30	0.72	0.40	0.16	0.92	0.34	0.28	0.80	0.40	0.16
0.24	0.34	0.76	0.50	0.26	0.74	0.20	0.18	0.72	0.18	3.23	0.66	0.28	0.18	1.0	0.30	0.10	0.70	0.32	0.10	0.78	0.36	0.08
0.08	0.08	0.50	0.08	0.06	0.74	0.20	0.30	0.50	0.38	3.54	1.0	0.34	0.34	0.60	0.32	0.32	0.58	0.34	0.32	0.a0	0.38	0.3C
0.50	0.54	0.70	0.40	0.56	0.52	0.56	0.64	0.56	0.64	3.64	0.48	0.70	0.68	0.84	0.74	0.74	0.80	0.58	0.72	0.80	0.50	0.78
0.22	0.34	0.70	0.18	0.40	0.72	0.48	0.60	0.70	0.42	3.52	0.74	0.66	0.60	0.84	0.52	0.40	0.64	0.68	0.86	0.64	0.74	0.64
0.46	0.40	0.60	0.16	0.16	0.58	0.48	0.50	0.78	0.48	3.50	0.86	0.60	0.54	0.96	0.56	0.54	0.72	0.56	0.38	0.96	0.58	0.44
0.18	0+12	0.32	0.18	0.14	0.34	0.16	0.28	0.42	0.18	3.26	0.44	0.42	0.30	0.68	0.42	0.32	0.68	0.32	0.18	0.52	0.30	0.10
0.08	0.26	0.40	0.14	0.24	0.40	0.48	0.28	0.58	0.46	3.18	0.58	0.44	0.28	0.62	0.58	0.26	0.70	0.38	0.26	0.82	0.88	0.44
0.34	0.34	0.84	0.08	0.30	0.66	0.48	0.38	0.74	0.30	3.24	0.34	0.56	0.42	0.70	0.54	0.42	0.60	0.44	0.50	0.80	0.42	0.50

TABLE : 3. Showing raw data for 2 KHz at 70, 80, 90 & 100dBHL for the absolute amplitude (in microvolts) for waves I, III & V (in the right ear) with and without centralateral noise.

70 Without Noise			70 With Noise			80 Without Noise			80 With Noise			90 Without Noise			90 With Noise			100 Without Noise			100 With No	
I	III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III	V	I	III
0.14	0.14	0.68	0.14	0.16	0.70	0.34	0.32	0.52	0.44	0.42	0.46	0.46	0.28	0.62	0.36	0.36	0.38	0.34	0.20	0.58	0.36	0.36
0.12	0.10	0.40	0.38	0.14	0.44	0.28	0.24	0.50	0.28	0.26	0.46	0.48	0.26	0.58	0.48	0.32	0.56	0.48	0.44	0.76	0.52	0.42
0.16	0.06	0.48	0.06	0.08	0.44	0.30	0.24	0.86	0.18	0.20	0.68	0.42	0.26	0.78	0.32	0.36	0.64	0.40	0.32	0.72	0.28	0.10
0.14	0.08	0.46	0.06	0.08	0.48	0.28	0.24	0.52	0.28	0.26	0.80	0.44	0.26	0.62	0.34	0.36	0.56	0.76	0.82	0.40	0.70	1.0
0.34	0.60	0.64	0.34	0.56	0.52	0.54	0.74	0.64	0.58	0.72	0.56	0.72	1.0	0.40	0.62	1.0	0.44	0.70	0.86	0.66	0.58	0.82
0.34	0.60	0.68	0.36	0.54	0.68	0.48	0.54	0.60	0.40	0.58	0.60	0.61	0.78	0.65	0.98	0.78	0.66	0.62	0.66	0.88	0.60	0.72
0.46	0.38	0.56	0.40	0.38	0.70	0.54	0.48	0.60	0.62	0.52	0.76	0.62	0.62	0.82	0.56	0.62	0.82	0.56	0.34	0.70	0.38	0.24
0.16	0.08	0.32	0.14	0.18	0.36	0.26	0.24	0.40	0.24	0.20	0.40	0.36	0.32	0.48	0.40	0.20	0.44	0.70	0.36	0.50	0.54	0.38
0.18	0.30	0.54	0.30	0.30	0.56	0.48	0.32	0.68	0.52	0.36	0.74	0.76	0.36	0.72	0.50	0.32	0.68	0.30	0.30	0.35	0.42	0.32
0.18	0.34	0.62	0.18	0.12	0.72	0.48	0.38	0.76	0.18	0.54	0.70	0.46	0.34	0.80	0.54	0.38	0.48	0.52	0.46	0.80	0.50	0.42

TABLE : 4. Showing raw data for 4KHz at 70, 80, 90 & 100dBH for absolute amplitude (in microvolts) for waves I, III & V (in the right ear) with and without centralateral noise.

70 ithout Noise			70 With Noise			80 Without NoiseWith			80 Noise			90 Without Noise			90 With Noise			100 Without Noise			10 With Noi		
II-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	III-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	V-I	III-I			
1.2	2.22	4.1	2	2.1	4.1	2	1.9	2	2.1	2	4.1	1.9	2.2	4.1	1.9	2.2	4.1	2	2.3	4.3	2	2.2	4.
2	1.9	3.9	2	1.7	3.7	1.9	1.2	3.1	1.9	1.2	3.1	2.1	1.6	3.7	2	1.5	3.5	2	1.7	3.7	2	1.7	3.
1.8	1.5	3.3	1.8	1.6	3.4	1.8	1.7	3.8	1.9	1.6	3.5	1.9	1.2	3.1	1.9	1.2	3.1	2	1.3	3.3	2	1.2	3.
1.9	1.7	3.6	1.8	1.8	3.6	1.8	1.4	3.2	1.8	1.5	3.3	1.9	1.7	3.6	1.9	1.7	3.6	1.9	1.6	3.5	1.9	1.7	3.
1.7	1.5	3.2	1.7	1.4	3.1	1.9	1.5	3.4	1.7	1.5	3.2	1.8	1.6	3.4	1.9	1.6	3.5	1.7	1.9	3.6	1.8	1.8	3.
1.3	1.7	3	1.7	1.7	3.4	1.9	1.9	3.8	2	1.8	3.8	1.9	1.6	3.5	1.9	1.6	3.5	1.8	1.6	3.4	1.9	1.5	3.
2.1	1.8	3.9	2	1.9	3.9	2	1.8	3.8	2.1	1.8	3.9	2	1.9	3.9	1.9	2	3.9	2	1.8	3.8	2.1	1.7	3.
1.3	2	3.3	1.2	2.7	3.7	1.9	1.8	3.7	2	1.8	3.8	2.1	1.8	3.9	2.3	1.8	4.1	2	1.7	3.7	2.2	1.9	4.
1.9	1.8	3.7	1.8	2	3.8	2.1	1.6	3.7	2.2	1.6	3.8	2	2.1	4.1	2.1	1.8	3.9	2	1.9	3.9	2	1.9	3.
1.9	1.9	3.8	1.9	1.9	3.8	2	1.8	3.8	2.2	1.9	4.1	2.2	1.7	3.9	2.2	1.7	3.9	2.2	1.7	3.9	2.2	1.8	4

TABLE : 5. Showing raw data for inter wave lentency (in Msecs) at 70, 80, 90 & 100dBHL for 2 KHz (in the right ear) with and without centralateral noise.

70 Without Noise			70 With Noise			80 Without Noise			80 With Noise			90 Without Noise			90 With Noise			100 Without Noise			10 with No	
III-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	V-I	III-I	V-III	V-I		
2.2	2.0	4.2	2.3	2.0	4.3	2	2.1	4.1	2	2.1	3.1	2	2.2	4.2	2	2.1	4.1	2	8.3	4.3	2	2.2
2.1	1.7	3.8	2.0	1.8	3.8	2.2	1.6	3.8	2.1	1.7	3.8	2	1.8	3.8	2	1.8	3.8	2	1.6	3.6	2.1	1.0
2	1.3	3.3	1.9	1.3	3.2	1.9	1.3	3.2	2.0	1.2	2.2	2	1.2	3.2	2	1.2	3.2	2	1.3	3.3	2	1.2
1.6	1.6	3.4	1.8	1.6	3.4	1.9	1.7	3.6	1.9	1.7	3.6	1.9	1.8	3.7	1.9	1.8	3.7	2	1.7	3.7	2	3.7
1.7	1.8	3.5	1.6	1.7	3.9	1.9	1.6	3.5	1.8	1.7	3.5	1.8	1.7	3.5	1.8	1.8	3.6	1.8	1.6	3.4	2.1	1.5
1.8	1.7	3.5	1.7	1.9	3.6	1.7	1.6	3.3	1.9	1.6	3.5	1.6	1.6	3.%	1.9	0.8	3.9	1.9	1.5	3.4	1.9	1.5
1.8	1.9	3.7	1.8	1.9	3.7	2	1.9	3.9	2	1.9	3.9	2	1.9	3.9	2	1.8	3.8	2.1	1.9	4	2.1	1.9
1.9	2	3.9	2.0	2	4.0	1.9	1.9	3.8	1.9	2.1	4	2	2	4	2	1.9	3.9	2	2	4	2.3	1.7
2	2	4	2.1	1.9	4	2.1	1.9	4	2	2	4	2	1.9	3.9	2.1	1.9	4.0	2	2.1	4.1	1.9	2
1.9	1.9	3.8	2	1.9	3.9	2	1.6	3.6	1.9	1.7	3.6	2.1	1.8	3.9	2.1	1.8	3.9	2.2	1.8	4	2.2	1.8

TABLE : 6. Showing raw data for interwave latency (in Msecs) at 70, 80, 99 & 100 dBMfor 4 KHz(in right Ear) with and without centralateral noise.

	70 Lthout Noise		70 With Noise			80 Without Noise			80 With Noise			90 Without Noise			90 With Noise			100 Without No&se			100 With Noi	
LI	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III
	1.60	1.60	1.08	1.23	1.33	0.92	1.67	1.54	0.94	1.73	1.63	1.15	1	1.15	0.65	2.18	1.41	0.39	4.29	1.67	0.64	3.33
,4	4	5.6	1.0	1.75	1.75	0.86	2.25	1.93	0.2	2.67	0.33	0.68	2.4	1.64	0.4	5.75	2.3	0.82	2.86	2.35	0.4	4.38
,42	2.24	3.17	0.52	2.85	1.48	0.69	4	2.77	1.56	2.36	3.67	0.64	5.56	3.57	0.33	7	2.33	0.31	7.8	4.44	0.22	9.5
	6.25	6.25	0.75	12.33	9.25	1.5	1.67	2.5	1.42	1.85	2.63	1	1.76	1.76	1	1.81	1.81	0.94	1.44	1.35	0.79	2
,08	1.30	1.4	1.4	0.93	1.3	1.14	0.88	1.0	1.0	0.73	0.75	0.97	1.24	1.2	1	1.08	1.08	1.24	1.11	1.38	1.56	1.05
,55	2.06	3.18	2.22	1.67	4	1.25	1.16	1.45	1.23	1.35	1.76	0.91	1 .4	1.27	0.37	1.60	1.23	1.26	0.74	0.94	0.86	1
,87	1.5	1.30	1	3.63	3.63	1.04	1.56	1.63	1.04	1.72	1.79	0.9	1.78	1.6	0.96	1.33	1.29	0.68	2.53	1.71	0.76	2
,67	2.67	1.78	0.78	2.43	1.89	1.75	1.5	2.63	1.44	1.69	2.44	0.71	2.27	1.62	0.76	2.13	1.62	0.56	2.89	1.63	0.33	8
25	1.54	5	1.71	1.67	2.86	0.58	2.07	1.21	0.39	3.22	1.26	1.29	1.41	0.45	2.69	1.21	2.11	0.68	3.15	2.26	1.16	1.68
	2.47	2.47	3.75	2.2	8.25	1.26	1.13	1.54	0.8	1.42	1.13	1.67	1.25	0.78	1.43	1.11	0.74	1.13	1.6	1.82	1.19	1.2

TABLE? 7. Showing raw data for relative amplitude values for 2 KHz at 70, 80, 90 & 100 dBHL in the right ear) with and without centralateral noise.

70 Without Noise			70 With Noise			80 Without Noise			80 With Noise			90 Without Noise			90 With Noise			100 Without Noise			With	
III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/III	V/I	III/I	V/II
1.0	4.86	4.86	1.14	4.38	5	0.94	1.63	1.53	0.99	1.95	1.05	0.61	2.21	1.35	1	1.33	1.33	0.59	2.9	1.71	1	1.6
0.83	4	3.33	0.78	3.14	2.44	0.86	2.08	1.79	0.93	1.77	1.77	0.54	2.23	1.21	0.67	1.75	1.17	0.92	1.73	1.58	0.81	1.1
0.38	8	3	1.33	5.5	7.33	0.8	3.58	2.87	1.11	3.4	3.78	0.62	3	1.86	1.13	1.78	2	0.8	2.25	1.8	0.36	3.8
0.57	5.75	3.29	1.33	5.5	7.33	0.86	2.17	1.86	0.93	3.08	2.86	0.59	2.38	1.41	1.18	1.56	1.65	0.75	1.17	0.88	0.76	1.2
1.76	1.07	1.88	1.65	0.93	1.53	1.37	0.86	1.19	1.24	0.77	0.96	1.39	0.4	0.56	1.61	0.44	0.71	1.18	0.49	0.53	1.43	0.5
1.76	1.13	2	1.5	1.26	1.89	1.13	1.11	1.25	1.45	1.03	1.5	1.28	0.83	1.15	0.79	0.85	0.67	1.23	0.77	0.94	1.41	1
0.83	1.47	1.22	0.95	1.84	1.75	0.88	1.25	1.11	0.82	1.46	1.22	1	1.32	1.32	1.11	1.32	1.46	1.14	1.33	1.42	1.2	1.2
0.5	4	2	1.29	2	2.57	0.92	1.67	1.54	1.2	2	1.67	0.89	1.5	1.33	0.5	2.2	1.1	0.61	2.18	1.25	0.63	2.6
1.67	1.27	3	1	1.87	1.87	0.67	2.13	1.42	0.69	2.15	1.42	2.11	2	0.95	0.64	2.13	1.36	0.51	1.39	0.71	0.70	1.4
1.89	1.82	3.44	0.67	6	4	0.79	2	1.58	3	1.29	3.89	0.74	2.35	1.74	0.70	1.26	0.89	0.88	1.74	2.4	0.84	1.4

TABLE : 8. Showing raw data for relative amplitude values for 4 KHz at 70, 80, 90 & 100dBHL(in the right ear) with and without centralateral noise.

Intensities	2 kHz WITHOUT NOISE Wave I	Wave III	Wave V	2 kHz WITH NOISE WaveI	Wave III	Wave V
70	1.52 (0.18)	3.30 (C15)	5.10 (0.28)	1.52 (0.34)	3.31 (0.16)	5.19 (0.32)
80	1.27 (0.38)	3.20 (0.15)	4.86 (0.32)	1.21 (0.18)	3.20 (0.15)	4.87 (1.43)
90	1.03 (0.09)	3.01 (0.16)	4.75 (0.36)	1.03 (0.94)	3.01 (0.17)	4.72 (0.31)
100	0.90 (0.13)	2.86 (0.44)	4.61 (0.08)	0.87 (0.14)	2.88 (0.31)	4.62 (0.29)

	4 kHz WITHOUT NOISE			4 kHz WITH NOISE		
70	1.41 (0.13)	3.33 (0.16)	5.12 (o.31)	1.46 (0.21)	3.33 (0.14)	5.13 (0.31)
80	1.26 (0.64)	3.22 (0.40)	4.94 (0.31)	1.24 (0.12)	3.19 (0.14)	4.93 (0.19)
90	1.12 (0.32)	3.08 (0.14)	4.87 (0.33)	1.11 (0.34)	3.09 (0.16)	4.86 (0.31)
100	0.98 (0.06)	2.79 (1.05)	4.76 (1.14)	0.99 (0.43)	3.05 (0.12)	4.76 (0.32)

Table 9 - Showing Mean Absolute Latency (in milliseconds) values of the 10 normal hearing subjects at 70, 80, 90 and 100 dBHL right ear with and without contralateral noise.

The figures in the parenthesis indicate standard deviations.

Intensities	2 kHz WITHOUT NOISE Wave I	Wave III	Wave V	2 kHz WITH NOISE Wave I	Wave III	Wave V
70	0.28 (0.13)	0.30 (0.15)	0.61 (0.17)	0.28 (0.11)	0.28 (0.12)	0.56 (0.ll)
80	0.86 (0.15)	0.36 (0.16)	0.59 (0.15)	0.39 (0.37)	0.35 (0.18)	0.58 (0.23)
90	0.48 (0.14)	0.40 (0 16)	0.73 (0.19)	0.47 (0.14)	0.35 (0.18)	0.68 (0.20)
100	0.43 (0.13)	0.37 (O.24)	0.72 (0.14)	0.43 (0.14)	0.36 (0.23)	0.73 (0.14)

	4 kHz WITHOUT NOISE			4 kHz WITH NOISE		
70	0.22 (0.11)	0.27 (0.20)	0.54 (0.11)	0.22 (0.15)	0.26 (0.16)	0.56 (0.12)
80	0.40 (0.10)	0.37 (O.17)	0.61 (0.11)	0.37 (0.16)	0.40 (0.18)	0.62 (0.11)
90	0.53 (0.14)	0.37 (0.35)	0.65 (0.11)	0.51 (0.18)	0.47 (0.14)	0.58 (0.09)
100	0.55 (0.13)	0.47 (0.23)	0.64 (0.14)	0.49 (0.11)	0.48 (0.29)	0.59 (0.16)

Table 10 . Showing Mean Absolute Amplitude values (in microvolts) of the 10 normal hearing subje0.ts at 70, 80, 90 and 100 dBHL in right ear with and without contralateral noise.

The figures in the parenthesis indicate standard deviations.

Intensities	2 kHz WITHOUT NOISE Wave I	Wave III	Wave V	2 kHz WITH NOISE Wave I	Wave III	Wave V
70	1.78 (0.27)	1.80 (0.22)	3.58 (0.36)	1.79 (0.23)	1.88 (0.35)	3.67 (0.29)
80	1.93 (0.09)	1.66 (0.23)	3.43 (0.57)	1.99 (0.17)	1.67 (0.24)	3.66 (0.36)
90	1.98 (0.12)	1.74 (0.27)	3.72 (0.32)	2.00 (0.15)	1.71 (0.27)	3.71 (0.32)
100	1.96 (0.13)	1.75 (0.26)	3.71 (0.29)	2.01 (0.13)	1.74 (0.26)	3.75 (0.31)

Intensities	4 kHz WITHOUT NOISE Wave I	Wave III	Wave V	4 kHz WITH NOISE Wave I	Wave III	Wave V
70	1.92 (0.15)	1.79 (0.22)	3.71 (0.28)	1.92 (0.20)	1.80 (0.22)	3.72 (0.35)
80	1.96 (0.13)	1.72 (0.23)	3.68 (0.29)	1.95 (0.08)	1.77 (0.27)	3.72 (0.28)
90	1.96 (0.09)	1.79 (0.26)	3.75 (0.30)	1.98 (0.09)	1.76 (0.24)	3.74 (0.27)
100	2.03 (0.08)	1.78 (0.30)	3.78 (0.34)	2.06 (0.12)	1.71 (0.28)	3.77 (0.31)

Table 11 : Showing Mean values of Interwave Latencies (in milliseconds) of 10 normal hearing subjects at 70, 80, 90 and 100 dBHL in right ear with and without contralateral noise.

The figures in the parenthesis indicate standard deviations.

Intensities	2 kHz WITHOUT NOISE Wave I	Wave III	Wave V	2 kHz WITH NOISE Wave I	Wave III	Wave V
70	1.32 (0.88)	2.56 (2.15)	3.75 (3.50)	1.42 (0.87)	3.07 (2.11)	3.57 (2.14)
80	1.10 (1.00)	1.85 (0.74)	1.82 (0.50)	1.00 (0.43)	1.88 (0.66)	1.76 (0.90)
90	0.84 (0.14)	2.04 (1.53)	3.32 (1.76)	0.71 (0.24)	2.70 (1.95)	1.59 (0.44)
100	0.80 (0.32)	2.84 (1.95)	1.76 (0.45)	0.79 (0.40)	3.41 (2.78)	1.76 (0.48)

Intensities	4 kHz WITHOUT NOISE Wave I	Wave III	Wave V	4 kHz WITH NOISE Wave I	Wave III	Wave V
70	1.12 (O.67)	3.34 (2.26)	2.80 (0.10)	1.16 (0.52)	3.24 (2.09)	3.57 (2.15)
80	0.92 (0.58)	1.85 (0.72)	1.60 (1.16)	1.23 (0.63)	1.89 (0.80)	2.01 (0.73)
90	0.98 (0.46)	1.82 (0.76)	1.15 (0.68)	0.93 (0.33)	1.46 (0.52)	1.23 (0.36)
100	0.86 (0.25)	1.60 (0.27)	1.32 (0.55)	O.91 (0.24)	1.62 (0.89)	1.25 (0.29)

Table 12 . Showing Means of Relative Amplitudes of the wavea/of III/I, v/III & v/I 10 normal hearing subjects at 70, 80, 90 and 100 dBHL in right ear with and without contralateral noise.

The figures in the parenthesis indicate standard deviations.

	Absolute Latency (V) at 70 & 90 dB				Absolute Amplitude(V) at 7o & 90 dB				V-I Interwave Latency at 70 & 90 dB				V/I Relative Amplitude			
2K WITH/OUT NOISE	0.1	0.05	0.02	0.01	0.1	0.05	0.02	0.01	0.1	0.05	0.02	0.01	0.1	0.05	0.02	0.01
	NS	NS	NS	3.88	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
2K WITH NOISE	NS	NS	NS	7.83	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
4K WITHOUT NOISE	NS	NS	NS	6.25	NS	Ns	NS	NS	NS	NS	NS	NS	NS	NS	NS	5.1
4K WITH NOISE	NS	NS	NS	7.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.7

Table 13 Showing significance of means and levels of significance for absolute Latency (wave V), absolute amplitude (wave V), Interwave Latency (I-V), and relative amplitude (V/C) for 70 & 90 dB HL with and without contralateral Noise.

or not.

From table 9 it is clear that there are hardly any differences between the mean values obtained with and without contralateral noise. There is a decrease in the latencies as the intensity is increased. Regarding amplitude measurements, with the increase in the intensity of the stimulus, there is a tendency for the amplitudes to increase (table 10).

The interwave latency (table 11) differences are minimal except for V-I interwave latency. For relative amplitude also variations are less.

The absolute latency of all components decreases with increase in intensity (Starr and Achor, 1975)* The present study abides with the rule that latency decreases with increase in intensity.

The interwave latency values also decrease when the stimulus intensity is increased. Stockard et al (1979) have found that I-V interpeak latency decreases from 4.02 m.sec. at 70 dB SL to 3.68 m.sec. at 30 dB. Rowe (1973) also observed minimal changes in interwave latency when stimulus intensity was decreased. Stockard et al (1979) observed that interwave-latency values for waves I-III and I-V were shorter (at lower stimulus intensity) than waves III-V. This was not observed in the present study as higher intensity stimulus was used.

Absolute amplitude changes with intensity. Picton et al (1982) state that the absolute amplitude decreases below 20 dB and increases more slowly above 70 dB. They report that with high.pass filter of 100 Hz wave V amplitude decreases from 0.6 uV at 70 dB to 0.3 uV at 20 dB. In the present.amplitude decreased from 0.72 uV at 100 dB to 0.61 uV at 70 dB for 2 kHz (without noise); from 0.73 uV at 100 dB to 0.56 uV at 70 dB for 2 kHz (with noise); from 0.64 uV at 100 dB to 0.54 uV at 70 dB for 4 kHz (without noise); from 0.59 uV at 100 dB to 0.56 uV at 70 dB for 4 kHz (with noise). .

Stockard (1975) observed that 30 dB reduction in stimulus intensity was associated with a 33% decrease in amplitude at the IV-V complex while the same reduction in intensity was associated with a 90% decrease in wave I amplitude consequently relative amplitude (v/I) ratio increased with decreased stimulus intensity. Rosenhamer et al (1973) found V/I to be between 1.5 and 2.53 and V/III to be between 1.40 and 1.72 for 80 and 60 dB SL. In the present study, the relative amplitude viz. V/I and V/III for 100 dB stimulus have been found to be 1.76 and 2.84 respectively. The relative amplitudes, viz., V/I and V/III for 70 dB stimulus have been found to be 3.75 and 2.56 respectively.

Discussion

Chuden (l972) studied the effect of simultaneously stimulating one ear with a burst of puretone and the other with noise such as might be used for masking the contralateral ear. N. peak in response showed the amplitude that was to be expected if only puretones had been given without contralateral masking. The response to puretones of various intensity in the presence of contralateral noise at a steady intensity was also measured. The results indicate that with binaural stimulation, the brain responds only to the distinct clearest stimulus more or less ignoring the steady state masking noise, even at higher intensity. Continuous noise will be effective centrally but seems to have no influence upon the summation of human cortical evoked potential

From the data obtained in the present study, it is clear that there is no effect of contralateral noise on brainstem evoked response elicited using 2K and 4 K logon stimulus. Therefore, it can be concluded that there may not be central masking effect operating when the noise is presented to the contralateral ear, while testing the test ear during BSERA. If the central masking phenomenon had operated the amplitude and latency of brainstem evoked response should have changed, during contralateral noise condition. But the literature shows that the threshold will be elevated due to central masking phenomenon. It is possible that the effect of central masking may be more pronounced when both tne test stimulus and the contralateral stimulus are similar in frequency characteristics. This point has to be explored.

At present, it can be concluded that there is no effect of contralateral broad-band masking noise on the brainstem evoked response produced by 2K and 4K logon stimulus. However, Picton et al (1970), in a study to find out the relationship between amplitude and intensity observed a definite decline in the amplitude-intensity curve above

70 dB ISO. They talk of contralateral masking as a possible reason for this effect. They believe that the decreasing amplitude of response with increased contralateral masking is probably due to central masking phenomenon. In the present study, such an effect was not found.

CHAPTER V

SUMMARY AND CONCLUSIONS

In the present days, ABR has gained importance as a diagnostic tool in neurology and otology. Abnormalities along the auditory pathways change the normal pattern, enabling us to accurately diagnose the disease conditions. While testing unilateral hearing loss cases, we need information on changes in amplitude and latency of the brain-stem response by masking the contralateral ear.

The present study was undertaken with the aim of understanding the changes in response pattern with and without contralateral noise. Electric Response Audiometer TA-1OOO was used. Absolute latency, interwave latency, absolute amplitude and relative amplitudes were measured and analyzed. Amplitude measurement is vague when compared to latency measurement. In this study, amplitude measurements were made by dividing one division of the graph paper into 10 equal divisions which yielded the amplitude reading in microvolts directly.

In the present study, as intensity was reduced, there was consistent and significant lengtnening of latency for all the five waves. This is in accordance with the studies by Beagley and Sheldrake (1978), Coats (1978), Hecox and Galambos (1974), Picton et al (1977), Rosenhamer et al (1980) and Starr and Achor (1975). This is true for the interwave latency too. This is in agreement with the studies by Chiappa et al (1979), Gilroy and Lynn (1978), Rowe (1978), Stockard and Rossister (1977).

In general, amplitude and relative amplitude tended to increase with intensity wnich is not consistent and significant as that of latency-intensity function. This is in accordance with the studies by Picton et al (1981), Pratt and Schmer (1977), Starr and Achor (1975) and Tollneret al (1976).

In the present study, masking did not yield significant differences at intensity levels, but yielded significant differences between two intensities when they were pooled.

The experiment was carried out in a sound treated room. Ten subjects (5 males and 5 females)with normal hearing were tested. Three electrodes were used, active, ground and reference ERA TA-1OOO which generated logon tone (2K and 4KHz) which was presented through the right earphone. To get a response, 2048 samples were used. The pulse repetition rate was 5 pulses/sec, and the sampling time was 10 m.sec. Response characteristics studied were absolute latency (I, III, V), absolute amplitude (I, III, V), interwave latency (I-III, I-V, III-7) and relative amplitude (III/I, V/III, V/I).

Data was analyzed to obtain the means, standard deviations and significance of means.

The following Conclusions are drawn from the Study: .

1) There are significant differences between the absolute latencies of peaks I, III and V obtained at four intensities in both unmasked and masked conditions.

2) There is significant difference between absolute latencies (wave V) obtained for 2 kHz logon stimulus at 70 and 80 dB HL. ($p \leq 0.01$) (without noise).

3) There is significant difference between absolute latencies (wave V) obtained for 2 kHz logon stimulus at 70 and 90 dB HL. ($P \leq 0.01$) (with contralateral noise).

4) There is significant difference between absolute latencies (wave V) obtained for 4 kHz logon stimulus at 70 and 90 dB HL. ($p \leq 0.01$) (without noise)

5) There is significant difference between absolute latencies (wave V) obtained for 4 kHz logon stimulus at 70 and 90 dB HL. ($P \leq 0.01$) (with contralateral noise).

6) There is no significant difference between absolute amplitude (wave V) obtained for 2 kHz at 70 and 90 dB HL (with and without contralateral noise).

7) There is no significant difference between absolute amplitude (wave V) obtained for 4 kHz at 70 and 90 dB HL (with and without

contralateral noise).

8) There is no significant difference between interwave latency (V-I) obtained for 2 kHz at 70 and 90 dB HL (with and without contralateral noise).

9) There is no significant difference between interwave latency (V-I) obtained for 4 kHz at 70 and 90 dB HL (with and without contralateral noise).

10) There is no significant difference between relative amplitude (v/I) obtained for 2 kHz at 70 and 90 dB HL (with and without contralateral noise).

11) There is no significant difference between relative amplitude (V/I) obtained for 4 kHz at 70 and 90 dB HL (with and without contralateral noise).

12) There are no significant differences between the absolute latencies of waves I, III and V obtained for 2 kHz with and without contralateral noise. (Intensities tested were 70, 80, 90 and 100 dB HL).

13) There are no significant differences between the absolute latencies of waves I, III and V obtained for 4 kHz with and without contralateral noise. (intensities tested were 70, 80, 90 and 100 dB HL).

20) There are no significant differences between the relative amplitudes (III/I) obtained for 2 kHz with and without contralateral noise. (Intensities tested were 70, 80, 90 and 100 dB HL).

21) There are no significant differences between the relative amplitudes (III/I) obtained for 4 kHz with and without contralateral noise. (intensities tested were 70, 80, 90 and 100 dB HL).

22) There are no significant differences between the relative amplitudes (v/III) obtained for 2 kHz with and without contralateral noise. (Intensities tested were 70, 80, 90 and 100 dB HL).

23) There are no significant differences between the relative amplitudes (v/III) obtained for 4 kHz with and without contralateral noise. (Intensities tested were 70, 80, 90 and 100 dB HL).

Limitations

1) Only ten subjects were used for the study due to the limited time which was available for testing purposes.

2) Data was obtained for 2048 samples and for four intensities only.

Recommendations

Since the present study has shown that there is no 'central masking effect' on BSER, it is worthwhile to study whether 'central masking effect' operates when test stimulus frequency and contralateral stimulus frequency are the same.

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