THE EFFECT OF PATIENTS RESPONSE INTERVAL ON BSERA

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TO

MY PAPPA AND AMMA

WHO MEAN EVERYTHING TO ME

CERTIFICATE

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

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CERTIFICATE

This is to certify that the Independent Project entitled "THE EFFECT OF PATIENT RESPONSE INTERVAL ON BRAIN STEM EVOKED RESPONSE AUDIOMETRY" has been prepared under my supervision and guidance.

Dr.M.N.Vyasamurthy
GUIDE

DECLARATION

I hereby declare that this Independent project entitled: "THE EFFECT OF PATIENT RESPONSE INTERVAL ON BRAIN STEM EVOKED RESPONSE AUDIOMETRY" is the result of my own study under the guidance of Dr.B.M.Vyasamurthy, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other diploma or degree.

Mysore, REG.NO. 8606

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INTRODUCTION 1

Brain-stem evoked responses are a aeries of vertex-positive time locked electric events. They are usually aroused by a brief, rapid onset, high intensity click or tonal pip. The vertex positive nature of the events is dictated by the placement of surface electrodes, usually featuring an active electrode on the vertex, a reference electrode on the mastoid or earlobe ipsilateral to the signal source, and a ground electrode on the forehead or other neutral tissue.

The size of the ABR is sufficiently small, often fractions of a microvolt, to require the use of many signal presentations (1000-2000 stimuli) and digital averaging of the resultant electrical activity for the stimulus time-locked potentials to be elicited from the other physiologic 'noise'.

BSERA differs from conventional pure tone audiometry in that it is an entirely objective procedure, the subjects response is totally involuntary even to the extent that normal responses reobtained from sedated, unconscious or comatose subjects whose auditory function is intact.

Since the auditory brain stem potentials are known to be elicitable near a subjects behaviour threshold for the stimulus used, and since the various potentials are thought to originate from different points in the brain stem, they have proved useful in hearing of evaluations of human beings for 2 purposes -

(a) they are useful as a means of measuring hearing sensitivity from patients who cannot or will not give accurate voluntary responses, and

(b) they are useful as a diagnostic too for determining the probable cause of an auditory disorder.

According to Buchwald (1983) BSER reflects graded post-synaptic potentials rather than all-or-none action potentials discharged at the call soma or transmitted along the axonal projection. He also said BSER latency and amplitude measures reflect different physiologic processes which may interact. BSER waves reflect functionally separable substrate system.

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

1. Cochlear
2. Superior Olivary (Complex
3. Nuclei of the lateral lenniscua
4. Inferior colliculua
5. Medial Ceniculate Body

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

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

1. First vertex positive potentials in the BSER sequence is produced by acoustic nerve activity (Cat, Jewett, 1970; Hashimoto, Ishyami and Yoshimoto, 1981).
2. Data from a variety of different experiments consistently indicate that the cochlear nucleus contributes to and is essential for BSER wave-II (Bushwald, Huang, 1975).
3. In view of the direct and indirect links between MSO field potentials and wave-III, the principal substrate for wave-III generation is hypothesized as dendritic post-synaptic potentials of the medial superior olivary nucleus (Buchwald,1983).
4. Wave-IV generation is postulated as post-synaptic potential activity within the lateral lemniscus cell population (Buchwald, 1983).
5. Wave-V result of lesion studies suggest that the deep ventro-lateral portion of the inferior colliculus is partially important for wave-V generation (Buchwald, 1983).
6. Wave-VI arises from medial geniculate body. It is consistently ranked hardest to recognize the BSER in a normal population, it is so irregularly present and variable in waveform that its clinical usefulness has been questioned (Chippa, Gladstone and Young, 1979).
7. Wave-VII arises from auditory radiations (thalamocortical) and is also irregularly present.

According to Bobie (1980), responses variable usually measured is the latency of wave-V, for several reasons:-

1) Wave-V is usually the largest component in BSER.
2) Wave-V is the least variable component of BSER trace, from subject to subject.
3) Under adverse conditions such as low stimulus intensity and high repetition rate, wave-V persists while the other waves become increasingly indistinct.
4) Latency of any of these waves is far less variable than response amplitude.

The evoked responses are known to change from the normal due to a number of factors. They are listed below:-

1. Stimulus Parameters:

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

2. Procedure Effects:

a. Position of electrodes
b. The use of fitters (Bandwidth)

c. Choice of response reference points for the computation of latency.

d. Difference in stimulus transducer.

e. Effect of masking and/or ambient noise level.

3. <u>Subject Effects</u>:

a. State of the subject (awake, asleep, sedated or anaesthetized)

b. Effect of the temperature

c. Sex differences

d* Effect of change in muscle tone and attention

e. Effect of age

These factors need to be controlled while testing in order to get valid and reliable results. This study also considers the effect of one of the stimulus parameters on the evoked response.

<u>Aim of the study</u>:

This study aims at observing and recording the effect of 10 m.sec. and 20 m.sec. settings on the brain-stem evoked response waves.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Basic Principles:

When a person is quite and relaxed his brain wave activity has a definite wave pattern. A change in this pattern of brain waves is found when an external stimulus eg. sound is presented to the person. This is called evoked response or evoked potential or complex or vertex potential. The type of audiometry which uses this basic methodology is called Evoked Response Audiometry.

The response evoked on presentation of stimulus just once is negligible. Hence the stimulus is presented a number of times and the averaging computer averages the stimulus time-locked responses and magnifies the change. Greater the number of stimuli used greater the amplitude of resultant stimulus.

Thus, BSERA finds clinical application in the evaluation of hearing abnormalities involving that portion of the auditory pathway between the cochlea, where the acoustic stimulus in first, converted to an electrical signal; and the brain-stem, where this signal initiates the coordinated neuron discharge subsequently recognized as sound.

Acoustic Stimuli for BSERA:

BSERA stimuli are characterized by abrupt onset and decay and short-duration, totally unlike the sustained pure-tone of conventional audiometry. This is necessiated by the diagnosis which depends on significance of response with the duration of stimulus and by the very rapid response of the cochlea to the acoustic stimulus.

In this study we have used LOGON stimulus. The logon stimulus is a 1.5 cycle burst of the desired stimulus frequency, having onset and decay times equal to 0.75 cycles of that frequency. Its waveform is a single major peak, preceded and succeeded by minor peaks of opposite polarities. The logon's energy spectrum is approximately one octave in bandwidth centered on that frequency determined by the interpeak time of its waveform. The logon stimulus is more frequency specific and finds clinical application in more detailed exploration of hearing abnormalities, typically in the 500 - 4000Hz frequency range.

Typically, the peak sound pressure level of a BSER stimulus at hearing threshold is approximately 25dB greater than that of a sustained pure tone.

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

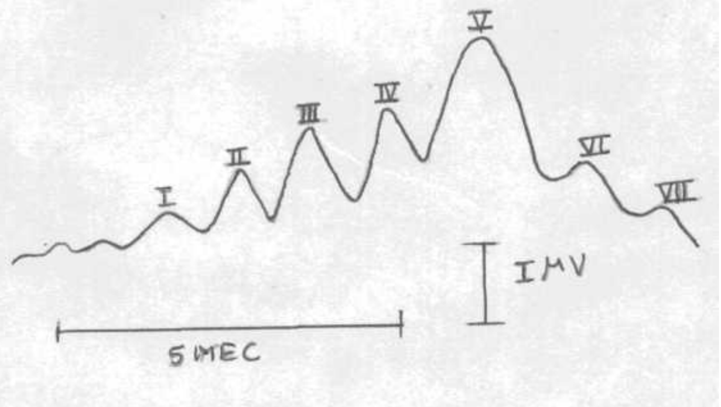


FIG-1

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

Sohmer and Feinmesser (1967) found that the early waves of the response (Wave-I through Wave-IV) were found to be particularly sensitive to increases in the stimulus repetition rate, i.e., the reduction of these waves was markedly reduced at higher repetition rates.

Jewett and Williston (1971) found that lower frequency tone pipe resulted in a less distinct waveform than higher frequency tone pipe.

Anatomical origins of Response Components:

From the very beginning, various investigators have speculated about the origin of ABR component waves.

Studies by sohmer et al, (1974); Starr and Acher (1978); Starr and Hamilton (1976) demonstrated that wave-I was typically the only recommand when lesions involved the ponto-meduilary function or when the brainstem was externally damaged. Alterations of II and III were associated with lesions in the medulla and pons i.e., the cochlear nucleas, trapezoid body and superior olive lesions affecting midbrain auditory structures were associated with changes in waves IV and V.

Picton et al, (1974) concluded that waves I through IV represented activity of the auditory nerve and brainstem auditory nuclei, but the ABR waves recorded from vertex to mastoid reflected the composite contribution of multiple generators.

Goff et al, (1977) produced the following table:

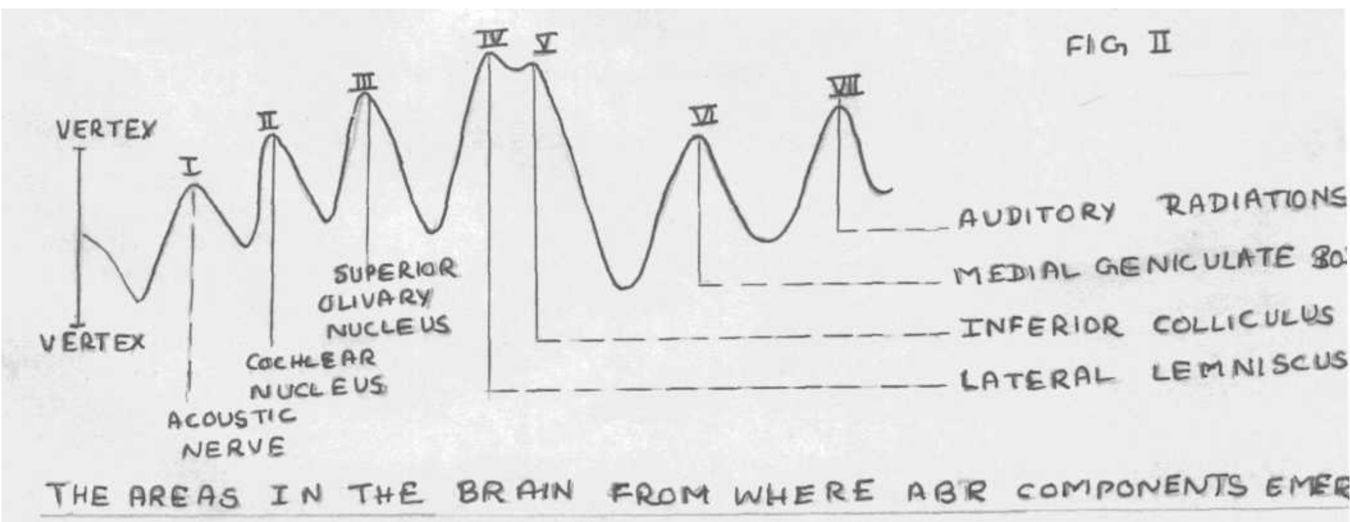
ABR component waves	specific Neural Generators
I	Acoustic Nerve
II	Cochlear Nerve (Medulla)
III	Superior Olivary Complex (Pons)
IV	Lateral Lemnisous (Pons)
V	Inferior Colliculus (Midbrain)
VI	Medial Genlculate (Thalamus)
VII	Auditory Radiation (Thalamo-cortical)

Normal Response Parameters.

Morphology refers to the visual appearance of waveform.

Several investigators observed that wave IV and V often are fused together into what has been called the 'IV-V Complex'.

Chippa et al, (1979) described six variant forms in normal young adults labelled A to F.



In normal adult subjects wave-V is the most frequently observed component of the ABR in response to high intensity clicks, whereas waves II and TV are seen with the least frequency (Rove, 1970).

Response Latency:

The time relationship between any response and the stimulus eliciting that response is commonly called "latency"

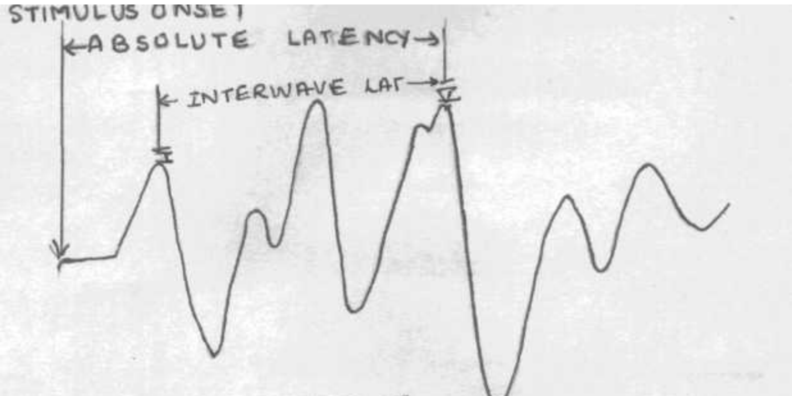


FIG.III

Absolute latency conform to the traditional definition? the time relationship between stimulus onset and associated response.

"Interwave latency" refers to the time difference between two component waves, example, the I-V interwave latency. Both are typically specified in multiseConds.

Variation between studies for a given ABR wave latency might reflect the number of subjects evaluated and/or the click intensity and fitter settings employed.

Absolute latency for each ABE Wave

-	N	Click intensity	Fitter	I	II	III	IV	V	VI
Jewett and willston (1971)	11	60-70dB	10-10,000	1.7	-	-	-	4.6 5-1	-
Picton et.al (1974)	20	60dB	10-3,000	1.5	2.6	3.5	4.3	5.8	7.4
Rosenhamer et.al(1978)	20	60d3	180-4,500	1.7	2.9	3.9	5.2	5.9	7.6
Rowe (1978)	25	60dB	100-3,000	1.9	2.9	3.8	5.1	5.8	7.4
Stockard etal. (1978)	50	60dB	100-3,000	1.8	2.9	3.9	5.2	5.8	-
Chippa et.al (1979)	50	60dB	100-3,000	1.7	2.8	3.9	5.1	5.7	7.3

Increasing tendency to focus on I-III, III-V and I-V interwave latencies is due the information made available by studying them.

I-III - We get transmission time through the ponto-medullary function and lower pons.

III-V - We obtain transmission time from caudal pons to caudal midbrain.

I-V - We obtain time needed for impulses to travel the entire system and is sometimes called "Central" on "brain-stem" transmission time.

Response Amplitude:

Response Amplitude refers to the hieght of a given wave components and it is usually measured in microvolts (MV) from the peak of the wave to the following trough (assuming that vertex positive waves are displayed as upward deflections).

Relative Amplitude of waves is absolute amplitude of ABR component waves expressed in relation to one another.

Starr and Anchor (1975) found that ratio of waves V:I amplitude exceeded 1.O in response to click intensities below 65dB.

Factors Affecting BSERA Results:

I. The Effect of Stimulus Parameters on the ERA:

A. The Choice of Stimulus:

Several types of acoustic stimuli have been tried out in various studies. Clicks of short duration were used by Perl Galambos and Glorig (1953) damped sinusoidal waves were utilised by Lowell and his colleagues (1961); William and Graham (1963) used pulses made up of the positive half of a pure tone.

It has been observed that it is easier to evoke a response to clicks than to pure tones. Rise time of a click is shorter than the rise time of a pure tone, and the cortical activity evoked by a click is more diffuse than with a pure tone (Perl, Galambos and Glorig (1953)y and Williams and Graham (1963).

Davis (1965) used tone pips which are fittered clicks at different frequencies. Recently he pointed out that although agreement between voluntary thresholds for PTS and tone pips is generally good, it tends to be poorer for persons with steeply sloped hearing loss.

It was also found in a study that the N_1-P_2 amplitude was greater when the 200Hz tones were out of phase than when they were in phase. This was considered to be due to a greater population of neurons being stimulated by the out of phase 200Hz signal than by the in phase 200Hz signal. (Butter and Kluskens, 1960).

In a study there was an attempt made to determine whether evoked response reflects the frequency spectrum rate of this amplitude modulated signal. It was found that the response to the amplitude modulated signal showed the effects of habituatlon In contrast, when this amplitude modulated signal was presented with signals of 200Hz, the response to the amplitude modulated signal was hardly affected.

B. The Effect of Stimulus Frequency on the Evoked Response:

Differences in response detectability was seen with changes in response detectability with changes in stimulus frequency (Suzuki and Taguchi, 1963).

Rose and Malone (1965) using pure tone stimuli having different frequencies between 200-8000Hz but with a 25 m.sec. rise-decay time and a 4000 m.sec duration, found that on and off effects did not vary as a function of tonal frequency.

In another study it was found that the greatest increase in amplitude was associated with the tonal stimuli of 1000Hz, and

and stimuli of 250Hz is associated with amplitudes of intermediate size. In contrast the smallest amplitudes was associated with stimuli of 6000Hz (Rapin et al.1966).

(Other investigators state that the frequency of the stimulus affects the form of the evoked response. Antinoro and Skinner (1968) examined the evoked responses at 250, 500, 1000, 2000, 4000 and 8000Hz when the stimuli were presented at equal loudness and equal sensation levels. Peak to peak amplitude decreased under condition of equal loudness and equal sensation level as frequency increased.

This is explained by the theory that at lower frequency, there is larger area of disturbance along the basilar membrane. A larger area means that a larger number of neural elements will be stimulated and the resultant evoked response amplitude will be greater than if a smaller number of neural units had been stimulated (Evans and Detherage, 1969).

C. Effect of Stimulus Intensity:

Stimulus intensity is related to the spatial configuration of neural aggregates and the number of active neural elements present. Intensity of stimulus influences the frequency of giving, and the number of neural elements capable of firing (Moore, 1978).

Intensity is designated as nHL whenever levels are referred to the threshold of a panel of normal hearing young adults when levels are reffered to individual's threshold for that stimulus, the designation dBSL is preferred. At intensities below 40dB (approximately) nHL, waves-I and III are seen more frequently than II and IV; but V often as the only remaining wave in response to stimulus intensities that approximate threshold levels (Rowe, 1978). When wave-V is fused into an undistingui-shable IV-V complex, its resolution is improved at lower stimulus, and intensities (Rowe 1978* stockard et al. 1978).

Bach 10dB decrease in the intensity of the stimuli shows a correspondingly increase in the latency of each wave. Latency is supposed to have an approximately linear relation to the log of the stimulus intensity (Moore, 1979).

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).

Wave-I latency was found to increase more than waves III-V when stimulus intensity was decreased in a study (Stockard et al 1979).

It is also known that ABR amplitude decreases with decreasing stimulus intensity.

Rapin and her associates (1966) observed that the amplitude of the N_1-P_2 component of the click response (N_1 peak latency 90-150 m.secy P_2 peak latency 180-260 m.sec) increased with intensity in an irregular and nonuniform manner. In contrast, the increase in amplitude was more regularly and definitely related to changes in stimulus intensity.

Butter Keidd and sprang (1969) found that the log amplitude of the component at 60-100 m.sec increased with intensity according to a power function having an exponent of 0.18 at 70 dB or less, and that the log amplitude of the component occurring at 100-140 m.sec increased with intensity according to a power function having an exponent of 0.27 again for the lower intensities.

It was also observed that the relationship of the average evoked response amplitude and sensation level was a linear one for frequencies between 125Hz and 2000Hz at levels between 20 and 100 dBSL. This trend was not consistent at 4KHz and 8KHz (Antinoro, Skinner and Jones, 1969).

It was found that the amplitude of single unaveraged responses was larger for higher intensities.

Rosenblith (1954) using a statistical model of nervous system, noted that the recording from an electrode in the nervous system is really sample of summated activity from a neural population at that particular spot in the auditory system. The number of neural units involved in dependent on intensity.

It was observed that clicks presented in an ascending order of intensity were associated with raised threshold responses having reduced amplitude when compared to responses presented in a descending order of intensity.

It was also found that the latency of the 3L component (peak latency 90-115 m.sec), and the P_2 component (peak latency 170-200 m.sec) remained constant for clicks, but at 50dBSL the latency for tone bursts was 10-15 m.sec. greater than for clicks of the same intensity.

D. The Effect of Stimulus Loudness on the Evoked Response:

Loudness is the psychological parameter of intensity.

The power function depends on both the range of the response and the range of the stimulus. Longer intervals between stimuli and restriction of frequency range of the stimuli make for larger responses (Keidel and Spreng, 1965).

Allen (1968) found that amplitude of the responses to binaural stimulation was about 21% greater than monaural stimulation regardless of frequency or intensity level. He interpreted this as binaural stimulation of loudness.

Further studies concluded that relationships of amplitude increments to intensity increments are best described as a linear function (Awtinoro, skinner, 1969).

Skinner and Antinoro (1970) compared evoked responses to 50dBSPL pure tone bursts contained within the critical band and pure tone bursts exceeding the limits of the critical band, finding no differences in amplitude or latency of the evoked responses.

Evoked potentials of similar frequency and intensity will be variable. The evoked potentials can be considered derivative in nature for they are present only at the onset and termination of a long stimulus (Davis, 1965).

Sutton (1963) has designated the amplitude changes of the vertex potential associated with loudness changes of the stimulus of the stimulus as a sign and not a code.

E. The Effect of Stimulus Duration on Evoked Response:

By simple visual inspection, it is noted that as duration is increased from 30 to 100 m.sec,the latency of all components increased (Haskins, McEvoy, and Scott, 1979). Also the amplitude of various components decreased, and various components become less distinct. However all waves can readily be identified at the longest duration; although the double peaked wave-IV-V complex has merged into one broad identifiable peak.

As the repetition rate is held constant the interstimulus intensity is decreased, while the duration is increasing or conversely as the interstimulus intensity is decreased, the various BSER waves are less distinct and show an increase in latency but a decrease in amplitude.

Satisfactory vertex response from normal hearing subjects could be obtained by employing tone pulses having a duration of 6-64 m.sec presented at a rate of one per two seconds (Cody and Buckford,1965).

When stimuli of 30 m.sec and 200 m.sec were employed clinical accuracy was better at a stimulation rate of one per 2 second as compared to one per second.

It was hypothesized that with the presentation of each stimulus a neural memory trace is set up in the brain. The match between the memory trace and the actual stimulus improves with each successive presentation of the stimulus. The evoked response amplitude is a measure of the amount of mismatch which is present, and habituation can be defined as a reduction in this match. It was noticed that the amplitudes of the evoked responses showed increasing reduction over time as the duration of the stimulus presentation increased (Weber, 1970). By further experimentation weber concluded that the observed amplitude reduction was a result of habituation not a change in central nervous system responsivity. He also pointed out that the interval of 28 sec. between runs makes for minimal central nervous system refractoriness. strengthening the contention that his findings are due to dishabituation.

It was also found out that of the duration is less than 0.1 sec it is difficult to obtain responses when stimulus intensity is less than 30d3. If the duration of the stimulus is greater than 0.5 second the time spent obtaining the data is unnecessarily prolonged (Derbyshire et al.1964).

Usually it is not possible to obtain a voluntary evoked response at the required intensity unless the duration matached the time needed to obtain the voluntary threshold.

Studies indicated that intersubject variability with regard to stimulus duration necessary for an off-offset was large ranging from 800-1500 m.sec (Rose and Malone, 1965). Skinner and Jones (1968) observed a maximum peak-to-peak voltage when the stimulus duration was 25-750 m.sec; they indicate agreement with Davis and Zerlin (1966) that an increment in response to amplitude at this point is probably due to an interaction of the on and off effects. The amplitude of the off-effect is increasing with stimuli of longer duration just as the amplitude of the on-effect is increased by using longer interstimulus intervals.

F. The Effect of Stimulus Rise—Decay Time on That Evoked Response:

The BSER may be equally influenced by various rise-dacay times of the input signal (Kimmelman Marsh and Yamana et al, 1979; Koder, Hink and Yamada et al 1979; Suzuki and Horiuchi, 1981).

The neural impulses that make up the BSER are best excited by fast rising stimuli. The latency of various components are also seen to shift to a later time of occurrence for longer rise-decay times.

On dimunition in the magnitude of the various components, a rise-decay time of 5.0 m.sec. causes wave-I to disappear into the ongoing background N of the response trace so that wave-I and II are not readily perceptible. So what is demonstrated is that distinct BSER potentials depend upon a synchronous discharge of auditory nerve fibers.

Fibers innervating the basal turn of the cochlea fire to a brief stimulus. The BSER components arising from the 100 m.sec. rise time is disproportionately weighted towards the basal end of the cochlea. The successive components insistently increase in latency as a function of increasing rise-time.

Hecox et al. (1976) observed that stimulus rise-time had the greatest effect on wave-V latency.

Goodman et al (1966) observed that a faster signal rise time is more effective in evoking EEG response from sleeping reonates. Cody and Kliss (1968) examined the evoked response latency at 65dB and l5dB at 1000Hz with rise times of 2.5, 25 and 50 m.sec. they found that latency increased with the increase in rise time, and this increase was greater at the lower intensity levels. At lower intensity levels, aural stimulation takes place when the signal nears its plateau. At the higher intensity levels, aural stimulation takes place when the signal is relatively distant from its plateau.

Further analysis of the monopolar recordings revealed that a decrease in rise-time was associated with a decrease in response latency and generally with an increase in amplitude. Response to clicks showed an increase in amplitude when intensity was increased from 10 - 20 - 30dBSL. Responses to signals with 10 m.sec rise-time showed an increase when intensity was increased 10 - 20dBSL, but showed no increase when signal intensity was increased from 20 - 30dBSL.

G. The Effect of Stimulus Polarity on the Evoked Response:

It is important to check whether stimuli was presented in a condensation of rarefaction phase, and the starting time from zero. This is important since audiogram shape and lesion location can influence the BSER waves when condensation and rarefaction responses are mixed (Coats and Martin, 1977; Omitz and Walter, 1975; Omitz and Olsen et al, 1980).

Changing click polarity from rarefaction to condensation has been reported to have an influx on the morphology of the IV-V complex.

Stockard et al (1979) found that wave-IV was more prominent than V in 70% of subject's responses to rarefaction clicks.

The use of alternating click polarity can affect the morphology of wave-I due to the possible cancellation of out of phase components when responses to the separate polarities are summed (Stockard et al, 1979).

Omitz and Walter (1975) suggested that if the frequency composition is limited primarily to 4000Hz or above, the likelihood of seeing differential ABRs to clicks opposite polarity is reduced.

H. The Effect of the Number of stimuli on the Evoked Response:

For a normal subject in order to observe an average responses, generally 25 out of 50 stimuli should be heard (Cody and Bickford, 1965).

Other studies pointed out that when the stimuli were only 10dB above threshold, it was necessary to present as many as 400 stimuli to record an average response (Rapin and her associates, 1966).

Webman and Graham (1967) pointed out that if samples was increased beyond 50, the percentage of responses increased but not significantly. They cautioned against obtaining more than 100-125 samples because habituation may take place, resulting in amplification reduction.

Walter (1964) pointed out that when averaging a time where signal is in the midst of white noise, the gain of the signal over the normal will be proportional to the square root of the number of samples.

I. <u>The Effect of Stimulus Presentation Rate and Iaterstimulus Interval:</u>

Increasing the rate of stimulation also increases the latency, but decreases the magnitude of the BSER waves (Campbell, Picton and Wolfe et al, 1981; Moore,1971; Picton et al. 1981). The effect is most pronounced for repetition rates greater than 10/sec, but the effect does not go unnoticed at rates below 10/sec.

Jewett and Williston (1971) found that increase in stimulus rate significantly decreased the definition of waves I through IV. This waveform degradation was slight at 10 clicks per second but quite noticeable at rates of 20/second. Wave-V dominances appears to be resistent to rate affects.

In general an increase in absolute latency of all ABR component waves is associated with an increase in stimulus repetition rate (Chiappa et al. 1979: Rosenhamer et al, 1978) Stockard et al.1979; Weber and Fuzikawa, 1977). It was found that I-V interwave latency increased with stimulus repetition rate.

Perl, Galambos and Glorig (1953) reported that discernible responses decreased when stimuli were presented too rapidly; the greatest number of responses was observed with interstimulus intervals of 10 sec. or longer.

Abe (1954) examined averaged evoked responses using Dawson's (1950) photographic superimposition technique, and found that no response could be evoked with clicks when the interstimulus interval was 0.5 sec or less. With interstimulus intervals of 0.75 sec, a reduced response could be evoked.

McCandles and Best (1964) examined the average evoked response to clicks presented at rates of 3 per sec, 2 per see, and 1 per sec, and 0.5 per sec. They found that with stimulus rates of 2 per sec or faster, response components occurring after 80 m.sec showed amplitude reduction and latency shifts. When stimulus repetition rates of 0.5 per sec or less were used, response components were affected very little.

In infants it is found that a response will not be evoked if stimulation rate is too fast. Interstimulus intervals of 10-15 sec were associated with largest responses (Appleby et al.1964]

It has been also concluded that response amplitude is greater when stimuli are presented at slow irregular rates. Rapin (1964) reports that the optimal rate lies probably between one per 3 sec and one per second.

Rothman Davis and Hay (1964) found out that in 16 of 24 instances, nonuniform stimulation produced responses with larger N_1-P_2 amplitudes than did uniform stimulation. They concluded that nonuniform stimulation was associated with an increment in response amplitude, but this association was not consistent across or within subjects.

On considering the P_1-N_2, N_1-P_2 and P_2-N_2 Peak amplitudes with respect to the intersignal interval, they found that amplitude increased with increase in interstimulus interval (Nelson and Lassman, 1968).

Butter (1972) studied the effect on the ERA of the delivery of sounds from different azimuths, and found that as angle between two sounds was increased to 90", the average evoked response amplitude increased. He suggested that by separating the sounds is space, some neural units activated by sound A will not be activated by sound B and vice versa.

On presenting tones at the rate of one per 2 seconds, it was observed that the amplitude of the positive component, having a peak latency of 150-200 m.sec, declined the delivery of the first stimuli. When the interstimulus interval was increased to 10 sec. this drop in amplitude was aot observed. The decrement in response amplitude observed with the shorter interstimulus intervals was attributed to refractoriness of the auditory system, not to habituation, because they could not demonstrate dehabituatlon.

J. The Effect of stimulus Repetition:

It was observed that the first of a series of identical stimuli was more likely to evoke a discernible response, and the first response was larger than subsequent responses (Perl, Galambos and Glorig, 1953).

It was found that frontal responses show less habituation When auditory stimuli are employed. Visual stimuli show a greater tendency to produce habituation and tactile stimuli show a still greater tendency (Walter et al. 1964).

Studies showed that the amplitude of the vertex potential was larger when the frequency of the intervening stimuli was more distant from the test frequency. This is because the more distant in frequency are the intervening stimulus from the test frequency, the more neural units are activated and habituation will be greater when the same or fewer neural units are repeatedly activated. This was when the frequency of the intervening stimuli was nearer the frequency of the test stimuli (Butter, 1968).

K. The Effect of Monaural vs Binaural Mode of Presentation:

In neurologically normal subjects with the same hearing in both ears, binaural stimulation usually results in a response of increased amplitude (Stockard et al.1978).

Stockard also reported that binaural stimulation increases wave III to V amplitude, but not the amplitude of waves I and II.

L. The Effects of Masking on Evoked Potentials:

Masking is said to occur when one sound makes another sound difficult or impossible to hear or when the threshold of the signal (the maskee) has been elevated by a second signal or none (the masker). The phenomenon of masking is a convenient method of study in frequency analysis (Wegel and Lane, 1924), if a signal of known frequency is interfered with by the introduction of another signals frequency analysis has been altered.

Temporal masking is a masking effect in which two sounds are not simultaneously presented. If a signal (A) occurs before say a masker (B), a backwards masking paradigm is noted. And if signal A is presented after signal B, a forward masking paradigm is operative. Simultaneous masking occurs if signal A and Masker B are on at the same time.

Ananthanarayan and Gerken recorded the BSER using a tone-on-tone forward masking paradigm. Wave V is prolonged in latency when compared to the unmasked condition, this is similar for wave V. Wave III exhibited a general reduction in amplitude for the simultaneous masking condition and a tendency towards recovery of amplitude values with increasing t. Wave V also exhibited a reduction in amplification for the simultaneous masking task, but exhibiting an increment in the amplification in the forward masking conditions, this wave enhancement was t dependent.

These effects are attributed to a peripheral masking effect. The temporal sequence that resulted in wave V enhancement was compared to the manner in which rapid spectral change affects medial geniculate evoked responses.

II. <u>Procedure Effects on Evoked Responses:</u>

Variation in recording technique can influence the parameters of obtained ABRs. Example, placement of electrodes may affect the response recorded. A number of investigators (Jewett and Williston, 1971; Martin and Moore, 1977; Picton et al, 1974; Plantz et al 1974; stackard et al.1978) have demonstrated that electrode location around the ear should be considered active for stimulus related neurogenic activity.

BSER recorded with external electrades on vertex and ear lobes, are excellent for audiometry of young children. The vertex positive wave with latency of 6 to 9 m.sec. resembles closely the action potential of the auditory nerve, with the same high intensity short latency component and low intensity long latency component.

At 1KHz and above, BSER + ECochG shows distinctive sharp waves with clearly defined latencies and low thresholds that they will almost certainly prove to be more reliable and sensitive at the middle and higher frequencies than the later cortical responses.

BSER rests primarily on the external placement of the electrodes, on vertex and earlobes.

The response is found to be maximum at vertex and diminishes gradually toward the nasion, union and the mastoid process. There are no significant differences between responses to ipsilateral and contralateral. It follows that no electrode positions can be used to record the activity generated in the neurons of nuclei of one aide.

There are indications that monolateral pathology of brain stem nuclei can be detected by comparing responses to stimuli presented on the right, the left and bilaterally.

Brain electrical activity mapping of ABR components were studied in normal hearing subjects. The scalp distributions of the highest electrical activity of ABR components on the scalp were as follows: (1) The highest electrical activity of wave I was most significantly detected on the parietal to the ipsilateral occipital area; (2) For the wave III, the highest area was not uniform however it tended to distribute to the contralateral hemisphere; (3) The wave V revealed, the high amplitude area at the parietal portion (fairly contralateral). Topographical distribution of ABR may have its applicability to the topographical diagnosis of central lesions.

Stockard et al (1978) observed that Wave I amplitude increased when responses were referenced to the earlobe instead of the mastoid process. This wave I amplitude increase effectively decreased V:I relative amplitude. ABR parameters were markedly altered when recordings were reference to the contralateral earlobe waves I and III decreased in amplitude, wave II become more prominent, wave IV and V were actually clearly separated and wave V latency increased.

The use of filters to eliminate unwanted low and high frequency information is a common method of noise depression prior to computer averaging. So, some investigators prefer broad filter cut-off points (eg. 30Hz to 3000Hz) in order to avoid the elimination of potentially useful response characteristics. There is a growing trend however, towards the adoption of 100Hz - 3000Hz bandpass as a standard for clinical applications.

The measurement of latency requires both stimulus and response reference points and the choice of reference points varies from one investigation to another. Latency measurements referred to stimulus onset have slightly longer value than when reference is computed time of arrival of stimulus at the ear.

For computation of latency different people choose different points of reference. When absolute latency of a given ABR wave component does not overlap on repeated runs, some investigators average the values of the two peaks. When the peak is broad or flattened, lines extended from rising and falling slope of the wave and these intersections is considered to give peak latency. Such differences in reference points across studies can assist understanding varying reports of normal absolute latency.

A difference in stimulus transducer can also account for varied reports of normal ABR parameters. Different earphones can have different resonance characteristics, thereby producing different spectral content which influences the latency of the response obtained.

III. Effect of Subject Parameters:

I. The Evoked Response During sleep:

Green (1956) has stated that the K—complex, which can be evoked by stimuli of different modalities, consisted of a sharp positive component. (The only component present in both the waking and sleeping states, a slow negative component, and a burst of 12-14 cycles per second activity). In sleep, the latency and duration of the first component increases. The K-complex, is concerned with transient stimuli and is probably correlated with a crude process of perception.

Studies also indicated that the response detectability in sleep is related to the subjects stage of sleep (Derbyshire et al. 1956).

It was also found that responses to bursts of random noise were detected more easily at near threshold levels and that responses showed more sensitivity to changes in stimulus intensity during the 2nd and 3rd stage of sleep. Recordings made after 64 hours of sleep deprivation showed that thresholds were unchanged, but sensitivity to increases in stimulation intensity was reduced during the 2nd and 3rd stage of sleep (Williams et al. 1966).

Investigation of the mean peak latencies for the N_2 snd P_3 components revealed that they increased throughout the stages of sleep when compared with the latencies obtained during the REM stage of sleep. Latency for the N_2 component increased during the 3rd and 4th stage of sleep compared to the latencies of stage 2. No significant changes in latency were noted for N_2 between the awake and REM stage or between stages 3 and 4. Thus it was concluded that these average evoked responses represented summed 'K' complexes which are detectable in all stages of sleep.

Ornitz et al (1967) examined the amplitude of the N_2 component which during stage 2 of sleep had a mean peak latency of 325 m.sec. for adult subjects and 295 m.sec. for children. The amplitude was larger during the first 10 minutes of sleep onset than it was prior to sleep onset or remaining sleeping.

Barnet and Goodwin (1965) found in neonates that during deeper sleep, there was increased latency and amplitude to be found. Akijama et al (1966) on the other hand found no such differences.

II. Effect of Drugs during ERA:

(Cody, Klass and Buckford (1967) reported using to 20 grains of chloral hydrate with adult subjects and did not observe any effect of this drug on the evoked auditory potential.

In a study with children, 3 mg. of pentobarbital sodium per kilogram of body weight was administered and it was concluded that the sleep induced by this drug was similar to natural sleep (Suzuki and Taguchi, 1968).

On using Nembutal, the time of sleep onset varied from 15-80 m.secs. and the duration of this action varied between 30 minutes and more than 3 hours. It also depressed the evoked response obtained from children, but may have accentuated the P_{180} and N_{220} components in the adult response. Brian and Gestring (1971) found tnat chloropromazine, triflorpromazine, moprobamli-valium and chloroprothixen did not affect ERA.

III. The Effect of Anaesthesia on ERA:

The effect of halathane and sodium thiopental on the brain stem response was assessed. No effect on the brain stem responses was observed to various levels of anaesthesia, successful hearing tests were carried out on all the children and results were helpful in their management.

IV. The Effect of Sex on Evoked Potentials:

Investigators demonstrated that the absolute latency of wave I was essentially the same for male and female subjects, but wave III and wave V latency was significantly earlier in females, i.e. III-V and I-V interwave latencies were longer in male subjects.

Both normal and hearing impaired subjects female subjects, showed consistently shorter latency and longer amplitude at all age levels. Wave-V latency was about 0.2 mg. shorter and wave-V amplitude was about 25% larger in female subjects.

V. The Effect of Age on Evoked Potentials:

A study reported that wave V latency decreased by 0.3-0.5m.sec. with each week of gestational age (schulmann, Galambos and Galambos (1970).

A decrease in absolute latency with increased age has also been observed through the second year of life (Hecox and Galambos 1974; Salamy and McKean, 1976y Salamy et al, 1975). Wave V latency approaches adult values much later in the infants life than the values for wave I.

McKean (1976) reported a depression in the latency of waves I through VI in infants ranging in age from 20 hours to 12 months.

The change in mean latency with age, however was greater for wave V (1.12 m.sec) than for wave I (0.41 m.sec). Also only a slight decrease in wave I latency was observed after 6 to 8 weeks of age, but wave V latency continued to decrease through 12 months of age.

Another study found that the I-V interwave latency decreased with maturation, in premature and full term newboms from 7.2 m.sec at 25 weeks gestational age to 5.2 m.sec at 40 weeks gestational age (Starr et al 1979).

The decrease in wave latency in the first 2 years of the human infant is life suggests tnat both peripheral and central auditory structures are maturing. The differential effect on early versus later waves implies that peripheral maturation precedes central maturation.

Age related changes are observed in morphology and amplitude of ABR waves (Leiberman and Salamy et al. 1973).

It was also observed that waves II and III began to appear as separate waves in 6 week old infants, and the pronounced negative wave was still seen in 62% of these babies. Waves I, II and III were clearly resolved in 3 month old intents and the general waveform closely resembled that of the adult. Stability of these responses increased with age.

Starr et al (1977) also reported that wave V amplitude increased with maturation. On comparing responses of old and young adults about 0.2 m.sec. increase with I-III interwave latency was found with increase in age (Rowe, 1978).

Both infant and geriatric subjects display abnormal BSER adaptation, wave V latencies increase more rapidly for a given increment in repetition rate, than is normal.

Thus, the above are the various studies and their findings on the factors affecting brain—stem evoked potentials.

METHODOLOGY

METHODLOGY

Subjects:

10 subjects (8 females and 2 males) in the age range of 17 years to 24 years were selected for the purpose of this study. The subjects had to satisfy the following criteria:-

1. They should have audiometrically and otologically normal ears, i.e.:

a. Hearing sensitivity within 20dBHL (ANSI, 1969) in the frequencies 500Hz, 1KHz, 2KHz, 4KHz.

b. Have no history of any ear ache? eardischarge, headache, giddiness, tinnitus, braindamage or been exposed to loud sounds.

2. Negative history of any neurological complaints and epilepsy.

3. No family history of hearing loss.

Equipment:

In order to measure the auditory brain-stem evoked responses, an electric response audiometer TA-1000 was used.

It is a clinical diagnostic system incorporating the essential precision versatality and reliability in a simple, compact and convenient instrument.

The instrument consists of a stimulating system (a stimulus generator which feeds the stimuli to a transducer earphone or a bone conductor) and a recordings system. The latter consists of electrodes, amplifiers, fitters, averager and display together with some device for obtaining a permanent record.

Brief Description of the Equipment:

TA-1000 system (from the Teledyne Avionics) consists of the SLZ 9793 desk-top console; the SLZ 9794 preamplifier and an accessory group.

The SLZ 9793 console contains all of the operating controls, indicates and read acts for the system. It provides the patient auditory stimulus, and accepts patients electrical response from the preamplifier, signal conditioning and digital averaging extract the patient's brain stem evoked response or EcochG responses from the background noise. Oscillographic display and ink-on-paper recording provide an on-going monitor as well as a permanent record of responses.

The SLZ 9794 preamplifier is a totally isolated EEG pre-amplifier, with frequency response and gain specifically designed for ERA. Patient response is sensed by a set of 3 electrodes and after amplification, is conducted to the console by an inter-connecting cable.

There is also a set of standard siloer chloride electrodes, TDH-39 earphones and circumaural cushions MX-41/AR. Calibrated paper to record the responses are also available, along with electrolyte gel, adhesive tape and spirit to conduct the experiment.

Functions of the control:

The TA-1000 is operated with 4 knobs and 9 push button switches. All knobs are clearly marked to indicate their function.

The Push Button switches:

Push button switches are of two types; alternate acting, i.e. push ON, Push-OFF and momentary acting, i.e. push to initiate. All push buttons indicate, by means of internal lamps, the active state of the selected function. Unwanted or illogical functions are internally inhibited.

The various push buttons are;

1. The alternate acting POWER switch energizes the system and indicates the system status.
2. The alternate acting SCOPE switch controls the Oscilloscope display.
3. The all acting AIR-LEFT and AIR-RIGHT push button apply the stimulus to the desired earphone.
4. The alternate acting MASK push button applies broad-band noise masking to the contralateral ear only when either AIR-LEFT or AIR-RIGHT stimulus is active.

5. The alternate acting B0NE push buttons applies stimulus only 2KHz and 4KHz stimulus to bone vibrator transducer.
6. The momentary acting CLEAR push button clears the micro-processor averager memory, resets the sample display counter and corrects the microprocessor operating mode to correspond to the current control status.
7. The momentary acting START/STOP push button initiates the micro-processor averages function. Averages function is automatically terminated when the selected number of samples has accumulated, or when any average memory channel is fully automatic termination requires a CLEAR to permit restart.
8. The momentary acting RECORD push button initiates the plotter readout, if the averages is not active.

The various knobs are:

1. The STIMULUS function switch permits selection of 2KHz, 4KHz or 6 KHz logon equivalent frequencies at 5 or 20 stimuli per second and patient's response intervals of 10ms or 20ms immediately following stimulus.
2. The SCALE function switch permits selection of system sensitivity and number of averaged response samples. For 2048 samples 0.2 uv , O.5uv , 1 uv and 2 uv per division sensitivities are available. Readout of the accumulated number of samples is displayed in digital form, directly below this control.

3. The STIMULUS ATTENUATOR establishes the presentation level of the stimulus, in dBHL (from 0dBHL to 100dBHL).
4. The LATENCY control knob provides a cursor mark on the oscilloscope display of the BSER wave for a precise determination of latency. Readout of latency in m.sec to 0.1 m.sec is displayed in digital from directly above this control.

Test Environment:

The study was carried out in a room away from noise sources and electrical appliances as fans etc, were put off. The room was away from excessive vibrations.

For good results the subject was made to recline relaxed, comfortable and isolated from disturbing influences. The room was kept dimly lighted.

Sedation is used only in cases of young or active children.

Test Procedure:

Subject was asked to lie down on a bed with a pillow under his head and neck to relax the neck muscles. The subject was asked to make himself comfortable and relax.

Surface electrodes were then placed. Before placement of the electrodes the skin and the electrodes was cleaned with spirit. Electrode gel was smeared on the electrode in sufficient quantities. Each electrode was then fixed to the skin with the help of adhesive tape.

The subjects were required to feel relaxed and comfortable with electrodes within 10-15 m.sec after their placement.

The placement of the electrodes were done as follows:

1. White or reference electrode on mastoid of the ear i.e, right ear.
2. Black or ground electrode on mastoid of the non-test ear, i.e. test ear.
3. Red or signal electrode on high forehead.

After the red light on the preamplifier, beside the sample counter disappeared, the earphones for AC logon stimuli were placed.

The power switch was put on. The TWF/RUN/EBG switch was put on "RUN" position. The scale switch was set to 2048 samples and 2uv/division.

The 10 subjects were tested at the frequencies 2 KHz and 4KHz at the intensities of 80 and 60dBHL. The subject's response intervals of 10 m.sec and 20 m.sec was noted at each of the above given frequencies and intensities.

Latencies of all the seven peaks were noted down when they were present. If any peaks were observed as being absent that toe was noted down.

Subjects were tested in a single session lasting for about one hour. They were tested only with presentation of the stimuli in the right ear.

The test data was rejected wheat

1. The limit light flickered often during the testing, and
2. The computer stopped before reaching 2048 samples.

RESULTS AND DISCUSSION

RESULTS AMD DISCUSSION

The study had aimed at studying the effect of 10 ms. and 20 ms. settings on the response pattern as well as inter-peak latencies at 2 KHz at 60dB and 8OdBHL.

Treatment of Data:

The following were determined:

a) The Differences in latencies between peaks at 20 ms and 10 ms settings, separately for each of the frequencies (i.e. 2KHz and 4KHz) at each of the two levels (i.e. 80dBHL and 60dBHL).

b) Means and Standard Deviation of differences in latencies between peaks, separately for each of the two frequencies (i.e. 2KHz and 4KHz), and at each of the two levels (i.e. 80dBHL and 60dBHL).

From the above data obtained results were inferred and discussed.

In Table-I the differences in latencies between peaks at 10 ms and 20 ms settings at 2KHz and 4 KHz at the levels of 60dBHL and 80dBHL have been tabulated separately.

Table-11 presents the Mean and Standard Deviation values obtained from the use of data from Table-1 at difference frequencies and intensities.

Table-1: The Differences in latencies between peaks at 20ms. and 10ms.

S. No.	Intensities	2KHz				4KHz				
		$I_{20}-I_{10}$	$II_{20}-II_{10}$	$III_{20}-III_{10}$	$V_{20}-V_{10}$	$I_{20}-I_{10}$	$II_{20}-II_{10}$	$III_{20}-III_{10}$	$IV_{20}-IV_{10}$	$V_{20}-V_{10}$
1.	80	-0.1	0.3	0	-0.2	0	0.2	0	0.2	0
	60	1.0	1.0	1.3	0.9	0.6	0.7	0.9	1.1	0
2.	80	0	0.2	0.3	0.2	0	90.3	0	0	-0.5
	60	0.3	0.7	0.7	0.1	0.9	1.2	0.1	0.3	0
3.	80	0.1	0	0.1	-0.2	0	0	0	0	0.1
	60	-0.1	-0.9	0.2	0.1	-0.1	0.1	0.1	0.3	0.5
4.	80	-0.1	0	0	0.1	0	0.3	-0.1	0	0.1
	60	-0.3	0.2	0.1	0	0.1	0	0.1	0.2	0
5.	80	-0.1	0.1	0	0.7	0	0	0	0.1	0
	60	0.3	0.2	0.1	0	0.2	0	0	0	0.2
6.	80	0.1	0	0.1	0.1	0	-0.4	-0.1	0.3	0.2
	60	0.1	0.1	-0.4	0.1	0.1	-0.4	0.3	-0.1	-0.1
7.	80	0	0.1	0.1	0	0.1	0.1	0.1	0.1	0
	60	0.4	0	0.5	0.3	0.1	-0.1	0.1	0.5	-0.1
8.	80	0	0.6	0	-0.2	0.2	0.1	0.1	-0.4	0.1
	60	0	0.1	-0.2	0.3	0.5	0.8	0.1	-0.2	0.2
9.	80	-0.5	-0.1	0.1	0	0.1	0.2	0	-0.3	0
	60	0	0.1	0.1	0	-0.1	-0.1	-0.1	-0.2	0
10.	80	-0.1	0	0.2	-0.2	0	-0.2	-0.5	0	-0.2
	60	0.3	0.6	0	0.1	0.4	0.9	0.2	0.5	0.3

Table-IX Mean and Standard Deviation of differences in latencies between peaks.

At 2 KHz			At 4 KHz		
At 80dBHL	Mean	Standard Deviation	At 80dBHL	Mean	Standard Deviation
For $I_{20}-I_{10}$	-0.07	0.1615	For $I_{20}-I_{10}$	0.04	0.0663
For $II_{20}-II_{10}$	0.1a	0.2357	For $II_{20}-II_{10}$	0	0.2190
For $III_{20}-III_{10}$	0.09	0.0943	For $III_{20}-III_{10}$	-0.05	0.1627
For $V_{20}-V_{10}$	0.03	0.1734	For $IV_{20}-IV_{10}$	0	0.2000
At 60dBHL			For $V_{20}-V_{10}$	-0.02	0.1886
For $I_{20}-I_{10}$	0.2	0.3376	At 60dBHL		
for$I_{20}-II_{20}$	0.17	0.3066	For $I_{20}-I_{10}$	0.27	0.3067
For $III_{20}-III_{10}$	0.24	0.4608	For $II_{20}-II_{10}$	0.31	0.5107
For $V_{20}-V_{10}$	0.19	0.1322	For $III_{20}-III_{10}$	0.18	0.2600
			For $IV_{20}-IV_{10}$	0.18	0.4188
			For $V_{20}-V_{10}$	0.1	0.1843

DISCUSSION:

It is seen that there is no significant difference between the Mean obtained for the 2 settings at different frequencies as well as intensities (Table-III).

Testing at 20 ms. setting, peaks IV, VI and VII are found to be missing on measuring at 2KHz, at 60dBHL as well as 80dBHL This is not so in case at 4KHz measurements.

The reason for the disappearance of the IV, VI and VII peaks could be due to the inability of these areas to perceive at patient's response interval of 20ms. Wave V dominances appear to be resistant to these effects. At the response intervals of 10 ms. these peaks is easily perceivable.

Thus, the present study has established that both 10ms and 20 ms settings can be utilized while testing adults (as has been done in this study), except that at 2 KHz 3 peaks IV, VI, and VII are found to be missing.

To put it clearly at 4KHz, at 60 dBHL as well as 60dBHL, no significant differences would be found while measuring at the two settings of 10ms and 20ms. Whereas differences will be seen in terms of the missing peaks (IV, VI, VII) at 2KHz measurements.

Table-III: Significance of Differences ia latencies between peaks:

Intensity	2KHz	4KHz
80dBHL	No significant difference.	No significant Difference.
60dBHL	No significant difference	No significant difference.

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

SUMMARY:

The study aimed at establishing of any significant differences were observed at the settings 10ms and 20ms on the readings and response obtained.

Ten subjects with normal hearing in the age range of 17 years to 24 years were selected for the purpose of the study. They were tested at the 2 settings at 2 KHz and 4KHz at the levels of 60dBHL and 80dBHL.

It was seen that at 4KHz no significant differences were observed in the latencies at the 2 settings. But at 2 KHz, though there were no significant differences in latencies at the two settings, peaks IV, VI and VII were observed to be missing.

Implications of the study:

As can be inferred from the results, the study implies that using the settings of 20ms and 10ms response intervals, no significant differences would be found in the latencies. Only at 2KHz, 3 peaks (IV, VI and VII) were found to be missing at subjects response intervals of 20ms.

Thus, the 2 settings can be used to obtained BSERA readings at 4KHz without hesitation.

Limitations:

The study was done using only two frequencies 2KHz and 4KHz, as well as only two levels 80dBHL and 60dBHL. The study could be conducted at a wider range of frequencies and intensities to Check and see if any significant differences would result.

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