A COMPARISION OF AUDITORY BRAEVSTEM RESPONSES THROUGH SUPRAAURAL EARPHONE AND INSERT EARPHONE CONDUCTED CLICKS

Register No. M. 9920

ndependent Project Submitted as Part fulfilment for the First Year M.Sc, (Speech and Hearing), to the University of Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE-570 006

MAY-2000

DEDICATED TO

MY TEACHERS

AND

AIISH

CERTIFICATE

This is to certify that the independent project entitled: **"A COMPARISION OF AUDITORY BRAINSTEM RESPONSES THROUGH SUPRAAURAL EARPHONE AND INSERT EARPHONE CONDUCTED CLICKS",** is a bonafide work done in part fulfilment for the first year degree of Master of Science (Speech and Hearing), of student with Register. No. M . 9920

Place: Mysore
May 2000

Director
AIISH
Mysore - 570 006

CERTIFICATE

This is to certify that the independent project entitled **"A COMPARISION OF AUDITORY BRAINSTEM RESPONSES THROUGH SUPRAAURAL EARPHONE AND INSERT EARPHONES CONDUCTED CLICKS"** has been prepared under my supervision and guidence.

Place:
May 2000

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DECLARATION

I hereby declare that this independent project entitled **"A COMPARISION OF AUDITORY BRAINSTEM RESPONSES. THROUGH SUPRAAURAL EARPHONE AND INSERT EARPHONE CONDUCTED CLICKS"** is a result of my own study under the guidence of **Mrs.C.S. Vanaja,** Lecturer in Audiology, AIISH, Mysore, and has not been submitted earlir at any other University for any other Diploma or Degree.

May 2000

Place: Mysore Register. No. M.9920

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CONTENTS

INTRODUCTION

Auditory Brainstem Response (ABR) is used widely in the field of Audiology. It is used to estimate the hearing thresholds of infants, young children, and other difficult-to-test subjects (Jerger and Hayes; 1976; Pratt & Sohmer, 1978; Davis & Hirsh, 1979). Other applications of ABR include detection, localization and monitoring of auditory neurological deficits.

A normal ABR waveform is characterized by five to seven peaks that occur within 10 milliseconds (Davis, 1976). Jewett & Williston (1971) gave Roman numericals to label the peaks of ABR. Several factors that are related to subject, stimulus and instrumentation affect the latency, amplitude and morphology of a normal ABR. Transducers used to present stimuli is one such factor.

Transducers used while recording ABR can be supra-aural or circumaural earphones, insert earphones, or bone vibrators. Initially conventional supra-aural/ circumaural audiometric earphones were used routinely for recording ABR. For neonates and infants, testing was usually accomplished by removing the earphone cushion and either supporting the TDH-39 earphone with a crib or bassinet (Jacobson & Hall,1994). This technique introduces a number of problems including potential ear canal collapse, unpredictable oscillation in frequency spectrum (low frequency leakage), intensity variation of the click signal and no effective ambient noise attenuation (Killion, 1984). These variables lead to both measurement and interpretation errors and likely to contribute to a high false positive rate in newborn hearing screening studies (Gorga, Reiland and Beachaine, 1988; Hall et al., 1988; Horton, Bubbin, Reiland et al., 1985; Schwartz et al, 1989). Gorga et al., (1988) have estimated that as many as half of all newborns hearing screening failures may be attributed to ear canal collapse secondary to conventional earphone placement.

To compensate for these technical problems, insert earphones (tube phones) have been used successfully in clinical evaluation. With commercial introduction of the Etymotic insert foam plugs and other methods of insert probe tip modification, the problem of head phones appear alleviated.

Hall (1992) reported seven clinical advantages of the Etymotic ER-3A insert earphones over conventional audiometer earphones. These includes elimination of stimulus artifact because of short delay induced by tube of insert earphone, limited acoustic ringing, reduced cross over and comparatively higher internal attenuation values. Other than these there is increased comformess when using inserts. It has been estimated that (through spectral observations) the frequency response of tubophones are little better than that of headphones because of negligible oscillation in frequency spectrum and reduced low-frequency leakage (Hall et al., 1988). This in turn can have an effect on the auditory brainstem responses. Also the length of tube used in insert earphones will have an effect on latency of ABR waveforms.

Need for the study:

A review of literature indicates that when the duration of signal transmission due to tube length is compensated (i.e., about 0.9m sec), an insert and circumaural earphone produces similar ABR latency measures (Beauchaine, Kaminshi and Gorga., 1987). Beauchaine et al., (1987) opined that the responses of Beyer DT-48 (circrim aural) earphones has a different response from TDH-39 (supra aural) earphones. Given these differences, it is necessary to empirically determine how ABR data obtained with an insert earphone compared with data obtained with other supraaural earphones.

Commercially available instruments have inbuilt correction factor for latency of ABR, recorded using insert earphones. There is a need to check if there is any inter subject variability for the correction factor. As there is slight difference in the low frequency spectrum of insert ear phone and there is a need to compare the relationship between the behavioral threshold for ABR for stimuli presented through supra-aural earphones and insert earphone.

Aim of the study:

The aim of the present study were:

1. To compare the latency, amplitude and wave morphology of ABR for stimuli presented through supra-aural ear phones and insert earphones.

2. Comparison of relationship between behavioural threshold and ABR threshold for stimuli presented through insert earphones and supra-aural earphones.

REVIEW OF LITERATURE

The measurement of the scalp recorded Auditory Brainstem responses(ABR) to air conducted stimuli has become an integral part of audiological practice to assist in otoneurological diagnosis. Estimates of hearing sensitivity from the ABR are typically derived from latency-intensity function for the Jewett Peak-V as recorded to a click or tone pip transduced by a matched pair of electrodynamic earphones (Hall, 1992).

A review of literature shows that the electrical stimuli presented from the oscillator are not delivered in exact acoustical form, rather the frequency response of the transducer modifies the acoustic signal (Gorga & Thorton, 1989). Hall (1988) reported that the frequency response of insert earphones are little better than that of supraaural or circumaural earphones because of negligible oscillation in frequency spectrum and reduce low frequency leakage. Similarly, Schwartz, Larson & De Chicchis (1985) determined difference in acoustic spectra of button type insert receiver, TDH-49 and bone vibrator B-70A, B-71 & B-72. They reported slightly wide dynamic range for insert earphones when compared with supraaural earphones. This difference in frequency response of the transducer is expected to have an effect on the recording of ABR.

Also a tube of length 280mm, is used in a insert earphone for conduction of sound from the transducer to the ear canal.(Hall et al., 1988; Gorga et al., 1987). This will lead to a delay in latency of ABR waves (Gorga et al, 1987). Therefore studies have been carried out to compare the

ABR recorded for stimuli presented through, Supraaural earphones and insert earphones.

Comparison of stimuli presented through circumaural Beyer-DT-48 and Etymotic insert earphones was carried out by Gorga et al., in 1987. They reported that the ABR thresholds were slightly higher for insert earphones and reasons for these differences were not obvious. Also there was a shift in latency of all components by an amount equivalent to the delay introduced by the insert earphones sound delivery tube. There was no difference between the interwave latency difference at higher levels.

Kaminski, Gorga and Beauchaine (1987), also reported equal performance by both inserts and circumaural earphones in testing babies, but elimination of ear-canal collapse with insert was an additional advantage. There was no difference between two transducers in terms of absolute latencies of 1st and Vth peak and interwave latency difference. They also reported a reduced electrical stimulus artifact when using insert earphones.

Cornacchia and Prette (1997) tested a group of normal preterm neonates with the aim of evaluating the cochlear, auditory nerve and brain stem waves as a function of stimulus intensity especially to find-out lowest intensity at which all 1st, IIIrd and Vth wave were present. They suggested that when evaluating the retrocochlear pathway, ABR should be recorded using an insert to deliver clicks at 90dBHL. As it creates an acoustic time delay between the beginning of the stimulus and the appearance of potentials, it impedes electro-magnetic artifacts of the transducer during receptor potential. The better morphological distinctiveness of each potential makes it easier to measure their latency parameters and amplitude.

Beattie (1998) compared normative wave-V latency-intensity function for eartone-3A insert earphone, and radio ear B-60. It was suggested that for comparing the values with any two transducers, only a single number may not fulfill the criteria, so each clinic has to establish its own values.

Various studies have reported that in behavioral audiometry, ER-3A earphones provide greater interaural attenuation (IA) than conventional earphones particularly for low-frequencies (Horford-Dunn, Kuklinski, Raggio & Haggerty, 1986; Sklare & Deneberg, 1987). Beachaine et al., (1987) recommended the use of the ER-3A whenever masking concerns are encountered during ABR testing. However Van campen, Sammeth and Peek. (1989) evaluated the IA property of ER-3A insert earphones and they concluded that Etymotic ER-3A insert earphones does not eliminate the need for contralateral masking of click stimuli in ABR measurement.

It has been reported consistently in literature that the ABR threshold correlates best with the behavioral thresholds between 2-4 kHz (Bauch & Olsen., 1988; Coats & Martin., 1973; Jerger & Maulin., 1978; Gorga & Thornton., 1989; Moller & Blegrad., 1976). Jerger & Mauldin (1978) derived ABR from 275 ears with varying degrees and configurations of sensorineural hearing loss, and their results demonstrated best prediction of behavior thresholds in 1000 to 4000Hz region through ABR results. They further reported that audiometric shape rather than absolute high frequency sensitivity has an effect on ABR latency. Gorga et al., (1985) compared the threshold predicted through auditory brainstem responses and pure tone behavioral audiograms in patients with cochlear hearing loss. The results indicated that the click evoked ABR thresholds correlated at 2000Hz and 4000Hz region.

Stappells (1989) reported that when 2000 to 4000 Hz frequency region is not the region of best hearing sensitivity, the ABR threshold may be consistent with hearing threshold in the other frequencies. He further stated that most of the time the ABR threshold for the click corresponds to the average of the hearing thresholds between 1000 and 4000 Hz or to the best hearing thresholds in the range. Coats and Martin (1977) simultaneously recorded auditory nerve action potentials and brainstem auditory evoked responses and correlated these results with audiogram shape. They reported best agreement between 2000 - 4000 Hz behavioral thresholds and auditory brainstem responses. A majority of these studies are carried out using supraaural / circumaural earphones.

It is possible that the slight difference in low frequency spectrum of inserts and headphones will lead to a difference in correlation between behavioral threshold and ABR threshold of two transducers. Hence the present study was carried out to explore these differences.

METHODOLOGY

This study was taken up with an aim of comparing ABR for stimuli presented through insert earphone and supraaural earphone.

Subjects:

Subjects were divided into two groups, group I and group II.

Group I:

Group I consisted of 30 normal hearing subjects, 15 males and 15 females. The age of the subjects ranged from 17-25 years (Mean: males - 20.8 years females - 20.6 years). Only one ear of the subject was tested. Subjects who met the following criteria were included for the study.

- Pure-tone thresholds less than 20dBHL at octave frequencies from 250 Hz-8000 Hz
- Normal middle ear functions
- No history of otological, neurological complaints.

Group II:

Group II included 20 ears with hearing loss, 10 with sloping hearing loss and 10 with flat hearing loss. Age of subjects ranged from 18 years to 78 years (Mean- 38.4 years). Following were the subject selection criteria.

- Sloping sensori-neural hearing loss (slope: -10 to -15 dB/octave), or Flat sensori-neural hearing loss (thresholds within 10 dB across frequencies 250 Hz - 8000Hz).
- Degree of hearing loss: Minimal to severe.
- Normal middle ear functions.

Equipment:

The following equipment were used in the study

a. Pure-tone Audiometer: A calibrated two channel clinical audiometer (GSI-61/OB 822) was used to assess **the** behavioral thresholds of all the subjects.

b. Immittance meter: A calibrated immittance meter (GSI-33 middle ear analyser version-I) was used to assess the middle ear function of the subjects.

c. ABR measuring system: Biologic traveler express with software EP-317 was used for recording ABR. A TDH-39P headset and ER-3A insert earphones were used to present stimulus for ABR.(Calibration of intensity of click for ABR testing-Appendix I)

Test Environment:

The tests were carried out in a quite room, the test room had adequate lighting and comfortable chair to sit during the test.

Test Procedure:

The tests were carried out in following steps.

1. Pure-tone Audiometry:

Air conduction and bone conduction thresholds were estimated using modified Hughson-Westlake method (Carhart and Jerger, 1959). Air conduction thresholds were established from 250 Hz to 8000Hz at octave intervals, and bone-conduction thresholds were established from 250 Hz to 4000 Hz at octave intervals.

2. lmmittance evaluation:

Immittance evaluation included tympanometry and measurement of acoustic reflex threshold for subjects with sensori-neueal hearing loss, whenever indicated reflex decay test was carried out.

3. Recording the ABR:

(a) The subjects were instructed to "Sit comfortably and relax, and close your eyes" on a chair facing away from the instrument. They were told to avoid extraneous movements of head, neck, and jaw for the duration of the test. Instruction were given in the language familiar to the subject.

(b) Three silver chloride disc type electrodes were used. The placement of electrodes were as follows:

Position	Function
Fore-head	Non-inverting
Mastoid test Ear	Inverting
Mastoid Non test-Ear	Common

Before placing the electrodes the sites were cleaned using skin preparation paste and conducting gel was used to increase the conductivity. Impedance matching for electrode was done to ensure that the impedance at all the electrodes was less than 5kilo ohms. ABR was then recorded using the parameters showed in table-1.

General Set-up	Amp. Set-up	Parameters
Test :EP 317 Channel :1 Window :10m sec Pre/post :0 Points :256	Gain Hi. filt Low. filt Notch Artifact	1,00,000 3000Hz lOOHz Enabled
	Montage	Cz/A_1 or Cz/A_2

Table 1: showing the parameters used for ABR recording.

Stimulus set-up:

Stimulater : ER-3A insert earphones / TDH-39P supraaural earphones.

Maximum stimuli : 1500

Ear : Right/Left

Type : Rarefaction clicks

Rate : 11.1 /second

Masking : None

RESULTS AND DISCUSSION

The results of the analysis of the data collected from 30 normal ears and 20 ears with sensori-neural hearing loss are are discussed separately in this chapter.

A. Subjects with normal hearing: Comparison of ABR recorded for stimuli presented through insert earphones and supraaural ear phones.

1. Wave-Morphology:

Figure 1 shows the waves of a normal subject for stimuli presented through supraaural ear phones (A) and insert ear phones (B). Morphology of ABR for stimuli presented through insert was similar to that of supraural ear phones. However, for a majority of subjects artifacts in the first mili second was less when stimuli was presented through insert ear phone. Also only when stimuli were presented through insert ear phone at 80dBnHL, a positive peak/wave appeared at a latency of 0.1 to 0.5 milli seconds. As shown in Figure 2 reversing the polarity the signal reversed the waveform polarity. This suggested that it was cochlear microphonics (CM). These results support the recommendation of Berlin et al., (1999) that insert earphones such as Etymotic ER-3A should be used to visualize cochlear microphonics, as they provide an artifact free-zone in first few milli seconds.

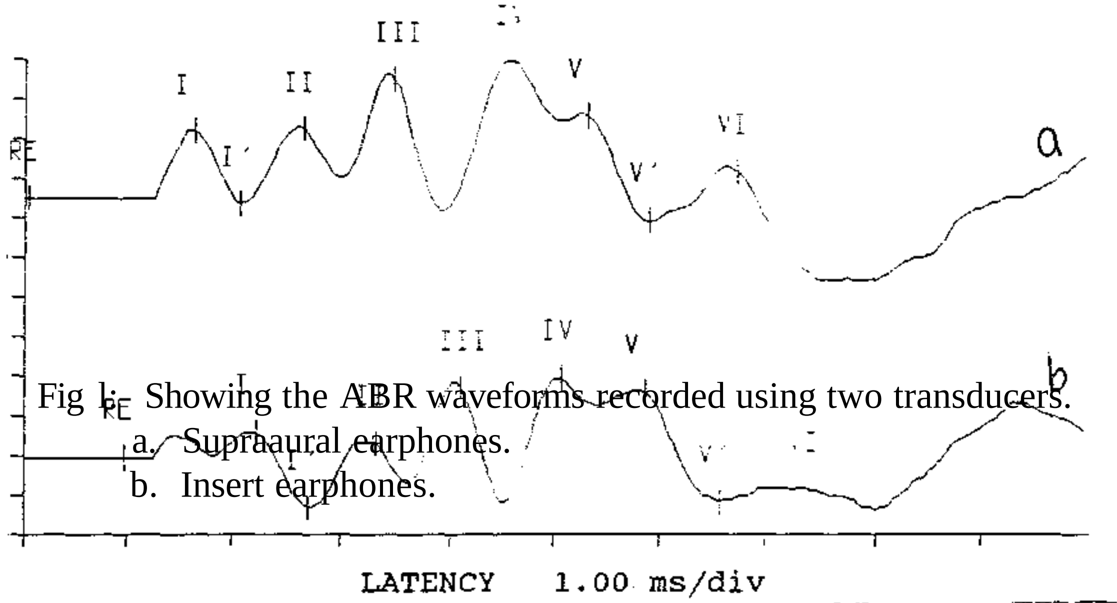

Fig 1: Showing the ABR waveforms recorded using two transducers.

a. Supraaural earphones.
b. Insert earphones.

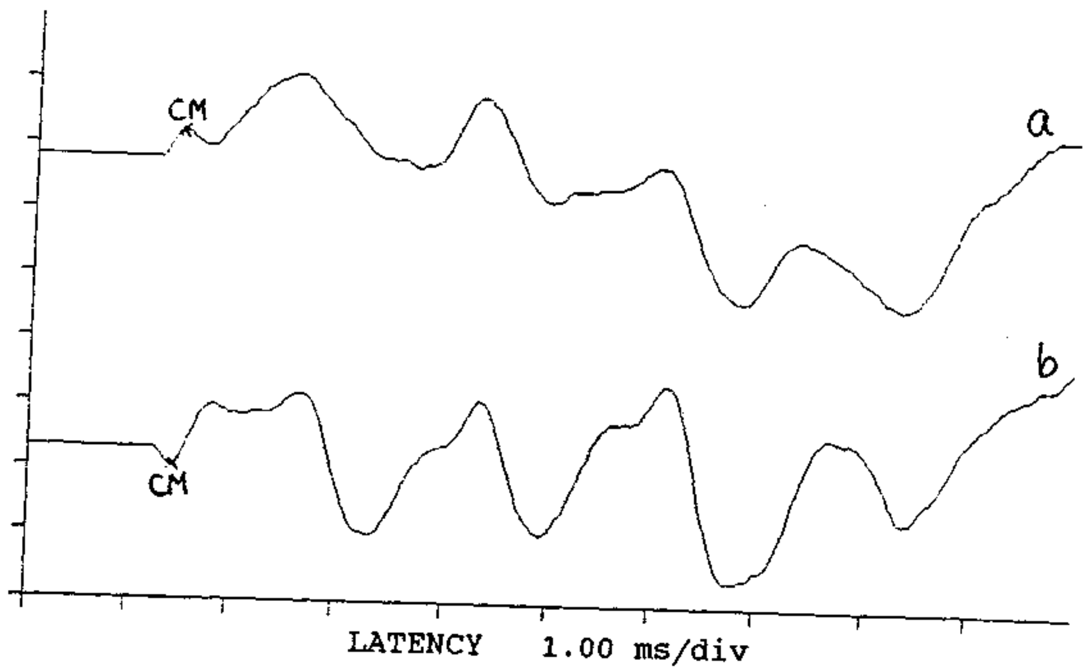

Fig 2: Showing the cochlear microphonics (CM) recorded for stimuli presented through insert earphones.

a. Rarefaction polarity
b. Condensation polarity

LEVEL IN dBnHL	1ST WAVE		IIIRD WAVE		VTH WAVE	
	SE	IE	SE	IE	SE	IE
80	2	0	0	0	0	0
60	19	16	4	5	0	0
40	9	7	24	23	1	1
30	-	7	2	2	3	2
20	-	-	-	-	22	21
10	-	-	-	-	4	6
0	-	-	-	-	-	-

Table 2: Showing the number of ears in whom the waves disappered at different intensities. (SE - Supraural earphones, IE - Insert earphone).

Inspecting the Table 2 it can be seen that not much difference between ABR for stimuli presented through insert earphone and supraaural earphone was observed in the number of ears showing the absence of various waves except for the first wave i.e., the first wave could be recorded at the lower intensities in seven ears when the transducer used for presenting the stimuli was insert earphone. This difference in wave morphology could be accounted to two reasons.

1. The problem of stimulus artifact extending the region of early AEP components such as EcochG, AP, or ABR-Wavel, is essentially eliminated by the time delay introduced by the tubing of the insert ear phones.

2. Reduced temporal wave form of click stimilus when using insert earphone (Hall et al., 1988 and Gorga et al., 1987).

II. LATENCY:

1. Absolute latency of different waves:

	1ST WAVE		IIIRD WAVE		\TH WAVE	
	SE	IE	SE	IE	SE	IE
M	1.62	2.39	3.16	4.49	5.38	6.27
S.D	0.12	0.19	**0.17-**	0.25	0.21	0.30
R	1.44 1.87	2.11 2.96	3.24 4.21	4.06 5.05	4.88 5.88	5.50 6.76
T **P**	24.91 >0.01		21.51 >0.01		15.26 >0.01	

Table 3: Showing the absolute latencies (in milli seconds) of waves at 80dBnHL (M-mean, SD- Standard deviation, R-range T-t values and P-Probabality level SE - Supraural earphones, IE - Insert earphone).

Inspection of Table 3 reveals that the absolute latency of all the waves were prolonged when insert ear phones was used. The paired t-tests for large samples showed that the difference in the latency of waves recorded for stimuli presented through insert ear phones and supraural ear phones was significant at 0.01 level for all the waves. As already established by Hall et al., (1988) and Gorga et al., (1987) this prolongation could be attributed to the delay caused by sound tube of insert ear phones.

	1st wave	IIIrd wave	V wave
M	0.77	0.88	0.89
S.D	0.27	0.35	0.32
R	0.43-1.34	0.48-1.45	0.42-1.39

Table 4: Showing the average difference in latencies (milli seconds) of ABR waves for stimuli presented through two transducers. (M-mean, SD- Standard deviation, R-range).

Examination of Table 4 indicates that the difference in latency of ABR waves for stimuli presented through the two transducers was not a single number rather a range.

Gorga et al., (1987) reported that the mean difference was 0.81, 0.78 and 0.99 milli seconds for I, in and V wave respectively. The standard deviation was 0.23, 0.17 and 0.22 for I, III, and V wave respectively. The mean value of in the present study is comparable with that of Gorga et al., (1987). However the standard deviation observed in the present study was greater, especially for wave III and V. The reasons for this discripency is not clear. The commercially available evoked potential systems have an inbuilt correction factor for ABR latency for stimuli presented through insert earphones. So one has to be cautious while interpreting the results from thse instruments

2. Wave V latency - intensity function:

Figure 3 and Figure 4 (refer next page) show the ABR waves recorded at different intensity levels, when stimuli was presented through supraaural earphones and insert ear phones respectively. The latency - intensity functions for wave V for two transducers is shown in figure 5.

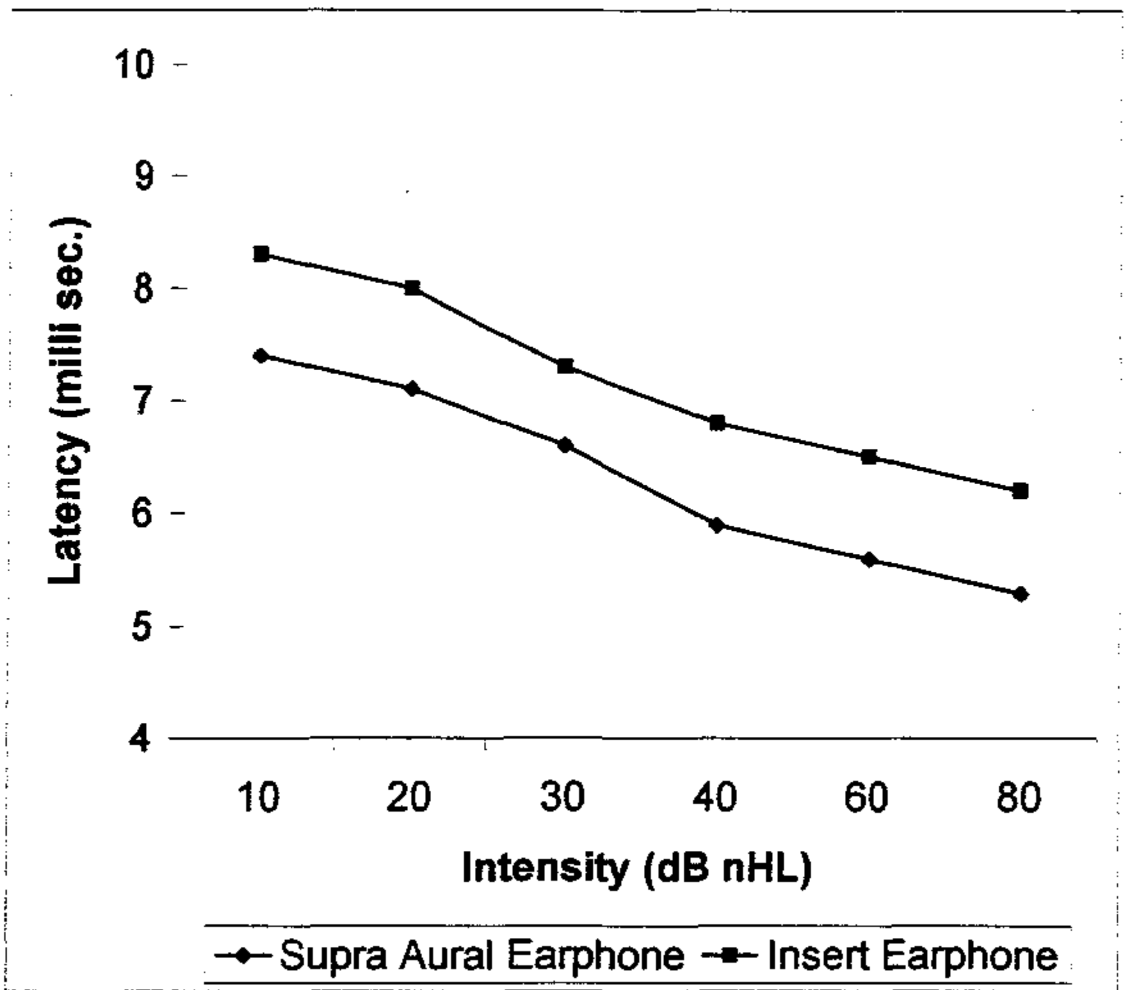

Fig 5: Showing the latency-intensity function for two transducers (latency - milli seconds and intensity-dBnHL).

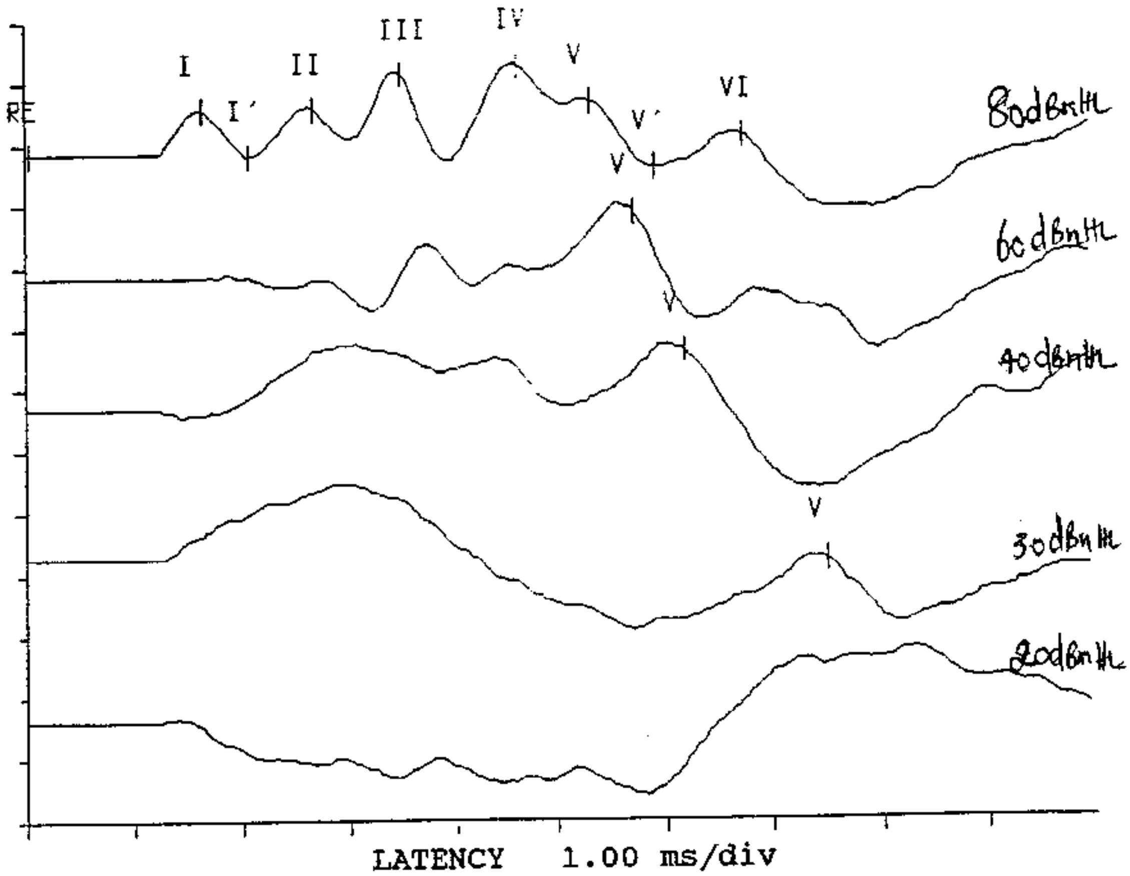

Fig 3: Showing the ABR waveforms recorded using supraaural earphones, at various intensities.

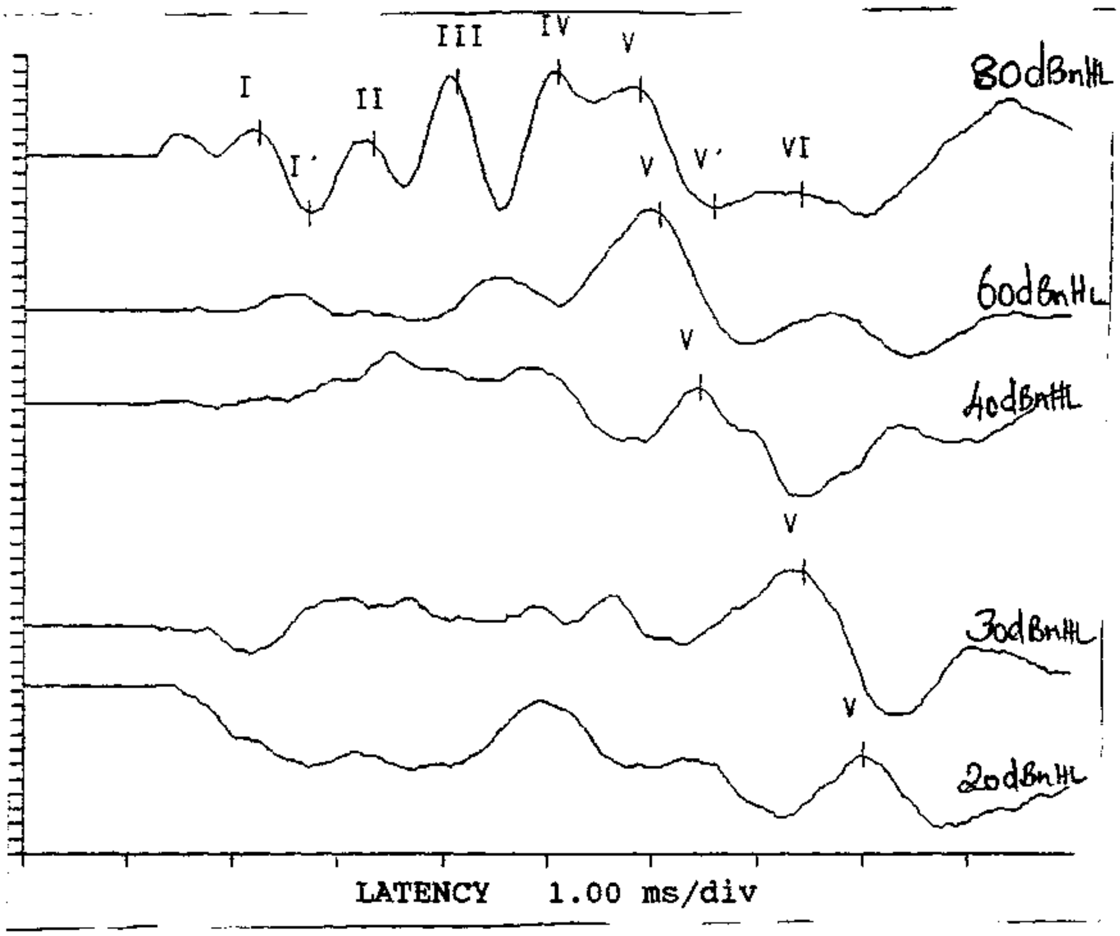

Fig 4: Showing the ABR waveforms recorded using insert earphones, at various intensities.

It can be observed from the Figure 5 that the latency intensity function for stimuli presented through supraaural ear phones and insert ear phones did not show any difference in the pattern. These results are inconcurrence with the findings by Gorga et al. (1987).

3. Inter wave latency difference:

INTERWAVE LATENCY DIFFERENCE	1ST WAVE		IIIRD WAVE		VTH WAVE	
	SE	IE	SE	IE	SE	IE
M	2.00	1.97	1.72	1.71	3.74	3.73
S.D	0.17	0.25	0.24	0.20	0.27	0.26
R	1.72 2.45	1.40 2.55	1.64 2.08	1.44 2.40	3.28 4.25	3.28 4.20
T P	0.28 >0 78		0.99 >0.32		0.76 >0.73	

Table 5: Showing the inter wave latency difference between various waves. (M-mean, SD- Standard deviation, R-range, T-t values and P-Probabality level SE - Supraaural earphones, IE - Insert earphone).

As expected there was no significant difference in terms of inter wave latency difference (Table 5). Similar results were earlier reported by Gorga et al., (1987) and Kiminski et al., (1987).

III. Amplitude Ratio:

	SE	IE
Ratio	0.52/0.38	0.53/0.44
M	1.36	1.20
S.D	0.54	0.52
R	0.59-2.54	0.45-2.54
T P	1.61 >0.11	

Table 6: Showing amplitude ratio (V/I) at 80dBnHL. (M-mean, SD-Standard deviation, R-range, T-t values and P-Probabality level SE - Supraeural earphones, IE - Insert earphone).

It can be observed from the Table 6 that the amplitude ratio was lesser when stimulus was presented through insert earphone. However this difference was not statistically significant. Inspection of absolute amplitude of Wave I and V revealed that use of insert earphones resulted in increased amplitude of the Wave I, whereas amplitude of wave V was unaltered. This enhancement of I wave amplitude may again be attributed to reduction in artifact when insert earphones were used.

IV. **Threshold** estimation:

	SE	IE
M	20.16	19.38
S.D.	4.92	4.80
R	10-30	10-30

Table 7: Showing the average ABR threshold when stimuli was presented through two transducers. (M-mean, SD- Standard deviation, R-range, SE - Supraural earphones, IE - Insert earphone).

A glance of Table 7 indicates that the difference in ABR threshold when stimuli were presented through supraaural earphones and insert ear phones was less than ldB. However the paired t-test for large samples between the means was not significant (P>0.23). These results are contradictory to that of Gorga et al., (1987) who reported that the ABR threshold for insert earphones was slightly higher than that obtained for circumaural earphones even though stimuli through both the transducers was calibrated in dBnHL. (6dBnHL for circumaural earphones vs lOdBnHL for insert ear phone). This difference in results could be attributed to methodological differences. In the present study the intensity was varied in lOdB steps. But, Gorga et al., (1987) varied intensity in 5dB steps. The supraaural earphones were used in present study, but circumaural earphones in previous study. However a difference in ABR threshold for insert earphones and supraaural / circumaural earphones should not be obtained when the stimulus is calibrated in dBnHL.

B. SUBJECTS WITH HEARING LOSS:

The difference between the ABR threshold and behavioral thresholds were calculated for 20 subjects in the pathological group. For this purpose PTA_1 (Average of behavioral thresholds at 500Hz, lOOOHz and 2000Hz), PTA_2 (average of behavioral thresholds lOOOHz, 2000Hz, 4000Hz) and average of 2000Hz and 4000Hz were considered.

	TH_{ABR}-PTA_1		TH_{ABR}-PTA_2		TH_{ABR} - Avg. for 2k & 4k.	
	SE	IE	SE	IE	SE	IE
M	21.54	15.38	12.62	8.64	8.62	4.62
S.D	12.72	9.39	8.7	8.07	10.14	11.33
R	1.6 46.6	1.6 36.6	1.6 31.6	-6.6 21.6	-15 27.5	-25 17.5
T P	2.55 >0.03		2.13 >0.06		1.48 >0.17	

Table 8: Showing the mean difference between the ABR threshold and behavioral thresholds for two transducers. (THABR - Threshold for ABR, SE - Supraaural earphone and IE - Insert earphone, M-mean, SD- Standard deviation, R-range, T-t values and P-Probabality level).

Inspection of Table 8 shows that the difference between ABR threshold for stimuli presented through supraaural earphones and behavioral thresholds was 21.54, 12.64 and 8.62 with a S.D of 12.72, 8.7 and 10.14 when PTA_1 PTA_2 and average of 2kHz & 4kHz was considered respectively. Even though least difference was observed between average of 2k & 4k and ABR threshold for supraaural earphones, the SD for this was greater than that obtained for difference between PTA_2 and ABR threshold for stimuli presented through supraaural earphones. Thus it could be said that ABR threshold for stimuli presented through supraaural earphone is related to with PTA_2 or average of 2k and 4k better than PTA_1. A similar trend was observed for insert earphone also. The difference between ABR thresholds for stimuli presented through insert earphone and behavioral thresholds was 15.38, 8.64 and 4.62 with a SD of 9.39, 8.07 and 11.33 when PTA_1, PTA_2 and average of 2kHz & 4kHz was considered respectively.

For a closer inspection of results the data obtained from two groups were analysed separately.

	TH_{ABR} PTA$_1$		TH_{ABR} PTA$_2$		TH_{ABR} - Avg. For 2k & 4k.	
	SE	IE	SE	IE	SE	IE
M	11.64	10.64J	9.95	8.95	10.64	8.25
S.D	7.54	6.67	7.15	5.93	6.67	6.01
R	1.6 21.6	1.6 20	1.6 21	1.6 18.3	1.6 20	2.5 17.5
T P	1.06 X).34		1.10 >0.34		1.08 >0.34	

Table 9: Showing the mean difference between the ABR threshold and behavioural thresholds for subjects with flat hearing loss. (THABR - Threshold for ABR, SE - Supraaural earphone and IE - Insert earphone, M-mean, SD- Standard deviation, R-range, T-t values and P-Probabality level).

The difference between ABR threshold for stimuli presented through supraaural earphone and behavioral thresholds were 11.64, 9.95 and 10.64 with a SD of 7.54, 7.15 and 6.67 for PTA$_1$, PTA$_2$ and average of 2kHz & 4kHz respectively. The same trend was observed when insert earphone was used with average difference of 10.64, 8.95 and 8.25 with a standard deviation of 6.67, 5.93 and 6.01 PTA$_1$, PTA$_2$ and average of 2kHz & 4kHz respectively. The analysis also showed that the ABR thresholds did not vary when the transducer was changed and the ABR threshold was always higher than the behavior threshold. Thus it could be said that the transducer - supraaural earphone / insert earphone is not a factor affecting the prediction of behavioral thresholds from ABR thresholds in subjects with flat hearing loss.

	TH_{ABR} PTA$_1$		TH_{ABR} PTA$_2$		TH_{ABR}-Avg. for2k&4k.	
	SE	IE	SE	IE	SE	IE
M	31.45	20.12	15.29	12.34	8.0	5.0
S.D	8.19	9.58	7.70	8.84	12.68	11.72
R	21.6 46.6	1.6 36.6	3.3 31.6	-6.6 21.6	-15 27.5	-25 17.5
T P	4.6 >0.01		2.29 >0.05		2.45 >0.05	

Table 10: showing the mean difference between the ABR threshold and behavioral thresholds for subjects with sloping hearing loss. (THABR - Threshold for ABR, SE - Supraaural earphone and IE - Insert earphone, M-mean, SD- Standard deviation, R-range, T-t values and P-Probabality level).

A scrutiny of the table 10 showed that the difference between ABR threshold for stimuli presented through supraaural earphones and behavioral thresholds were 31.45, 15.29 and 8 with a SD of 8.19, 7.70 and 12.68 for PTA$_1$, PTA$_2$ and average of 2kHz & 4kHz respectively. Even though least difference observed between ABR threshold and average of behavioral threshold at 2000Hz and 40000Hz, the standard deviation was large. The lower limit of the range was -15 indicating that the ABR threshold was not related to behavioral threshold at 2000Hz and 4000Hz in a few subjects. The standard. Deviation was minimum for difference between ABR threshold and PTA$_2$.

Analysis of ABR stimuli presented through insert earphone showed that the mean difference between ABR threshold and behavioral threshold at 2000Hz and 4000Hz was also less but the standard deviation was large. The lower limit of the range was -25. The mean difference between ABR threshold and PTA_2 was 12.34 with a standard deviation of 8.84. Again the lower limit of the range was negative value indicating that the ABR threshold underestimate hearing loss at high frequencies in subjects with sloping hearing loss. ABR threshold for both supraaural and insert earphones was always higher than PTA_1. These results showed that the ABR threshold depends on the hearing sensitivity at low frequencies in subjects with sloping hearing loss. This supports the statement of Stappels (1989) that when 2000 to 4000 Hz frequency region is not the region of best hearing sensitivity, the ARR threshold may be consistent with hearing threshold in the other frequencies.

The analysis of the results also revealed that in subjects with sloping hearing loss the ABR threshold was lower when insert earphone was used to present the stimulus. In other words, when insert earphones was used the difference between ABR threshold and behavioral threshold was less than that obtained when supraaural earphones were used. This difference between the two transducers was significant at 0.05 level when $PTA_{2;}$ and average of 2000Hz and 40000Hz was considered and was significant at 0.01 level when PTA_1 was considered. This indicated that low frequencies contributed more for ABR when insert earphone was used. This can be supported by Moller (1983) opinion that the earphone modified the resonance effect of the outer ear (canal & concha). An earphone inserted in the ear eliminates the effect of the concha and modifies the effect of the ear canal. The result is a loss of the acoustic gain at high frequencies normally obtained by the external ear.

Further studies need to be carried out on ears with low frequency hearing loss to check whether ABR threshold increases correspondingly.

SUMMARY AND CONCLUSIONS

ABR is affected by several factors that are related to subject, stimulus and instrumentation. Conventional supraaural / circumaural earphones are used for presenting stimuli. With commercial introduction of Etymotic insert earphones, use of supraaural / circumaural earphones for recording ABR has reduced. It has been estimated that the frequency response of tubophones are better than that of supraaural earphones because of reduced oscillation and negligible low frequency leakage (Hall et al., 1992). Also the tube used for conduction of sound from transducers to ear canal introduces a delay in latency of ABR.

The present study was taken up with the aim of comparing:

1. The ABR responses obtained through insert earphones and supra-aural earphones in terms of morphology, latency and amplitude of various waves.
2. Correlation between ABR threshold for stimuli presented through two transducers and behavioral thresholds.

For this purpose ABR was recorded for stimuli presented through supra-aural earphone and insert earphone from 30 young adults (15 Males with mean age 20.8 years and 15 females with mean age of 20.6 years and ages ranging 17-25 years) and 20 ears with sensori-neural hearing loss (mean age 38.4 years with range 18-69 years. Among the 20 ears with sensori-neural hearing loss 10 had flat hearing loss and 10 had sloping hearing loss. The obtained results were analyzed to investigate the aims *of* the study.

The results of the study indicated that:

1. The wave morphology was similar for ABR recorded for stimuli presented through supraaural earphones and insert earphones. However at higher levels of stimulations Cochlear Microphonics (CM), could be recorded when stimuli were presented through insert earphones.

2. Absolute latency of all the waves were delayed when stimuli were presented through insert earphones, the average delay was comparable with that reported in literature. However the value was not a single number, rather a range indicating individual variabilities. Thus while carrying out ABR using insert earphones one has to be careful in interpreting the ABR results.

3. No significant differences were obtained for interwave latency difference, latency - intensity functions for wave V and amplitude ratio. However amplitude of wave I was improved when stimuli presented through insert earphones, which could be attributed to the reduction of artifacts.

4. In subjects with normal hearing there was no significant differences in ABR thresholds obtained when the two transducers were used.

5. In case of pathological group it appeared that low frequency contribution was comparatively more when ABR carried out using insert earphones.

SUGGESTIONS FOR FURTHER RESEARCH:

1. To obtain a correlation between ABR threshold and behavioral thresholds recorded using insert earphone and supraaural / circumaural earphone with various patterns of hearing loss.

2. To carry out the study on a larger group of pathological population.

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APPENDIX -1

Calibration of Tonal Stimuli For ABR Testing:

In conventional pure tone behavioral audiometry behavioral thresholds are expressed in dBnHL units. Normal hearing level (nHL) refers to normal threshold for click. Zero dBnHL will differ for two transducers of different frequency and duration.

Procedure:

A group of ten normal hearing subjects (5 males. 5 females) were taken. The behavioral threshold for clicks, using two transducers were estimated. The behavioral threshold estimation was done using the same instrument and in the same test environment as the actual ABR testing. Threshold was defined as the lowest level at which 50% of the responses were observed. Their average behavioral threshold was taken as 0 dBnHL for that stimulus. The obtained values are

		Supraaural earphone	Insert earphone
0dBnHL	=	40 dB SPL	35 dB SPL