# *A study of Auditory Brain Response using Chained stimuli and BERAphone.*

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A dissertation submitted in part fulfillment for the degree of
Master of Science (Audiology)
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ALL INDIA INSTITUTE OF SPEECH & HEARING
NAIMISHAM CAMPUS
MANSAGANGOTHRI, MYSORE-570006

MAY 2006

*Dedicated*
*To*
*my loving family*

# Certificate

This is to certify that this dissertation entitled **"A *study of Auditory*** *Brainstem Response using Chained stimuli and BERAphone"* is a bonafide work in part fulfillment for the degree of Master of science (Audiology) of the student Registration no: A0490001. This has been carried under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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# Certificate

This is to certify that this dissertation entitled *"**A study of Auditory** Brainstem Response using Chained stimuli and BERAphone"* has been prepared under my supervision & guidance. It is also certified that this dissertation has not been submitted earlier to any other university for the award of any diploma or degree.

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# Declaration

This is to certify that this master's dissertation entitled *"A study of Auditory Brainstem Response using Chained stimuli and BERAphone"* is the result of my own study and has not been submitted earlier to any other university for that award of any degree or diploma.

MYSORE

May 2006

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A0490001

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# INTRODUCTION

Auditory brainstem response (ABR) is an electrophysiological measure that can be used for assessment of hearing sensitivity as well as differential diagnosis of auditory disorder. It has gained popularity in screening program and assessment of threshold in difficult to test children as it does not require voluntary cooperation from subjects and is not affected by state of subject. This can be used for hearing screening of newborn babies also. Hence it has been widely used in universal hearing screening, programmed conducted by many state in the western countries. (Galambos, & Galambos 1979; Galambos, Hicks and Wilson, 1982,1984; Alberti, Hyde, Corbin, & Abramovich, 1983; Alberti, Hyde, Riko, & Corboin, 1985; Hyde, Malizia, & Alberti, 1991; Sininger & Abadala, 1996; Mason, and Herrmann 1998; Mehl, and Mas, 1998; Hyde, Sininger and Don, 1998; Norton et al., 2000). Although conventional ABR has gained wide acceptance as an objective measure of hearing sensitivity, one of the limitations of this conventional approach is the time required is more for testing. (Mc Neill's & Klein, 1997; as cited in Northern and Downs 1991).

Several modifications have been tried to overcome the limitations of test time required. The modifications include use of higher repetition rate, maximum length sequence (MLS) and chained stimulus ABR. Chained stimuli ABR given by Hamill, Yanez, Collier, and Lionbarger (1990) was adapted from Rapid electrocochleography technique given by Spoor (1974). Chained train stimului / Steeped train stimulus ABR involves presentation of chain of different intensity clicks instead of one click stimulus at a single intensity. This enables recording of responses to several intensity signals in a short time.

Hamill et al. (1990) reported that results of chained stimulus technique and conventional ABR for threshold estimation were similar in simulated conductive hearing loss and sensory-neural impairment. Another study carried out by Hamill, Hussung and Sammeth (1991) compared estimation of threshold using automated conventional and chained stimuli ABR in normal hearing adults. It was observed that the thresholds obtained using the two methods were comparable and both techniques yield this information very rapidly, although the chained stimuli method was on an average, two minutes quicker. However, they did not include hearing impaired subjects and/or infants, children in the study. Thus there is a dearth in literature comparing threshold with conventional ABR and chained stimulus ABR in subjects with hearing loss.

Mitchell, Kempton, Creedon, and Trune (1999) compared conventional single intensity tone burst response with multiple tone burst and intensity chained train response in mice. Multiple chained stimuli ABR threshold was found 10 dB higher than conventional tone burst ABR and latency was prolonged than conventional ABR. Although these difference in latency and amplitude was not significantly different for all the frequency. Difference observed in higher frequency threshold was more than conventional tone burst ABR thresholds. Amplitude was found to be less for chained stimulus ABR than for conventional ABR. They did not report about waveform morphology.

Conventional ABR and chained stimulus ABR require additional time for the preparation of the subjects for testing. Preparation time includes positioning of subjects, preparation of the skin, placement of electrodes and transducer. To reduce the time required for subject's preparation, a transducer, BERAphone was developed by Finkenzeller (1996, 1997, cited in Shehata-Dieler, Dieler, Keim, Finkenzeller, Dietl, & Helms 2000). BERAphone is a transducer in which electrodes are attached to the earphone with a supraural cushion. The reference electrode, signal converter (loud speaker) and pre amplifier are integrated in an easily operated applicator. The transducer is positioned over the ear that is to be tested and on the head of the child after applying electrode gel to the electrodes. This automatically establishes the electrode contact and acoustic coupling of the signal converter to the ear. It has been reported that screening-using BERAphone with stepped train stimulus is cost effective and less time consuming (Shethata-Diler, Keim, Finkenzeller, Dietl, & Helms, 2000; Newmann, Gall & Berger 2001). Though BERAphone was initially used as a screener with stepped train stimulus, it can be used for threshold estimation.

# NEED FOR THE STUDY

In literature, it has been reported that, increased repetition rate, maximum length sequence or chained stimuli ABR is reduce the test time. Studies have compared chained stimuli and automated ABR in normal hearing and simulated hearing loss subjects, whereas there is a dearth for investigations comparing chain stimulus and conventional ABR.

Mitchell et al. (1999) reported higher mean threshold for chained stimulus ABR in mice when compared to that of conventional ABR. Study done on human beings with simulated hearing loss using two stimuli is reported comparable results. However, in these studies exact threshold difference is not reported. Hence there is a need to compare if there is a significant difference in the threshold obtained using two methods.

In literature comparison has been made between chained stimuli ABR incorporated with BERAphone and automated ABR. Result have revealed suggested that time required for BERAphone is less compare to automated ABR. No comparison have been made between usefulness conventional ABR and BERAphone for threshold estimation in infants. Hence there is a need to make comparison between thresholds obtained from BERAphone and conventional ABR, and check the difference in threshold obtained by these two methods.

## AIMS OF THE STUDY

Following were the aims of this study:

- Comparison of ABR thresholds obtained with conventional and chained stimuli ABR.
- Comparison of waveform morphology, latency and amplitude of ABR obtained with chained stimuli and Conventional click.
- Comparison of ABR Thresholds obtained with conventional ABR and with BERAphone.
- Comparison of waveform morphology, latency and amplitude of response obtained using Conventional ABR and with BERAphone.

# REVIEW OF LITERATURE

Auditory brainstem response (ABRs) was first described in 1970 (Jewett, Romano & Williston, 1970) and success of this technique for assessment of hearing sensitivity in infant was proven soon after (Hecox & Galambos, 1974). It gained popularity as a screening tool and is being used extensively for screening of infants in newborn nurseries. The ABR is well established due to high sensitivity and specificity rates in the identification of hearing impairment and is generally impervious to ambient noise and sedative medication (Mason & Hermann, 1998).

Limitations of conventional ABR screening include the expense of the equipment, qualified manpower and time required for testing. Several modifications have been adopted to reduce test time while recording ABR. One such modification was automated ABR, which was developed for neonatal hearing screening in 1980's. The automated ABR system works by comparing the response obtained from the infant with "normal" template response pattern obtained from a large sample population newborns. If the infant being tested falls with in the normative values, the automated instrument renders a "pass" decision where as if the response pattern falls outside the acceptable response template a 'refer' response is obtained suggesting the need for additional testing. A minimum of 1000 stimulus repetition is required under optimal recording condition to yields reliable screening results. In less than optimum condition (E.g. excessive noise or physiological artifact), more stimulus presentation may be required. The infant passes the screening if reliable response were present at the screening level of 35 dBnHL automated ABR is especially efficient and practical because non-professional can manage the testing.

Hermann, Thornton, and Joseph (cited in Sininger et al., 2000) reported that the results of ABR using an automated ABR is comparable to that of standard ABR protocol run by experienced audiologist. Of the 153 high- risk infants, all those who passed the screening were determined to have a response by standard ABR. However, four of 25 infants failing the automated protocol were found to have an ABR by standard testing and one infant could not be tested. In the second experiment, Herrmann et al. (cited in Sininger et al., 2000) reported that automated protocol produced a slightly higher fail rate (11%) than when compared to conventional ABR

Peters (1986) reported 94% agreement between the result of automated ABR system and conventional ABR testing of 304 infants ear. When rigid and strict research protocol were applied in a single clinical site there was 98.5% agreement between results obtained using two ABR systems. Kilney, 1988; Mason, and Hermann 1998; Clarke 2002, reported that time required for testing with these automated ABR ranges from six to fifteen minute.

Another method used for automated detection of ABR is Fsp. Fsp introduced Elberling and Don in 1984, was first introduced in newborn screening by Sininger et al. (2000). The initial Fsp often identifies the procedure, where F is statistic representing a distribution or variance estimate noise, and "sp" represents a single point in the analysis window whose measured noise over many sweep determines the F value. The quality of the response to the eliciting signal, or the Fsp, is determined by a ratio of the variance of response portion of the total recording to variance to background noise. The quality of the response to the eliciting signal, or the Fsp, is determined by a ratio of variance of the background noise. A test run is terminated when Fsp reaches a stronger than weaker signal levels. Sininger et al. (2000) reported that "average" total test time taken, by using Fsp technique for 30 dBnHL screening in both ears was under 8 minutes. The time taken for screening well babies took longer than NICU babies. ABR implemented with Fsp algorithm using a 30-dBnHL click stimulus is reliable technique for rapid assessment of auditory status in newborns. Initially the automated ABR system used conventional click stimuli.

During conventional ABR repetition rate of more than 100/s is not used as it will result in overlapping response. (Don, Allen, & Starr 1977; Gerling & Finitzo-Hiber 1983; Pratt, & and Sohmer 1976; Yagi & Kaga 1979; Lasky, 1997; Leung, Slaven, Thorton, Brickly 1998). One method of circumventing the rate limitation imposed by conventional averaging is use of pseudorandom pulse train as test stimuli proposed by Eysholdt and Schreiner (1982). These pulse trains, called maximum length sequence (MLS), are binary sequence that have length L, where L = 2" - 1, with sum of- 1, where n is the number of bits in the shift register used to generate the sequence. The mathematical appeal of the MLS is that its autocorrelation function is two valued, - 1 or 1. When applied to linear time-invariant system, maximum length sequence (MLS) analysis will yield a sustain impulse response by circulating convolving the MLS evoked response with the temporal inverse of the MLS used to excite the system. Eysholdt and schreiner (1982) used this technique and obtained ABRs that were remarkably similar in appearance to conventional ABRs.

Another faster method for evaluations of auditory system is Lengendre sequence (LGS). The lengendre sequence consists of pseudorandom pulse with length = 4m-1, where L is a prime and m is a proper integer Schroder (1979). Like the MLS, the Legendre sequence has flat spectrum, but unlike, MLS it has only two phase values, +90 and -90 degree. The limited phase values provide advantage when using FFT computational methods, in addition to exciting and resolving different nonlinear aspects of the system behavior than is true for the MLS.

Burcard, shi and Hecox (1990) compared MLS and LGS with conventional ABR technique, both techniques produced reliable responses remarkably similar in morphology to evoked responses obtained by conventional averaging. The results of these experiments support the possibility that analysis method based on pseudorandom pulse sequence may prove more efficient in data collection and provide a more clear description of the electro phjysiology behavior of the auditory system compared to conventional averaging. Jiang et al. (2005) compared MLS in preterm and full term baby and found similar results for both the groups suggesting that MLS does not get affected by age of infant.

Eggermont-Shi 1982; Weber, and Rouch, 1990 indicated that MLS technique requires less time than conventional ABR by eight factors (E.g. suppose conventional ABR requires 80 sec than MLS was completed with in 10.5 sec). Thus, the total test time is considerably reduced when using MLS technique. The main feature of the ABR was preserved, but due to adaptation, the latency of later wave complexes was found longer at higher repetition rates, and wave IV was not seen. The latency of wave V was found to be at 6.9 ms with MLS whereas it was only 5.6 ms when it was recorded with conventional ABR.

Chained stimuli/ stepped train stimulus is another modification of stimuli used to reduce test time. This technique was first used for reducing test time by Spoor (1974) for measurement of electrocochleography and he used the term "Rapid Electocochleography". Egger Mont, Spoor, and Odenthal (1976; cited in Hamill et al. 1990) reported that hearing threshold estimated with this technique were equivalent to conventional electrocochleography methods. Hamill, Yanez, Collier, and Lionbarger (1990) adopted Spoor's technique in ABR for finding out the threshold of individual and used the term Chained stimuli ABR. Chained train stimuli involves presentation of chain of different intensity click stimuli instead of a click stimulus at single intensity. The instrument is programmed to average click stimulus at different intensity clicks. This enables recording of response to several intensity signal in short time.

Hamill et al. (1990) compared estimation of threshold using conventional ABR with chain stimulus ABR in simulated conductive and sensory-neural hearing loss. It was found that the thresholds obtained with both the methods are comparable and both the techniques are less time consuming. However they did not include subjects with hearing-loss in this study. Hamill, Hussung, and Sammeth (1991) compared the estimation of threshold using automated conventional ABR and chained stimuli ABR. Thirteen normal hearing adults were participated in the study. Stimuli were presented through TDH-39 earphones mounted in MX/41-AR cushions. Gold disc electrode was attached at the vertex (non inverting), ipsilateral earlobe (inverting), and contra lateral ear lobe (ground). The EEG was amplified by a factor of 100,000 and band pass filtered from 200 to 3000 Hz with a filter slope of 12 dB/octave. For conventional automated ABR 100 micro second rarefaction clicks with 70.1/s repetition rate was used and for each run 2000 sweeps were used. For chained stimuli ABR technique stimuli used was 100 micro second rarefaction clicks. Each chain began with a 10 ms silent interval at subsequent 10 ms interval clicks were presented at intensity increasing in 10 dB steps from lOdBnHL to 70 dBnHL. Each waveform was the sum of responses to 2000 presentation of the stimulus chain. Latency observed for chain stimuli ABR was slightly lesser than conventional ABR and waveform morphology was found to be good at higher intensity for chain train stimulus. Thresholds obtained an average were similar. An average chained stimuli ABR required 2 minute lesser than conventional automated ABR. They did not recommend chained stimuli for the clinical evaluation because the technique has not been thoroughly investigated on hearing-impaired population.

Mitchell, Kempton, Creedon, and Trune (1999) compared ABR for conventional single intensity tone burst response with multiple tone burst and intensity chained train stimuli in mice. Multiple chained stimuli ABR threshold was found 10 dB higher than conventional tone burst ABR and latency was prolonged when compared to that of conventional ABR although the difference is in latency and amplitude was not significantly different for all the frequency. The difference observed was more at higher frequency. Amplitude was found less for chained stimulus ABR than for conventional ABR.

Finkenzeller (1994, cited Sturzebecher, Cebulla, & Newmann 2003) used only six intensity of click stimulus with 5 ms interstimulus gap and chain repetition rate 14.3/s .The stimulation rate used for this six clicks of stepped train stimulus cross pond to a click rate of 200/s. They reported that the response is comparable with conventional ABR in neonates, at least at 40 dB and above. Finkenzeller (1993 cited in Sturzebecher, Cebulla, & Newmann 2003) reported that even with repetition rate of 400/s for chained stimuli ABR response could be obtained.

Finkenzeller (1996, 1997 cited in Shehata-Dieler, Dieler, Keim, Finkenzeller, Dietl, & Helms 2000) developed a BERAPhone stepped train stimulus for newborn hearing screening. BERAPhone is a transducer in which electrode are attached to earphone with supra-aural cushion .The reference electrodes, signal converter (loud speaker) and pre amplifier are integrated in an easily operated applicator. The transducer is positioned over the ear that is to be tested and on head of the child after applying electrode gel. This automatically establishes the electrode contact and acoustic coupling of the signal converter. Shehata-Dieler et al. (2000) screened 1349 newborns using BERAphone with stepped train stimulus algorithm to overcome the problem of lengthened test time. Here clicks of stimuli are separated by 5 ms gap, measuring time window was kept at 40 ms, stimulus in 10- 60-dBnHL levels with alternating polarity. The interval between click was 5 ms with repetition rate of 14/s. In each case, 1000 summation were made. If clear, consistent and reproducible responses were achieved the measurement was terminated after 500 summations. Test time required to complete the testing was 3-4 minutes. As BERAphone is simple to handle and less time consuming it can be the choice for hearing screening test. Finkenzeller did not compare BERAphone results with conventional ABR.

Newmann, Gall, and Berger (2001) compared time taken for two automated ABR measurements for universal screening results indicated that with ABR measuring, time for hearing measurement was 2 - 4 minutes with automated ABR and measuring time for BERAphone both with and without automated algorithm was 1-2 minutes. Total examination time remains 6 minutes for the BERAphone and under the 10 minutes for automated ABR. Those who failed with automated ABR did not pass with BERA phone also. Sturzebecher et al. (2003) suggested that use of BERAphone and stimulus presentation of 90/ s rates at 35dBnHL is very efficient technique for the hearing screening.

Thus, a review of literature shows that use of chained train stimuli and BERAphone reduces time required for recording ABR. Investigators have also reported that the ABR waveform obtained using chained stimulus and BERAphone comparable to automated ABR. The present study designed to compare conventional and chained stimulus ABR waveform recorded using conventional chained stimuli. An attempt was also made to compare the waveform using BERAphone with that obtained using conventional ABR.

# METHOD

Two experiments were conducted to investigate the aims of the study. Experiment I compared the ABR obtained for conventional stimuli and chained stimuli and in Experiment II ABR using BERAphone was compared with that of conventional ABR.

**Experiment I:**

Subjects:

The following four groups of subjects were included for experiments I:

1. Adults with normal hearing: This group included 30 ears of normal adults with normal hearing (pure tone thresholds less than 15 dBHL. The age range of subject was (18-45 years).
2. Adults with hearing Loss: This group included 40 ears of adults with hearing loss (pure tone average ranged from 30 - 90 dBHL). The age of the subject ranged from 18-45 years.
3. Children with normal Hearing: This group included 23 ears of normal children with normal hearing. The age range was (0-2) years.
4. Children with hearing Loss: 30 ears of subject with history of hearing loss were included in study. The age range of (0-2 years).

**Instrumentation:**

Interacoustics EP-15 (evoked potential -15) electrophysiological system with software version 4.08 was used for recording ABR.

**Test Environment:**

All the testing was carried out in an acoustically treated environment.

**Test Procedure:**

Adult subjects were instructed to sit comfortably on reclining chair. They were asked to avoid any extraneous movement of head, neck and jaw movement for the duration of the test. Children were tested under natural/sedated sleep. Non-inverting electrode was placed on the forehead, inverting electrodes were placed on the mastoid and common electrode was placed at (Fpz). Before placing the button type electrodes, the electrode site was cleaned by rubbing the surface with cotton wool dipped in skin preparing paste. It was ensured that the impedance at all electrode sites was less than five-kilo ohms.

Table 1: Test protocol used for experiment I

| | Conventional ABR | Chained Stimuli ABR |
|---|---|---|
| Stimulus | 100 µs clicks | 100 us clicks |
| Number of sweeps | 2000 | 2000 |
| Repetition rate | 26.1/sec | 26.1/sec |
| Filter | 100-3000 Hz | 100-2607 Hz |
| Time window | 15 msec | 45 msec |
| EEG | 80uv | 80 uv |
| Transducer | ER-3A | ER-3A |
| Amplifier Gain | 1,00000 | 1,00000 |
| Polarity | Alternate | Alternate |

During conventional recording intensity of the stimulus was varied to find out lowest intensity at which a peak could be recorded. Interstimulus interval within a chain was five msec. The intensity range of the stimulus varied from 20-70 dBnHL for normal hearing subjects and it varied from 40-90 dBnHL for the pathological groups. Stimulus intensity was calibrated in dBnHL (0 dBnHL equal to 30 dBPeSPL). Two experienced audiologists independently judge the waveforms for both conventional and chained stimuli ABR.

**Experiment II:**

Subject: A total '5' ears in age range from (0-6) months were included for study.

**Instrumentation:**

Interacoustic EP-15 (Evoked potential-15) electrophysiological system with software version 4.08 was used.

**Test Environment**

All the testing was carried out in an acoustically treated environment.

**Test Procedure:**

The electrode sites were cleaned with skin preparing paste before placing BERAphone on the test ear. The transducer was positioned over the ear that is to be tested and on head of the child after applying electrode gel. Intensity of the stimulus was varied to find- out the lowest intensity at which ABR could be recorded. Stimulus intensity was calibrated in dBnHL (0 dBnHL equal to 30 dBPeSPL). Data was collected using the protocol given in Table 2.

Table 2: Test protocol used in experiment II

| | Conventional ABR | BERAphone |
|---|---|---|
| Stimulus | 100 µs clicks | 100 us clicks |
| Number of sweeps | 2000 | 2000 |
| Intensity | Varied | Varied |
| Filter | 100-3000 Hz | 100-3000 Hz |
| Repetition rate | 26.1/sec | 26.1/sec |
| Amplifier Gain | 1,00000 | 1,00000 |
| EEG | 80 uv | **80 uv** |
| Transducer | ER-3A | BERAphone |
| Time window | 15 msec | 15 msec |
| Polarity | Alternate | Alternate |

Data obtained were analyzed by two audiologists independently and the latency and amplitude of the peaks were recorded.

Table 2: Test protocol used in experiment II

| | Conventional ABR | BERAphone |
|---|---|---|
| Stimulus | 100 µs clicks | 100 µs clicks |
| Number of sweeps | 2000 | 2000 |
| Intensity | Varied | Varied |
| Filter | 100-3000 Hz | 100-3000 Hz |
| Repetition rate | 26.1/sec | 26.1/sec |
| Amplifier Gain | 1,00000 | 1,00000 |
| EEG | 80 uv | 80 [iv |
| Transducer | ER-3A | BERAphone |
| Time window | 15 msec | 15 msec |
| Polarity | Alternate | Alternate |

Data obtained were analyzed by two audiologists independently and the latency and amplitude of the peaks were recorded.

# RESULTS AND DISCUSSION

To investigate the needs of the present study statistical analysis using SPSS software (Version 10.0) was carried out for the data obtained. The statistical analysis included descriptive analysis and Wilcoxon matched pairs signed ranks test. Comparison of conventional and chained stimulus ABR was carried out separately for adults and children. ABR for both conventional and chained stimuli could be recorded for all the normal hearing adults. In '12' number of subjects with hearing loss, ABR was absent at maximum intensity at (90 dBnHL) due to severity of hearing loss. The data was not considered for statistical analysis if responses were absent. After deletion of no response data, the number of subjects considered for statistical analysis was '28' in adult hearing loss group and '18' in children. ABR could be recorded from the infants using BERAphone as well as conventional ABR.

**I. Comparison of conventional ABR and chained stimulus ABR.**

Wave morphology:

Representative waveforms of one normal subject, for conventional clicks and chained stimuli/stepped train stimulus ABR are displayed below in Figure 1.1 and 1.2. In conventional click evoked ABR all the peaks were observed at 70 dBnHL in normal hearing subjects whereas for chained stimulus ABR even at 70 dBnHL wave III and V only observed. Only in 18 normal adult subjects wave III was observed for chained stimulus ABR where as for conventional ABR wave III was observed in 28 ears till 40-50dBnHL. In normal hearing children in '12' ears III peak was observed at

70 dBnHL for chained stimuli ABR whereas for conventional ABR peaks III peak was observed in '17' ears till 50-55 dBnHL. At higher intensity waveform morphology was better for chained stimulus ABR than conventional ABR.

Figure 1.1 Waveforms using conventional ABR.

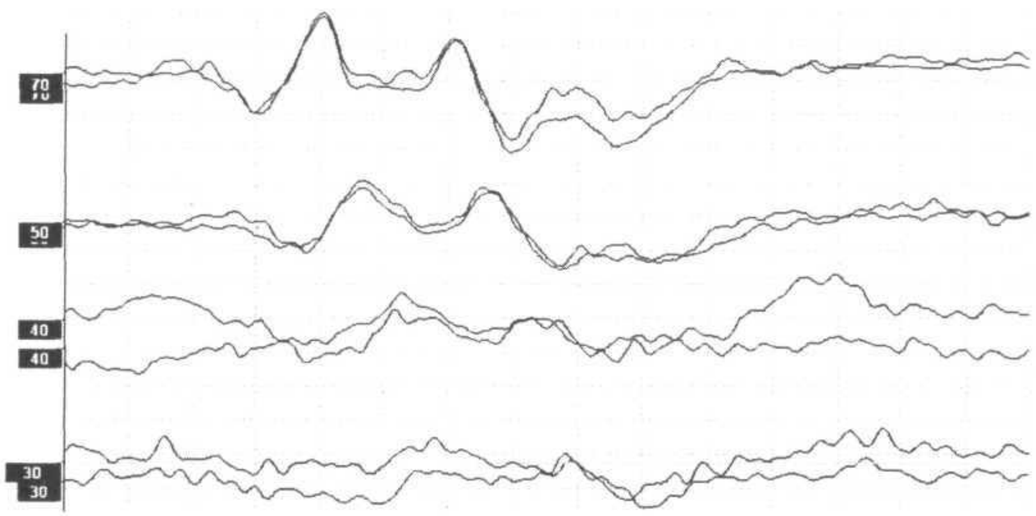
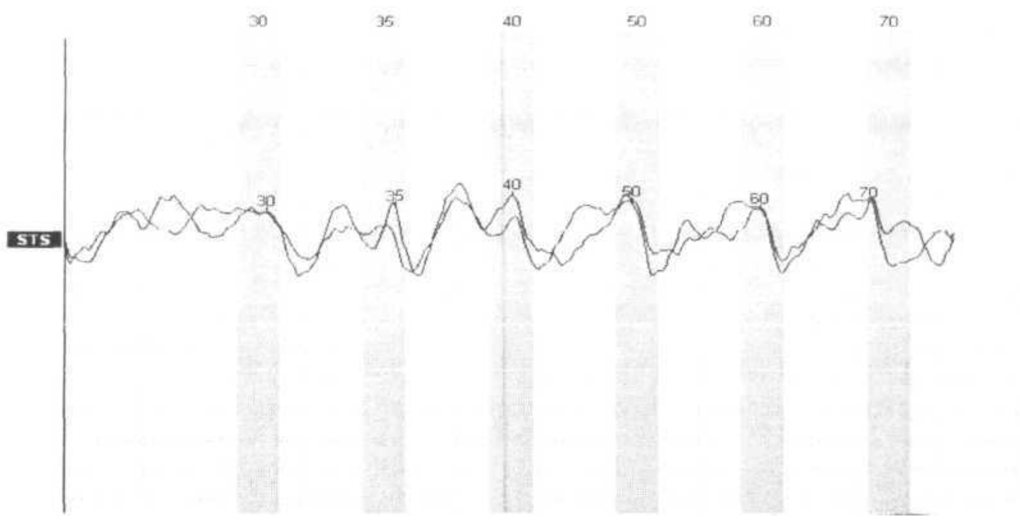



Figure 1.2 Waveforms using chained stimuli ABR.



In subjects with hearing loss wave morphology for chained stimulus was better at suprathreshold levels whereas for lower intensity peak degradation / poor wave morphology was observed than conventional ABR in almost all the subjects. Similar results were observed in children and adults.

There has been no published report comparing chained stimulus ABR and conventional ABR in normal hearing and with hearing loss, although studies have compared automated ABR and chained stimulus ABR. Hamill et al. (1991) advocated that chained stimuli ABR has better morphology at suprathreshold (i.e. 60 dB and 70 dBnHL) than automated conventional ABR. Hamill et al. (1991), reported that there are difference neural adaptation for the stimuli within the chain than for conventional ABR. Results indicated that at lower intensity wave morphology was poorer than conventional ABR in all the groups, these differences could be seen due to higher repetition rate is used in this study. Higher repetition rate has more effect near threshold, so in this study this could be the reason at lower intensity waveform morphology was degraded.

**(A) Latency and Amplitude of** Wave V:

Table 3: Mean and Standard Deviations of latency (L)and amplitude (A) pf V peak at supra threshold SD is given in parenthesis.

| | Normal Hearing | | | | Haring Loss | | | |
|---|---|---|---|---|---|---|---|---|
| | Chained stimuli | | Conventional | | Chained stimuli | | Conventional | |
| | **L** ABR | **A** | **L**ABR | **A** | **L**ABR | **A** | **L**ABR | **A** |
| Adults | 5.70 (.188) | .662 (1.19) | 5.46 (.209) | .512 (.662) | 5.69 (.409) | .325 (.231) | 5.48 (.322) | .269 (.214) |
| Children | 6.20 (.49) | .33 (.18) | 5.99 (.55) | .35 (.20) | 6.41 (.64) | .36 (.30) | 6.19 (.60) | .32 (.168) |

Table 3 shows the mean and standard deviation of latency and amplitude of wave V obtained at suprathreshold level. Comparison was made between latency and amplitude of chained stimulus and conventional ABR for 70dBnHL in normal hearing group. For subjects with hearing loss latency and amplitude of ABR recoded for 90 dBnHL clicks were compared. As the earlier peaks were not observed for chained stimulus ABR, only latency and amplitude of peak V was considered for statistical analysis. The mean latency recoded for chained stimulus ABR was prolonged and amplitude was higher when compared to conventional ABR in all the groups. Wilcoxon matched pairs rank test showed that the difference in latency was statistically significant at (0.01) level Z=4.68 for normal group and Z=2.59 for hearing loss group. However, the difference in amplitude was not statistically significant.

Results for children and adult followed similar trend. There was a significant difference in latency but not for amplitude (p>.05 level Z= .265).

These findings are in concurrence with the report of (Mitchell, Kempton, Creedon, and Trune (1999) who observed an increase in mean latency by about 0.1 msec. Hammil, Hussang, carol and Summeth (1991) observed that though not statistically significant, mean latency was shorter and mean amplitude was higher for chained stimuli, ABR than that observed for automated ABR. However, they did not compare their results with conventional ABR.

Reason for increased latency obtained in the present study could be because at higher repetition rate neurons got adopted in chain stimulus as the rest period was very less. It has been well established that there is an increase in ABR latency with increased repetition rate (Burkard-shi & Hecox, 1990; Eysholdt, and Schreiner 1982).

**(B) ABR Threshold:**

Table-4: Mean, Standard Deviations values of ABR thresholds for chained stimuli ABR and conventional ABR.

| | Normal Hearing | | | | Hearing Loss | | | |
|---|---|---|---|---|---|---|---|---|
| | Chained stimuli ABR (dBnHL) | | Conventional ABR (dBnHL) | | Chained stimuli ABR (dBnHL) | | Conventional ABR (dBnHL) | |
| Adult | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| | 35.83 | 5.427 | 30.50 | 6.11 | 76.25 | 13.45 | 72.08 | 12.84 |
| Children | 39.34 | 5.70 | 32.82 | 5.39 | 74.44 | 19.76 | 67.22 | 17.75 |

As shown in Table 4, the mean threshold for chained stimulus was higher when compared to that of conventional ABR in both the groups. Wilcoxon matched pairs signed ranks test showed that difference is significant at (0.01) level for all the groups (Z= 3.36 for normal hearing adults, Z=3.67 for normal hearing children, Z= 3.05 for children with hearing loss group) but in adult hearing loss group difference is significant at (0.05, Z = 2.013).

Mitchell et al. (1999) reported that in mice ABR threshold was higher for chained stimuli than that for conventional stimuli. However, the difference was not statistically significant. Hamill et al. (1990) reported that the thresholds for

ABR, conventional ABR and chained stimulus ABR were comparable but they did not report the exact threshold obtained for the two stimuli. In the present study, even though there was statistically significant difference in the thresholds, the difference was only 5 dBnHL and this can be considered insignificant for during clinical evaluation.

On average, the time required for testing using chained stimuli was 5 minute. During conventional ABR testing, 7 minute were required to test at each intensity Therefore time required to test at each intensity in normal hearing subjects or those with lesser degree of hearing loss was more when compared to time require for severe degree of hearing loss. Therefore, comparison of time required for testing using conventional ABR and chained stimuli ABR was almost same for subject with severe degree of hearing loss. But a chained stimuli ABR was less time consuming while testing those with normal hearing or lesser degree of hearing loss.

**II Comparison of ABR obtained using BERAphone conventional system.**

**It** was observed that for both conventional ABR and with BERAphone all the peaks were observed at supra threshold. Waveform morphology was comparable between two ABRs. However, during acquisition of data artifact rejection was observed more for BERA phone than conventional ABR.

Table 5: Mean, standard Deviations of V Peak latency and amplitude.

| Conventional ABR | | | | BERA Phone | | | |
|---|---|---|---|---|---|---|---|
| Latency (ms) | | Amplitude (µv) | | Latency (ms) | | Amplitude (µv) | |
| Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| 6.12 | .55 | .44 | .11 | 6.12 | .40 | .47 | .11 |

Table 7 shows comparable mean latency and amplitude for both ABR. As data only obtained with only '5' subjects, due to instrumental problem, data cannot be generalized on large population. Wilcoxon pairs matched signed rank test value shows, no statistically significant difference in amplitude and latency.

The mean threshold for conventional ABR was 35dBnHL with standard deviations of 5.0 and it was 36dBnHL with standard deviation of 4.01 for BERAphone. Wilcoxon pairs matched Rank test shows no significant difference between thresholds obtained with both ABR at the level of (0.05 Z=1.0). These results show that BERAphone can be used for threshold estimation in infants. There is no study in literature that compares BERAphone with conventional ABR. Sturzebecher et al. (2003) reported that the mean threshold around 40 dBnHL for clicks presented through BERAphone at 90/sec repetition rate.

Preparation time of subject using BERAphone is approximately (2 minute) compared to that taken by conventional ABR (5 minute). However, artifacts were higher in BERAphone probably due to higher impedance. As conventional click stimuli were used with, BERAphone the reduction in time required only related to time required for patient preparation. Probably use of chained stimuli with BERAphone will further reduce the time required for testing. Thus, the results of study revealed that thresholds obtained using chained stimuli and BERAphone are comparable with that obtained with conventional ABR.

# SUMMARY AND CONCLUSIONS

Chained train stimuli involve presentation of chain of different intensity click stimuli instead of a click stimulus at single intensity. The instrument is programmed to average response for click stimulus at different intensity separately. This enables recording of response to several intensity signal in a short time. Comparison has been made between chained stimuli and automated ABR in normal hearing and in simulated hearing loss subjects, whereas there is dearth for studies comparing chain stimulus and conventional ABR. Although stepped train ABR is time efficient but it does not reduces preparation time of subjects. Hence, BERAphone was designed to reduce the preparation time of subject. BERAphone is a transducer in which electrodes are attached to earphone with supraural earphone. This automatically establishes the electrode contact and acoustic coupling of the signal converter to the ear. There are a few studies which have compared automated and BERAphone ABR with stepped train stimulus and reported BERAphone with stepped train stimulus quicker than automated ABR. However there is a dearth in literature comparing conventional and BERAphone ABR.

Hence, the present study was designed to investigate the following:

- Comparison of ABR thresholds obtained with conventional and chained stimulus ABR.
- Comparison of waveform morphology, latency and amplitude of ABR obtained with chained stimuli and conventional click.

- Comparison of ABR thresholds obtained with conventional ABR and with BERAphone.
- Comparison of waveform morphology, latency and amplitude of response obtained using conventional ABR and with BERAphone.

Two experiments were conducted in the present study

Experiment-I consisted of four groups, 30 normal ears of adults with the age range of 18-45yrs., 40 ears with hearing loss of adults in the age range 18-45 yrs., twenty three normal and 30 hearing loss ears in children with age range of 0-2 yrs. Experiment-II was carried out on 5 infants.

Interacoustic EP-15 (evoked potential -15) electrophysiological system with software version 4.08 was used for recording ABR in both experiments. During conventional and BERAphone, recording intensity of the stimulus was varied to find out the lowest intensity at which a peak could be recorded. The intensity range of the chained stimuli varied from 20-70 dBnHL for normal hearing subjects and it varied from 40-90 dBnHL for the pathological groups.

The waveforms obtained were independently analyzed by two audiologists. Latency and amplitude of the peaks as well as the lowest level at which ABR was obtained were recorded and subjected to statistical analysis.

The analysis revealed the following results:

- Chained train stimuli waveform was better than conventional ABR at higher intensity in all the cases whereas near threshold chained train stimulus ABR waveform was poorer than conventional ABR.

- Chained stimuli ABR threshold was significantly poorer than conventional ABR in all the groups.

- The mean latency for chained stimuli ABR was significantly higher than conventional ABR, but the difference in amplitude was not statistically significant.

- Waveform morphology, latency and amplitude of ABR as well as ABR threshold obtained using BERAphone was comparable with those obtained using conventional ABR.

- Preparation time of subjects using BERAphone was less as compared to conventional ABR.

- For chained train stimuli ABR overall test duration were reduced than conventional ABR in normal hearing and in cases with lesser degree of hearing loss. However, it was seen that in-group of subjects with severe degree of hearing loss time required was almost same with both the methods.

Thus, it can be concluded that chained stimuli ABR as well as BERAphone can be used to obtain hearing threshold or as a hearing screening tool.

**Future Directions:**

1. Effect of chained stimuli ABR with lower repetition rate on thresholds could be investigated.
2. BERAphone with stepped train stimulus can be compared with conventional ABR.
3. BERAphone with chained train stimuli, and chained train stimuli with insert receiver can be compared with conventional ABR.
4. The present study can be replicated on a large population.

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