<u>ELECTROPHYSIOLOGICAL TESTS IN HUMAN FOR AUDIOLOGICAL PURPOSES</u> -

<u>A REVIW OF LITERATURE, 1985-1989</u>

Register No.M8903

AN INDEPENDENT PROJECT SUBMITTED AS PART FULFILMENT FOR FIRST YEAR M.Sc.(SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE.

ALL INDIA INSTITUTE OF SPEECH AND HEARING: MYSORE - 570 006

MAY 1990

MY

PARENTS

CERTIFICATE

This is to certify that the Independent Project entitled: Electrophysiological tests in Human for Audiological Purposes - A Review of Literature, 1985-1989 is the bonafide work, done ia part fulfilment for First Year M.Sc., (Speech and Hearing) of the student with Register No.M8903.

Mysore

May 1990

Director
All India Institute of
Speech and Hearing
Mysore-6.

CERTIFICATE

This is to certify that the Independent Project entitled: Electrophysiological Tests in Human for Radiological Purposes -A Review of Literature, 1985-1989 has been prepared under my supervision and guidance.

MYSORE
MAY 1990

GUIDE

DECLARATION

This Independent Project entitled: Electrophysiological Tests iN Human for Radiological Purposes -A Review of Literature, 1985-1989 is the result of my own study undertaken under the guidance of dr.(Miss) S. Nikam, Professor and Head, Department of Radiology, All India Institute of Speech and Hearing, Mysore aNd has not been submitted earlier at any University for any ether Diploma or Degree.

Mysore

May, 1990 Register NO.M8903

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I thank my other classmates and friends who helped me in writing this project, directly or indirectly.

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TABLE OF CONTESTS

INTRODUCTION

The clinical utilization of the electrophysiology of the auditory system has opened a new era in our ability to diagnose receptive auditory impairment. Baring the last three decades, there has been a substantial impetus in electric response audiometry (BRA) due, no doubt to the developments in computer technology and te enhanced insights into auditory physiology particularly at the level of the sense organ and the brain stem.

The methods currently available to assess the auditory function are many and varied ranging from very simple behavioural tests such as observing the child's behavior in response to the sounds produced by toys, bells aad noise-makers, to very sophisticated computer averaged objective methods, such as, electrical response audiemetry (ERA).

Need for Electrophysiological tests:

One of the problems encountered by the clinician in testing patients with hearing loss is in testing the mentally handicapped, physically handicapped and language impaired population. Early identification and diagnosis is especially essential in these groups as hearing loss can interfere with their language development and further treatment and management. This can also interfere with their social, adaptive and cognitive development.

In older to test children, many modification of pure tone and speech testing procedures have been made which makes use of a variety of conditioning techniques, to get reliable audiograms. Despite, these, problems persist in testing children, especially if they are too young say less than one year, where the clinician has to rely more on behavioral observations. Also, in certain difficult to-test patients, or children with multiple handicaps such as cerebral palsy or children with emotional problems like autism, conventional test procedures do not yield reliable results. With the development of objective testing methods, the electrophysiological tests have been found with greater accuracy in identifying hearing problems.

It was found that using the electrophysiological tests accurate estimate of hearing is possible. Even age related changes in hearing can be assessed accurately. Apart from the normal, other subjects were also tested using these objective measures and these were found to give reliable results.

In general, all auditory response systems, both specific (direct) and non-specific(medlated) can be broadly classified into:

1. Behavioural response system
2. Electrophysiologlcal response system.

Electrophysiological response system:

Auditory responses prefaced through the electrophysiological response system manifest themselves as recorded changes in the electrical properties of body structures, as a result of direct (specific) or indirect (non-specific/ mediated) auditory stimulation.

The electrophysiological response system can be further classified as:

1. Electrodermal response (EDR)
2. Electroencephalic response (EER)
3. Electrocardiac response (EKR)

Electrodermal response (EDR):

It involves studying the recordable changes in the electrical properties of the skin. These changes occur as a direct result of either increased or decreased sweat gland activity, and the changes in the electrical properties of the sweet glands is recorded.

Radiological procedures utilizing the electrodermal response (EDR) system is referred to as "Electrodermal audiometry" (EDA). It is also known as "Psychogalvanic skin resistance" (PGSR) and "Galvanic skin response" (GSR) (Bordley and Hardy (1949), Goldstein and Derbyshire (1957).

Electroencephalic responses (EER):

Responses evoked by the auditory stimuli end produced through the electroencephalic response (EER) system are represented as changes in the on-going electrical activity at the cortex. These electrical events can be recorded using scalp electrodes and constitute the Electroencephalogram (EEG) This EEG activity undergoes change when there is sensory stimulation (Berger, 1929).

Audiological procedures employing the EER system have been termed "Eleectroencephalic audiometry"(EEA) (Golstein, and Derbyshire, 1957).

Electrocardiac response (EKR):

The electro-cardiac response is measured as a change upon stimulation in the electrical activity of the heart. This response system is quite non-specific to auditory stimulation and like EDR, EKR is mediated through the autonomic nervous system. The apparent objectivity of eleetrophyaiologic responses must be carefully qualified, since the techniques may be objective but the interpretation of the graphic recording, meter variations or other signals are still open to subjective error.

Radiological procedures employing the EKR system have been termed "Electrocardiac Audiometry" (Goldstein, 1963).

Among a11 these electrophysiological tests, the most commonly used tests are, (a) Auditory Brainstem Response (ABR); (b) Electrocochleography (ECochG)
(c) Middle Latency Response (MLR).

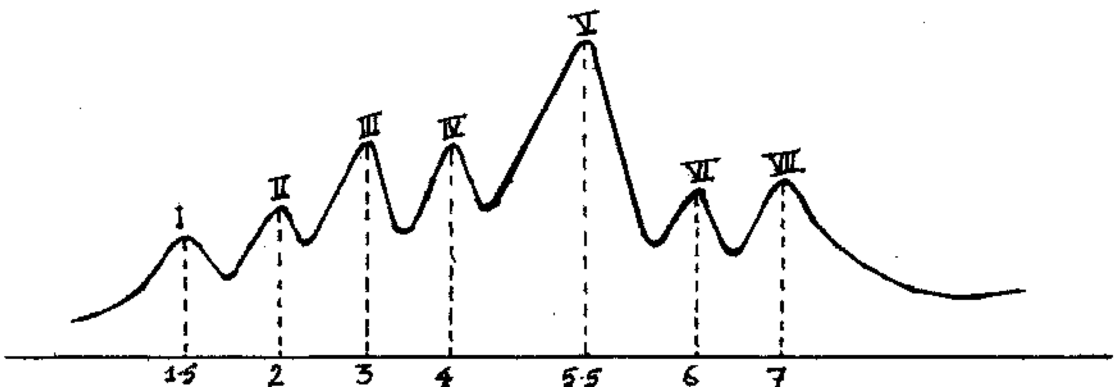
The clinical application of ABR began in the 1970s. These early potentials waveform was first recorded by Sohmer and Feinmesser (1967) and later described by Jewett and Williston (1971).

These auditory evoked potentials can be classified in various ways. One common classification is baaed on the latency "epoch" of response. The various epochs are designated as :

First; 0 - 2 msec.
Fast : 2 - 10 msec.
Middle; 10 - 50 msec.
Slow - 50 - 300 msec.
Late - 300 - and above msec.

Among the above possible, auditory evoked potentials (AEPs) Auditory brainstem responses (ABR) is one of the several clinically useful evoked potentials and is extensively used than other electrophysiological tests. As the name suggests, the origin of these waves is in the brainstem. These waves are identifiable within 10 m.sec. after stimulus onset. Stimuli which are commonly used for electrophysiological tests are; Clicks,brief tonepips, and tone bursts. In a normal person following stimulus presentation, a series of 7 waves have been identified and numbered as wave I, wave II, ... Wave VII. (Jewett and Williston, 1971).

Typical brainstem response is:



The sonree of origin of these 7 waves are as below:

Wave I - Auditory nerve

Wave II - Cochlear nudeus

Wave III - Superior olivery complex

Wave TV - Lateral Lemniscus

Wave V - Inferior Collicolus

Wave VI - Medial Genicnlate body

Wave VII - Auditory radiation.

Among these, wave V is the one which is most identifiable and is often used as a criteria for determining threshold.

The parameters which are considered in interpreting BSERA wave forms are:

1. Absolute latency of the waves

2. Wave form morphology
3. Interpeak latency values
4. Intra aural latency differences
5. Amplitude ratio of V/I waves.

Based on these, diagnosis of hearing loss and identification of possible site of lesion too is possible.

Purpose of this project:

1. To study the advancement in different electrophysiological tests in the recent 3 years.
2. To know the diffrent variables viz. subject variables, administration variables, stimulus variables, which are used in the tests.
3. To Know about the effect of variables of age, sex, normal and disordered.
4. To find out the changes in the auditory system post parameters, methodologies and instrumentations over the years, i.e. last 5 years.
5. It is helpful for researchers, clinicians,students and those who are interested in the field of electrophysiological tests to get organized data and methodology, getting an overall view of research.

They get information on recent advances in technology and methods of testing.

REVIEW OF LITERATURE

Sl. No.	Author	Year	Articles: Experiment	Case study	Subject variables: Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Administration and stimulus variable: Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
1.	Andree D.S. Terence Picton et al	1985	✓	Study of new born babies	31-54 weeks	N.M.	N.M.	Not mentioned	Both fullterm & preterm babies	✓		30 - 70 dBnHL	2 KHz to 4 KHz	Used as standard for Cribogram			61/sec		✓	✓	
2.	Michael J. Wilson et al	1985	-	Parametric studies in human adults	20-31 years	Both	-	Normal Hearing	-	✓		75 - 115 dB SPL	500 Hz, 2KHz & 8 KHz	To observe Bi-naural interaction in ABR			10,20,30/sec		✓	✓	
3.	Jerry L. Vauz et al	1985	✓	To evaluate an earcanal electrode in the ABR testing	18-29 years	N.M.	-	Normal Hg. adults	-	✓		20 - 70 dBSL	500 Hz to 8 KHz	To evaluate the effectiveness of earcanal ele ctrode.			11/sec		1.6 - 2.2msec for I, 5.5 - 6.2 msec for II	✓	
4.	Michael P. Gorga et al	1985	✓	Comparative study	Adults N.M.	N.M.	-	SN hg.loss of cochlear origin	-	✓		80 dBnHL	1K, 2K, 4K & 8K Hz.	Comparisons with Audiograms			12/sec		Seen at 70 to 90 dBnHL	-	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
5.	Gian E.L. Adelina L.W. et al	1985	✓	Summating potentials detection from the human E A M	12 - 67 years	Both	-	Normal hearing	-	✓		83 dB HL	3000 Hz			Used to analyse summating poten trails	Broad band 8.3/sec		-	present in A SP	
6.	Janice A.M. Brenda M . Ryals	1985	✓	Effect of reduced cerebrovascular circulation of ABR	45 -73 years	Male	-	High frequency hearing loss	Reduced carotid blood flow tinnitus	✓		80 dB nHL	N.M.	ABR was used			11.3/sec		✓	✓	
7.	Sally A. Arnold	1985	✓	Objective Vs Visual detection of ABR	24 - 35 years	N.M.	-	Normal	-	✓		40 dB SL	100 to 3 KHz	ABR used			✓			✓	
8.	Dean Linden R, Kenneth B,C et al	1985	✓	Evoked potentials during sleep	23 - 35 years	4 Male 6 Female	-	Normal	-	✓		60 dB SL	500 Hz		MLR used to see the amplitude varn.			✓		✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
9.	Edwards C.G. et al	1985	✓	Ipsilateral contralateral ABR	37 - 43 weeks Neonates	N.M.	–	N.M.		✓		30 dB nHL 70 dB nHL	2 KHz & 4 KHz	ABR used for screening			61/sec, 11/sec			✓	
10.	Anne E. Davis et al	1985	✓	ABR in congenital nystagmus	11 - 56 years	Both	–	Normal	Congenital Nystagmus	✓		80 dB HL		ABR was recorded			10/sec		✓	✓	
11.	Paludetti G. et al	1985	✓	ABR in multiple selerosis	21 - 55 years	Both	–	–	Multiple Selerosis	✓		70 dBnHL	200 to 2000Hz	ABR was measured			21, 51 & 81/sec		✓	✓	
12.	Osterhammel P.A. et al	1985	✓	Effect of sleep on ABR and MLR	25 - 34 years	Only females	–	Normal Hearing	–		✓	30 or 60 dBnHL	2 KHz to 500 Hz	ABR was measured	MLR was also measured		20/sec & 9/sec	✓	✓	-	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
13.	Barajas J.J.	1985	✓	BSERA as neuro-logical test	13 - 53 years	Both	-	Normal hearing	Multiple selerosis	✓		70 dB SL	220 to 3200 Hz	ABR was measured			✓		✓	✓	
14.	Takagin et al	1985	✓	Stimulus freq. on fast and slew ABR	20 - 26 years	Both	-	Normal hearing	-		✓	40 dB nHL	50 to 300 Hz 400 to 1500 Hz	ABR was measured				✓	✓	✓	
15.	Elberlinge & Wahl-green O.	1985	✓	Estimation of ABR by means of Bayesian inference	infants	Both	-	Normal hearing	-	✓		115 dB pe SPL	120 Hz to 5KHz	ABR recordings are made			30/sec		✓	✓	
16.	Airakan-kkunen & Ulf Rosen-hall	1985	✓	Threshold measured by PTA Vs MLR	One month to 50 years	Both	-	Normal and Sensory hg.loss	-	✓		15 dB	40 Hz		MLR was measured			✓	✓		

Sl. No.	Author	Year	Articles: Experiment	Articles: Case study	Subject variables: Age	Subject variables: Sex	Subject variables: Socio-economic status	Subject variables: Hearing normal/abnormal	Subject variables: Other problems	Administration and stimulus variable: Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
17.	Michael P. Gorga et al	1985	✓	ABR in conductive hearing loss	6 years 9 months	Male	—	Conductive hearing loss	—		✓	90 dB & 80 dBnHL	100 to 3 KHz	ABR were measured			13/sec		✓	✓	
18.	Ferguson J.T. et al	1985	✓	BSEP & Blink responses in multiple selerosis	M: 16-53 years F: 11-52 years	Both	—	—	Multiple Selerosis	✓		85 dB	550Hz to 3KHz		BSEP was recorded		20/sec		✓	✓	
19.	Anne E. Davis et al	1985	✓	ABR in congenital nystagmus	11 - 56 years	Both	—	Normal	Conginetal Nystagmus	✓		80 dB HL		ABR was recorded			10/sec		✓	✓	
20.	Ferguson J.T. et al	1985	✓	BSEP & Blink responses in multiple selerosis	M: 16-53 years F: 11-52 years	Both	—	—	Multiple Selerosis		✓	85 dB	550 Hz to 3 KHz		BSEP was recorded		20/sec		✓		

		Articles			Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
21.	Rottereel J.J. et al	1985	✓	BMC - AR composite group avg. in infants	1 - 5 days of age	Both		Not mentioned		✓		30 dB SPL to 70 dB		ABR was measured	MLR was also measured		11.1/sec		✓	✓	
22.	Mori N. et al	1985	✓	ECoG and Gly- cool test in Menierals disease	29 to 64 years	Not mentioned		Hearing loss	Menierels disease	✓		20 dB HL to 45 dB HL	1 to 4 KHz			Extra tympanic ECoG were performed	8/sec		✓	✓	
23.	Rotteveel J.J. et al	1986	✓	Central Auditory canduction	39 to 41 weeks	Not mentioned		Healthy New borns		✓		30 dB SPL to 70 dB	256 Hz to 512 Hz	ABRs were recorded	MLRs were measured	ACRs were also measured	4.7/sec		✓	✓	
24.	Jacobson G.P. et al	1986	✓	P1 in central demyelination	30 years	Male		High frequency hearing loss	Mild dysarthiria	✓		70 dB nHL	150 Hz to 3000 Hz	ABR testing conducted			21.3/sec		✓		

			Articles		Subject variables					Administration and stimulus variable										
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.
25.	Nancy S. Christine Ollo et al	1986	–	BSERA in mentally retarded	26 - 34 years	Both		Mild conductive hg. loss	Mental Retardation	✓		75 dB	4 KHz	ABR recording were used			21/sec		✓	✓
26.	Frank E. Musick et al	1986	✓	Interwave measurements in Acoustic Neuromas	21 - 57 years	Both		SN Hearing loss			✓	80 dB nHL	2 KHz, 4 KHz 8 KHz	ABR used			11.3/sec		✓	
27.	Rosendo Rodrigues et al	1986	–	Effect of intensity and frequency	21 - 44 years	Both		41 normal 22 with Cond.& SN hearing less		✓	✓	55, 70 85 dB pe SPL	500 Hz to 4000 Hz		MLR to evaluate hg. threshold			✓	✓	
28.	Randall C. Beattie et al	1986	✓	Effect of electrode placement	18-28 years	Both		Normal		✓		40 to 70 dB nHL	150 & 3 KHz	ABR was measured			9.2/sec		✓	✓
29.	Paul Kileny & Susan L. Shea	1986	✓	MLR and 40 Hz ERP	18-54 years	Both		Normal		✓		0 to 30 dB nHL	500 Hz to 1 KHz	ABR was recorded	MLR was recorded		9.1/sec	✓	✓	✓

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
30.	Christopher D. Bauch & Wayne O. Olsen	1986	✓	Effect of 2K-4KHz hearing sensitivity	19 - 80 years	Both		Hg.loss cases	Suspected retro-chlear pathology		✓	85 dB nHL	2 KHz to 4 KHz	ABR results were observed			✓		✓		
31.	William D. & Kevin T. Kavanagh	1986	✓	Need and use of digital filtering	22 - 52 years	4 Males,6 Females		Normal	-	✓		70 dB HL	500 Hz to 3 KHz	ABR waveform were used			✓		✓	✓	
32.	James W. Hall	1986	✓	ABR spectral content	21 -76 years	Both		25 Normal	70 acute severely head injured cases	✓		85 dB	200 Hz to 2 KHz	ABR in coma type head-injured cases			✓		✓	✓	
33.	William J. & Anne Greville	1986	-	Audiometric configuration and ABR	Mean age 43.4yrs	Both		Normal	Cochlear hg. loss	✓		30 dB pe SPL	150 to 3000 Hz	ABR was measured			21/sec		✓		

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
34.	Kevin T. Kavanagh & William D. Domico	1986	-	Effect of high pass filter	22 - 52 years	N.M.		Normal	-		✓	70 dB & 40 dB nHL	100 Hz & 200 Hz		MLR wave form was detected		9.7/sec		✓		
35.	Paul R. Kileny & Joni Peters Kripal	1986	✓	Test re-test variability	17 - 37 years	N.M.		Normal	-		✓	60 dB nHL	1000 & 1500 Hz	ABR was used				1.7/sec	✓	✓	
36.	John T. Jacobson et al	1986	✓	ABR rate in multiple selerosis	24 - 57 years	Both		Not mentioned	suspected brainstem	✓	✓	70 dB SL	150 to 3 KHz	ABR was recorded			10, 33, 67 80 per sec.	✓	✓	✓	
37.	Alison M Grimes, Cheryl L. Grady & Anita Pikns	1986	✓	AEPs in dimension of the Alzheimen type	43 - 78 years	Both		Normal and SN hg. loss cases	Patients with the dimension of the Alzheimen type	✓		100 dB pe SPL	200 to 2000 Hz	ABR was used	MLR was also used		11 & 66/sec 9/sec		✓	✓	

Sl. No.	Author	Year	Articles: Experiment	Articles: Case study	Subject variables: Age	Subject variables: Sex	Subject variables: Socio-economic status	Subject variables: Hearing normal/abnormal	Subject variables: Other problems	Administration and stimulus variable: Monaural	Administration and stimulus variable: Dicotic	Administration and stimulus variable: Intensity	Administration and stimulus variable: Frequency	Administration and stimulus variable: BSERA	Administration and stimulus variable: MLR	Administration and stimulus variable: ECochG	Administration and stimulus variable: Clicks	Administration and stimulus variable: Tone burst/pips	Administration and stimulus variable: Latency difference	Administration and stimulus variable: Amplitude difference.	Administration and stimulus variable: Symmetry
38.	Peter Paulsen & Janne Hartvig Jensen	1986	✓	BSER & electro nystagmography	35 - 49 years	Both		—	Chronic toxic encephalopathy		✓	N.M.	2000 Hz	BSERA was done			20/sec		✓	✓	
39.	Ben-David J. et al	1986	✓	Auditory Brain stem evoked potential	Adults	Both		Diabetes Mellitus	Idiopathic peripheral facial palsy	✓		75 dB HL	100 to 3000Hz	ABEP were recorded			10 & 40/sec		✓	✓	
40.	Holdstein Y. et al	1986	✓	ABEP in a symptomatic lead-exposed	8 - 56 years	Both		—	Exposed to lead through food	✓		75 dB HL	100 to 3000Hz	ABEP were recorded			50/sec		✓	✓	
41.	Vanden Honert C. & P.H.Stypul Kowski	1986	✓	ABR characteristics in Cat and Human	Adult	N.M.		Implaned Cochlear prosthesis		✓		90 dB peak . SPL	3 KHz	ABR were recorded			25/sec		✓	✓	
42.	Kimitaka Kage etal	1986	✓	ABR and behavioral responses in pre term infants	40 weeks	Not mentioned(N.M.)			Pre-term infants	✓		85 dB HL	3000 Hz	ABR was recorded			10/sec		✓	✓	

Sl. No.	Author	Year	Articles		Subject variables					Administration and stimulus variable											
			Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
43.	Quaranta A Minini F & Longo G.	1986	✓	ABR in multiple Selerosis	9 - 59 years	Both		Normal hearing	Multiple Selerosis	✓		100 dB p.e. SPL	200 to 2000Hz	ABRs were recorded			21/sec		✓		
44.	Lankli E. & Mair W.S	1986	✓	Frequency specificity of ABR	Adult	Not mentioned		Normal hearing subjects		✓	✓	70 dB nHL to 90 dB, 96 dB	2 KHz to 8 KHz & 0.5 KHz	ABR was obtained			22.3/sec	✓		✓	
45.	Rosenhall Ulf et al	1986	✓	Effect of prespycusis on ABR	50 - 70 years	Both		Sensory Neural hearing loss		✓		80 dB nHL	150 - 2500 Hz	ABR Audiometry was performed			25/sec		✓		
46.	Kevanishvili Z & Lagidze Z.	1987	✓	Electric responses and MLD	26 - 43 years	Not mentioned		Normal Hearing			✓	7 to 22 dB & 60 dB	580 Hz	ABR was measured	MLR was recorded	SCPs were registered		Pips	✓		

		47.	48.	49.	50.
	Sl. No.	47.	48.	49.	50.
	Author	Svensso Owe et al	Elberling C. and Parbo J.	Elberling C. and Don M.	Randal C. et al
	Year	1987	1987	1987	1987
Articles	Experiment	✓	✓	✓	✓
	Case study	Low frequency & analog filter--ing on ABR	Reference data for ABRs	ABR detection function	Amplifier type and electrode placement
Subject variables	Age	20 - 53 years	20 - 30 years	20 - 30 years	21 - 40 years
	Sex	Both	Both	Both	Not mentioned
	Socio-economic status				
	Hearing normal/abnormal	Normal hearing	Normal patient	Normal hearing	Normal
	Other problems		No Neurological disease		
Administration and stimulus variable	Monaural	✓	✓	✓	
	Dicotic				✓
	Intensity	70 dB SL	95 dB to 115 dB SPL	34 to 52 dB pe SPL	70 dB nHL
	Frequency	350 to 1700 Hz	120 Hz to 5 KHz	100 to 3 KHz	3 KHz to 6 KHz
	BSERA	ABR was recorded	ABR was tested	ABR was tested	
	MLR				AEPs were recorded
	ECochG				
	Clicks	✓	✓	✓	✓
	Tone burst/pips			4.8/sec	11.1/sec
	Latency difference		✓		✓
	Amplitude difference.	✓	✓	✓	✓
	Symmetry				

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
51.	David A.P. Donald A.S. David N. Rose	1987	✓	ABR Screening in neonates with Cribo-Gram	New borns	Both		Not known		✓		30 dB screening threshold	Not mentioned	ABR and Cribo-o-Gram were used			✓		✓	✓	
52.	Paul R. Ki-leny & Meredith G. Magathan	1987	✓	Predictive value of ABR	Pre School ages cases	Both		Moderate to profound hearing loss			✓	-	1 KHz to 8 KHz	ABR threshold obtained			✓	Pips		✓	
53.	Michael P. Gorga et al	1987	✓	High frequencies ABR	Adult	N.M.		Normal	H/O noise exposure and Rxwith ototoxic drugs	✓		100 dB SPL	9 KHz to 16 KHz	ABR Responses				44/sec	✓		
54.	Edward Y. Allen L et al	1987	✓	Developmental Bone conduction ABR	Neonates 1 yr old infants	N.M.		Considered Normal			✓	15, 25 35 dB nHL	500 & 1600 Hz	ABR Responses			30/sec			✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monautal	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
55.	Abramovich J.S. et al	1987	✓	Hearing detection using BSER	Within 24 hours	Both		High risk babies		✓		30 - 40 dB nHL	2 KHz & 4 KHz	BSERA was done			40/sec		✓	✓	
56.	Abramovich J.S.	1987	-	Acoustic tumour investigation by ABR	25 - 65 years	Both		Normal		✓		95 dB nHL	4 KHz	ABR were recorded			✓		✓	✓	
57.	Wilder A. et al	1987	✓	ABEP in sudden deafness	21 - 80 years	N.M.		Sudden hearing loss		✓		75 dB HL	100 to 3000 Hz	ABEP were recorded			10 & 40/sec		✓	✓	
58.	Paul H. Stypul Kowsk &	1987	✓	...hG ...trode ...uation	...bjects not mentioned	...ale-31 ...emale-2		Normal		✓		...dB nHL	...0Hz to ...000 Hz			...hG responses were elicited	1/sec			✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
59.	Rotteveel J.J. et al	1987	✓	ACR in preterm infants	25-52 weeks	N.M.			preterm infants until 3 months	✓		70 dB	30 to 3 KHz		ACR was recorded		11/sec		✓	✓	
60.	Rotteveel J.J. et al	1987	✓	ABR in preterm infants	25-52 Weeks	N.M.			Preterm infants until 3 months	✓		70 dB	30 - 3 KHz	ABR was recorded			11/sec		✓	✓	
61.	Rotteveel J.J. et al	1987	✓	ABR & MLR in preterm infants	25 - 52Weeks	N.M.			Preterm infants	✓		30-80 dB	30 to 3KHz	ABR was recorded	MLR was recorded		11/sec		✓	✓	
62.	Kathleen C.M. Campbell & Paul J. Abbas	1987	✓	Effect of stimulus repetition rate on ABR	24 - 83 years	N.M.		SN hearing loss	Cochlear & Acoustic neuroma patients	✓		25-105 dB HL &10-70 dB HL	2000 Hz & 4000 Hz	ABR were recorded			9.7, 49.7, 39.7/sec		✓	✓	
63.	Michael P. Gorga et al	1987	✓	ABR from ICN graduates	33 - 44 weeks	N.M.		Suspected normal		✓		20 - 80 dBnHL		ABR was recorded			13/sec		✓	✓	
64.	Steen Gimsing	1987	✓	BR arte act caused y calorie esting	7 years	emale		ormal		✓		15 dB SPL	000 Hz	BR was ecorded	✓		0/sec		✓	✓	

Sl. No.	Author	Year	Articles: Experiment	Articles: Case study	Subject variables: Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Administration and stimulus variable: Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
65.	Sturzebec--her E and Werbs M.	1987	✓	Effect of age & sex on ABR	35 - 50 years	Both		Normal		✓		115 dB pe SPL	30 Hz to 3 KHz	ABR was investigated	MLR was measured		10/sec		✓	✓	
66.	Thornton A.R.D. et al	1987	✓	Objective estimation of LDL	20 - 40 years	Both		Normal		✓		10 to 30 dB below LDL	2 KHz to 4 KHz	ABR recording taken			✓		✓	✓	
67.	Gerwell G. et al	1987	✓	BSR to single slope stimuli	25 - 45 years	Both		Normal hearing loss			✓	92 dB nHL	3000 Hz to 5KHz	ABR was recorded			✓		✓	✓	
68.	Barajas J.J. et al	1988	✓	MLR to Tone pip	14 - 34 years 7 - 80 years	Both		Normal hearing loss		✓		50 dB nHL	500 Hz		MLR was measured		9.3/sec	pips	✓	✓	

Sl. No.	Author	Year	Articles: Experiment	Articles: Case study	Subject variables: Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Administration and stimulus variable: Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
69.	James W. Hall Joan M. Bull et al	1988	–	ABR and Temperature	11 & 23 yrs.	Male		Not mentioned	Head injury. Hyperthermic for advanced cancer	✓		85 dB nHL	30 to 3 KHz	ABR measurements			11.1 to 21.1/sec		✓		
70.	Michael P. Gorga Jan R.Kawinski, & Kathryn A Beauchaine	1988	✓	ABR using an Insert earphone	Infants	N.M.	Graduates from intensive care nursery	Abnormal hearing		✓		20 to 80dB nHL		ABR were recorded			13/sec		✓	✓	
71.	Nina Kraus and Therese Mc Gee	1988	✓	MLR colour mapping	Adult - N.M.	N.M.		Normal		✓		70 dB HL	500 & 2000 Hz	MLR activity is measured			9/sec 41/sec		✓	✓	
	James Jerger & Steven Johnson	1988	✓	ABR latency effect of age, sex, & HL	14 - 80 years	Both		SN hearing loss	Retro Cochlear lesion	✓		60 dB to 100 dB HL	500, 1K & 2 KHz	ABR was measured			11. 1 to 21.1/sec		✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
73.	Aksel Grontmed et al	1988	✓	ABR in Dyslexic and Normal children	10 - 17 years	Both	Children of primary school	Normal hearing	Dyslexic	✓		100 to 110dBSPL	250Hz to 4 KHz	ABR was recorded			20/sec		✓		
74.	Randall C. Beattic	1988	✓	Interaction of Click Polo.Stim level and repn. rate on ABR	18-28 years	Both		Normal hearing			✓	60,75 & 90dBnHL	150 - 3000 HZ	ABR was recorded			2.3 & 9.2/sec		✓	✓	
75.	Vishaka Rawool & Stanley Zerlin	1988	✓	Phase, int effect on ABR	25 - 35 years	Female		Normal subjects		✓		35 dB 85 nHL	100 - 3000Hz	ABR was measured			5.5/sec		✓	✓	
76.	Stanley Zerlin	1988	✓	Half-sine stimuli and ABRI wave	Adults	Female		Normal		✓		90 dB SPL	1KHz to 8KHz	ABRs were recorded			11/sec		✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
77.	Maurizi M. et al	1988	✓	ABR and sex in infancy	360 - 720 days	Both		Normal infants		✓		70 dB nHL	200 to 2000 Hz	ABR was measured			21/sec		✓	✓	
78.	Lanklio E. et al	1988	✓	0.5 KHz ABR Threshold	8 - 2.33 months	N.M.		Not known	Multi handicapped Juveniles	✓	✓	96 dB/Octave 80 dB nHL	2 KHz	ABRs were recorded				21.3/sec	✓	✓	
79.	Stanley Zerlin	1988	✓	Band limited clicks and ABR	Adult - N.M.	Female		Normal		✓		90 dB SPL	1K, 2K & 4KHz	ABR was recorded			11/sec		✓	✓	
80.	Cynthia G. et al	1988	✓	Adding and subtracting ABR wave	27 - 29 years	N.M.		Normal in one ear	Congenital Profound SN in one ear	✓		100 dB SPL	150 to 3000Hz	ABR was recorded				25/sec	✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
81.	Moffat D.A. et al	1988		ABR in acute severe head injury	Adult	Both		Head injury cases				85 - 90 dBHL	300 to 3000 Hz	ABR were recorded				21.1/sec			
82.	Lan S.K. et al	1988	✓	BAEP after itradiation of nasophal ca	58 yrs & 49 yrs	Male			Tinnitus & blood stained nasal discharge	✓		70 dB nHL	200 to 2 KHz	BEAP was measured				10/sec	✓	✓	
83.	Purmessur M N S et al	1988	✓	BERA in Δ of deafness in children	18 months	Both		Normal	Multiple handicapped	✓		110 dB	1000 Hz	BERA was done			✓		✓	✓	
84.	Michael P. Gorga et al	1988	✓	Tone burst ABRs	Adult	Not mentioned		Normal		✓		20 to 100 dBSPL	500, 2K & 8 KHz	ABR was recorded				44/sec	✓	✓	

		Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
85.	Lesley A. Jones & Richard J. Baxter	1988	✓	MLR in sleep	23-30 years	Both		Normal			✓	45 dB SL	500 Hz & 4000 Hz	ABRs were recorded	MLR were recorded		✓	Pips	✓	✓	
86.	F.Grandon et al	1988	✓	Peak inhancement in ABR	18 - 25 years	Both		Normal		✓		50 dB to 100 dB SPL		ABRs were recorded			11 to 21/sec		✓	✓	
87.	Bell-I-E. & Thornton A.R.D.	1988	✓	ABR threshold estimation technique	Not mentioned	Not mentioned		Normal		✓		20 dB to 70 dB SL	2 KHz & 4 KHz	ABR was recorded			30/sec	30/sec	✓	✓	
88.	Sherri MD & Newell T.D.	1988	ı	Frequency dependence and binaural interaction	20 - 35 years	Both		Normal		✓		70 dB nHL	500 Hz to 4 KHz		ABR was elicited		11.1 to 21.1/sec	23/sec	✓	✓	
89.	Jos J. Eggermont & Alan Salamy	1988	✓	ABparameters preterm and m infants	12 weeks to 5 years	Both		Full term Preterm infants		✓		60 dB nHL	100 to 3000 Hz		ABRs were recorded		15/sec		✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
90	Kavin T. Kavanagh William D. et al	1988	✓	Digital filtering of the low frequency ABR	22 - 52 years	Not mentioned		Normal subjects		✓		35 to 75 dB	100 Hz high pass	Measurement of ABR			9.7/sec		✓		
91	Lynn G.S. Michael R. Seitz	1988	✓	Asymmetry and Binaural Interaction	Mean age 22.3 years	12 male 12 female		Normal		✓	✓	50 dB & 70 dB	150 to 3000 Hz	ABRs were obtained			11/sec			✓	
92	Cynthia G. Fowler & Robert S. Broadard	1988	-	Binaural Interaction Component of the ABR	20 - 35 years	All females		Normal adult		✓		100 dB HL	150 to 3000 Hz	ABR Recorded				10, 25 50/sec	✓	✓	
93	Buller N. et al	1988	✓	Delayed ABER in diabetic patients	Adult	Not mentioned		Normal	Diabetic patients		✓	115 dB SPL		ABER was measured			10/sec		✓		

Sl. No.	Author	Year	Articles: Experiment	Articles: Case study	Subject variables: Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Administration and stimulus variable: Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
94.	Irvin J. Gerling	1989	✓	Stimulus parameter interaction. A normal variant.	22 - 55 years	Male		Hearing loss with Cochlear pathology	Noise induced hearing loss		✓	60 to 80 dBnHL	100 to 3000 Hz	ABR were recorded			10 - 33/sec		✓	✓	
95.	Kevin T. Kovanagh et al	1989	✓	ABR/MLR in the mentally handi capped	8 months to 32 years	Both		Normal hearing	Mentally handicapped		✓	30 dB nHL with 10 dB increment	15 to 3 KHz 15 to 250	ABR was recorded	MLR was recorded		9.7/sec		✓	✓	
96.	Frank E Musiek et al	1989	✓	ABR, ILD in patients with brain stem lesions	23 -71 years	Both		Hearing loss	Brainstem lesion	✓		80 dB& 90 dB nHL	150 Hz to 3 KHZ	ABR was measured for ILDs measurement			11 - 15/sec		✓		
97.	Anita Maiste & Terence Picton	1989	✓	Evoked poten- tials to frequency modulated tones	23 - 42 years	N.M.		Normal hearing			✓	40 to 70 dB HL	750 to 1250 Hz		ditory evoked tentials were tained			✓	✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
98.	Lenzi A. et al	1989	✓	ABR and MLR in elderly subjects	60 - 85 years	Both		Normal		✓		15 and 50 dB SL	1000 Hz 200Hz to 2KHz	ABR was recorded	MLR was recorded		✓	✓	✓	✓	
99.	Suzanne C. Purdy et al	1989	✓	Frequency specific ABR masking levels	18 - 30 years	Both		Normal			✓	28.6 & 36.6 dB pe SPL	500 Hz and 4 KHz	ABR was recorded				Pips	✓	✓	
100.	Randall C. Beattie & Leslie A Taggart	1989	✓	Electrode position and mode of recording	21 - 38 years	Both		Normal		✓		15 to 75 dB	500 Hz to 6000 Hz	ABR was recorded			✓		✓	✓	
101.	Milford C. A. and Birchall J.P.	1989	✓	Steady, State-Auditory evoked potentials	41 - 82 years	Both		Hearing loss patients		✓		16 to 27 dB HL	2 KHz and 8 KHz		AEPs were recorded			Pips	✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
102.	Pratt H. Urbach D. Bleich N.	1989	✓	FIR filters for peak identification	19 - 31 years	Both		Normal		✓		15, 45, 75 dB nHL	10 to 3 KHz		ABEP was recorded		10/sec		✓	✓	
103.	Debruyne & Tyberghein J.	1989	✓	Age effect in speech audiology and in BERA	31 - 69 years	Both		Normal			✓	100 dB SPL	2 KHz	ABR was recorded			21/sec & 63/sec		✓	✓	
104.	Pelizzone M. et al	1989	✓	EER in Cochlear Imprant patients	19 - 67 years	Both		deaf		✓		80 dB SPL	1000Hz & 3KHz	ABR was recorded	MLR was recorded			✓	✓	✓	
105.	Vander Dreft J.F.C.	1989	✓	BERA, Estimation of cord hearing loss	10 - 85 years	Both		Normal Cochlear loss, cord loss mixed loss			✓	15 dB to 85 dB SPL	2KHz to 4 KHz	ABR was recorded					✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-econo-mic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
106	John A. Ferraro & Roxann Ferguson	1989	✓	Tympanic ECochG and conventional ABR	Adult	Not mentioned		Normal hearing & hearing impaired	Confirmed acoustic tumours	✓		16 dB nHL to 76 dB nHL	150 to 3000 Hz	ABR potential were recorded		ECohG recording were made	11.3/sec		✓	✓	
107	Michael P. Gorga et al	1989	✓	ABRs from children	3 months to 3 years	Not mentioned		Normal		✓		80 dB HL to 20 dB HL	100 to 3KHz	ABR was recorded			13/sec		✓	✓	
108.	Moffat D.A. et al	1989	✓	Contralateral ABR in acoustic neuroma	Adult	Male & Female		Tumours of cerebello routine angle	Unilateral acoustic neuroma	✓		70 dB	3000 Hz	ABR was recorded			18.7/sec		✓	✓	
109	Aler G. Alder J.	1989	✓	Influence of dtimulus intensity on AEP	19 - 30 years	Both		Normal			✓	30 to 90 dB SL	1 KHz		AEPs were recorded		✓		✓	✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/ abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/ pips	Latency difference	Amplitude difference.	Symmetry
110.	Fjermedal O. and Einar Lankli	1989	✓	ABR and Puretone threshold	2 months to 20years	Both	Delayed speech development	Suspicion of hearing loss	Multi handicapped Juveniles	✓		70 dB nHL to 100 dB nHL	2 KHz	ABR threshold were determined				22.3/sec	✓	✓	
111.	Vishakha W. Rawool	1989	✓	SRS & ABR in Cochlear impairment	40 - 60 years	Male		Moderate hearing loss	Cochlear pathology	✓		90 dB nHL	100 to 3000Hz	ABR was recorded			5.5/sec		✓	✓	
112.	Oddbjorn Fjermedal & Einar Lankli	1989	✓	Low level low frequency ABR	24 - 42 years	Both		Normal		✓		75 dB nHL to 100 dB peak BPL	500Hz to 1 KHz	ABR was recorded				22.3/sec	✓	✓	
113.	Michael P. Gorga & Aaron R. Thornton	1989	-	The choice of stimuli for ABR measurements	Not mentioned	Not mentioned		Stimuli is described for ABR		✓		80 dB SL	6 KHz to 8 KHz	ABR measurements			✓			✓	

			Articles		Subject variables					Administration and stimulus variable											
Sl. No.	Author	Year	Experiment	Case study	Age	Sex	Socio-economic status	Hearing normal/abnormal	Other problems	Monaural	Dicotic	Intensity	Frequency	BSERA	MLR	ECochG	Clicks	Tone burst/pips	Latency difference	Amplitude difference.	Symmetry
114.	Robert A Dobie and Michael, J. Wilson.	1989	✓	AEPs by magnitude squared coherence	21 -33 years	Not mentioned		Normal		✓		70 dB	500 Hz to 1000 Hz	ABR and an apparent myogamic response			20/sec		✓	✓	
115.	Daniel,M Schwartz, et al.	1989	✓	ABR in preterm infants	24 - 38 weeks	10 Males 10 Females		Low birth weight hyperbili rubinemia	Respiratory distress, sepsis	✓		30 yo 95 dB 80 dB nHL	100 to 1500 Hz	BSER was recorded			✓		✓	✓	

Percentage of articles studied in different variables.

Administration and Stimuli variable	Subject variable.			
	Adult		Infant	
	Normal	Abnormal	Normal	Abnormal
1. Brainstem evoked response.	41	26	13	10
2. Middle latency response	14	5	3	
3. Electrocochleo-graphy	3	3	2	1
4. Monoaural	36	25	12	12
5. Dichotic	17	8	2	2.5
6. Clicks	41	27	13	8.5
7. Tone pips	5	2	0	1
3* Tone burst	8	2	2	3

CONCLUSIONS

Electrophysiological response systems manifest themselves as recorded changes in the electrical properties of body structures, as a result of direct or indirect auditory stimulation. The articles which have been studied so far reflect the following conclusions:

1. Around 95% of the articles are experimental studies and others are reviews.
2. 58% experimental studies have been conducted on adult normals and 34% studies have been onducted on abnormal adult subjects.
3. In 30-35% articles, the exact age and sex of the subjects have not been mentioned.
4. Normal infants and children have been studied in 18% of articles where as, abnormal infants and children have been studied in 14% of articles.
5. In 90% of the articles clicks of different frequencies have been used. The rate of clicks varied from 9/sec. to 64 clicks per sec. This shows that clicks are the most valid and reliable stimuli for electrophysiological tests.
6. BSER was recorded from subjects in 90% of the studies which shows that a majority of the research still centers around BSER. It is found to be useful in differential diagnosis

of cochlear & retrocochlear lesions sensori-neural from conductive lesions both in adults and children. This has been found to be useful in diagnosis of the multiplyhandi capped to find out organic lesions and detection of hearing in non-cooperative subject..

7. Though more interest is seen in MLR, it is basically centered around normal Mults (14% articles on normall adults, 3% on normal infant, 5% on abnormal adults and 3% on abnormal infante) in establishing norms.

8. Other stimuli such as tone pips and tone bursts have been used. 8% and 15% respectively in articles, which shows that these are loosing their effectiveness in electrophyslological tests.

9. The stimuli were presented monoaurally in 85% of studies where as it was presented dichotically in 28% of the experimental studies.

10. The clinical use of eleetrophysiological tests are not restricted to measurement of auditory threshold. Detailed analysis of EcoehG responses show consistent varieties, in several types of heating impairment. It may also be used to monitor the electrophysiological changes which occur within the cochlea after some event such as the infusion of a drug.

Finally one must remember that each class of auditory electrical response has its own theoretical and practical advantages for electrical response audiometry (ERA) choices must be made according to particular objectives and with respect to possible limiting conditions. Results of the ERA cannot stand alone and they mast be interpreted in the context of other clinical information.

BIBLIOGRAPHY

Abramovich, s.J. (1987): ABR and computed tomography in acoustic tumour investigations. Journal of Laryngology and Otology, 101(5', 334- 342.

Abramovieh, s.j., Hyde, M.L., Rik, K. tad Alberti, P.w. (1987): Early detection of heating loss in high risk children using BSERA. Journal of Laryngology and Otology, 101(2), 120-12.

Arnold, S.A. (1985): Objective versus visual detection of the ABR. Bar and Hearing, 6(3), 144-150.

Barajas, J.J. (1985): BSERA as subjective and objective test for neurological diagnosis. Scandinavian Audiology, 14(1), 57-62.

Bell, J.E. and Thornton, A.R. (1980): Measures for the optimum estimation of audiometry threshold from the ABR potentials. British Journal of Audiology, 22(l), 21-28.

Buller, N., Shrili, Y., Saurian, N., Laurian, L. and Zohar, Y. (1988): Delayed BAERs in diabetic patients. Journal of Laryngology and Otology, 102(10), 957-863.

Christopher, D.B. and Olsen, W.O.(1986): The effect of 2000-4000 Hz hearing sensitivity on ABR results* Ear and Hearing, 7(5), 314-317.

Collet, L., Chanal,J.M., Hellal, H., Gartner, M and Morgan, A. (1989). Validity of bone conduction stimulated ABR, MLR and Otoacoustic emissions, Scandinavian Audiology, 18(l), 43-46.

Daniel, A.S.(l987): ABR laboratory norms: when is the data base sufficient. Ear and Hearing, 8(1), 56-60

David, J.B. Gertner, R., Podeehin, L. Fradis, M. Pratt, H. and Rabina, A. (1986): Auditory brain stem evoked potentials in patients suffering from peripheral facial nerve palsy and diabetes maleiths. the Journal Laryngology and Otology, 100(6), 629-633.

Davis, A.E., Maw, A.R. and Coleman, M(1985): Acoustic brainstem eletrical responses in congenital nystagmus. Journal of Laryngology and Otology* 99(2), 147-150.

Dean, L.R., Campbell, K.B., Gilles, H. and Picton,T.W. (1985): Human auditory steady state evoked potentials during sleep. Ear and Hearing, 6(3), 167-174.

Devries, S. Decker. T.N. (1988): Frequency dependence of inter ear asymmetries and binaural interaction in the human ABR. Ear and Hearing. 9(5), 275-282.

Dobie, R.A. and Wilson, M.J. (1989): Analysis of AEPs by magnitude squared cofernce Ear and Hearing, 10(1),. 2-13.

Edward, C.G., Smith, A.D. and Picton, T.w. (1985): Neonatal auditory brainstem responses from ipsilateral and contralateral recording montages. Ear and Hearing, 6(4), 175-178.

Eggermont, J.J. and Salamy, A. (1988): Development of ABR parameters in a preterm and a term born population. Ear and Hearing, 9(5), 283-289.

Elberling, C. and Don, M. (1987): Detection functions for the human ABR. Scandinavian Audiology, 16(2),89-92.

Elberling C and Parbo, J. (1987): Reference data for ABR in retrocochlear diagnosis. Scandinavian Audiology, 16(1), 49-55.

Elberling, C. Wahlgren, 0 (1985): Estimation of auditory brainstem responses (ABR) by means of bayesian infers nce, Scandinavian Audiology, l:(2); 89-96.

Ferguson, I.T. Ramsden, R.T. and Hythogue, M. (1965): Brainstem auditory evoked potentials and blink reflexes in multiple sclerosis. The Journal of Laryngology and Otology, 99(7), 677-683.

Ferraro, J.A. and Ferguson, R. (1989): Tympanic EcochG and conventional ABR: A combined approach for the identification of wave I and I-v interwave interval. Bar and Hearing, 19(3), 161-166.

Fjermedal, 0. and Lanki, E. (1989): Paediatric audiology brain stem responses and pure tone audiometry threshold comparisons. Scandinavian Audiology, 18(2), 105-112.

Fowler, C.G., and Broadard, R.S.(1988): Low frequency activity in the binaural interaction component of the ABR. Ear and Hearing 9(2), 65-69.

Gerling, I.J. (1989): Interaction of stimulus parameters on the ABR: A normal variant. Ear and Hearing, 10(2), 117-123.

Gian, E.G., Wirch, A.L., Edwards, K.H., Turella, G.S., Kaufman, M.A., and Snyder, J.M.(1985): Coehlear summating potential to broad band clicks detected from the human external auditory meatus. A study of/subjects with normal hearing for age. Ear and Hearing, 6(3), 130-139.

Gimsing, S. (1987): ABR artefact caused by caloric testing. British Journal of Audiology, 2l(4), 301-303.

Gorga, M.P., Kawinski, J.R. and Kathrya, A.B. (1987): ABR to high frequency tone burst in normal hearing subjects. Ear and Hearing, 8(4), 222-223.

Graaf, R., De., Colon, E.J., Stegeman, D.F. and Visco, Y.M. (1987): The maturation of the central auditory conditions in pre term infants until 3 months, post term: a composite group average of ABR, MLR, AER. Hearing research, 26, 21-35.

Grandori, F.,Bonfioli, F., Peretti, G. and Autonelli, A.R. (1988): A method of digital filtering to enhance the peaks of evoked potentials: Application to ABR. British Journal of Audiology, 22(3), 171-178.

Grimes, A.M., Grady, C.L., and Pikus, A. (1987): AEPs in patients with dementia of the Alzheimer type. Ear and Hearing, 8(3), 157-161.

Grontred, A., Walter, B. and Gronborg, A (1988): ABR in dyslexic and normal children. Scandinavian Audiology, 17(l), 53-54.

Hall, J.W., Bull, J.M. and Cronau, L.H. (1988): Hypo and hyper thermia in clinical ABR measurement: Two case reports. Ear and Hearing, 9(3), 137-143.

Holdstein, H. Pratt, H., Goldsher, M. Rosen, G., Shenlar, R. Linn, S., Mor, A., and Barkai, A (1986): ABEP in asymptomatic lead exposed subjects. Journal of laryngology and otology, 100(9), 1031-1038.

Jacobson, G.P., Means, E.P. and Dhib-Jal-But. S. (1986): Delay in the absolute latency of ABR: Component P in acute inflammatory demylinating disease. Scandinavian Audiology, 15(2), 121-124.

Jacobson, J.T., Murrary, T.J., and Deppe, V. (1987): The effect of ABR stimulus repetition rate in multiple sclerosis. Ear and Hearing, 8(2), 115-120.

James, W., and Hall III (l986): ABR spectral content in comatose head injured patients. Ear and Hearing, 7(6), 383-389.

Janice, A.M. and Ryals, B.M (1985): The effect of reduced cerebrovasculaar circulation on the ABR. Ear and Hearing, 6(3), 139-143.

Jerger, J., and Johnson, K. (1988): Interaction of age, gender and sensory hearing loss on ABR latency. Ear and Hearing, 9(4), 168-176.

Jerger, J. Rose, C. James, D.F. and Newton, C (1986): Effect of sleep on the auditory steady state evoked potential. Ear and Hearing, 7(4), 240-245.

Jerry, L.Y. and Dodds, H.J. (1985): An ear canal electrode for the measurement of the human ABR. Ear and Hearing. 6(2), 98-104

Jones, L.A. and Baxter, R.J. (1988): Changes in the auditory middle latency response during all night sleep recordings. British Journal of audiology, 22(4), 279-288.

Kaga, K., Hashira, S. and Marsh, R.R. (l986): Auditory brain stem responses and behavioural responses in pre term infants. British Journal of Audiology, 20(2), 121-128.

Kathleen, C M . and Abbas, P.J. (1987): The effect of stimulus repetition rate on the ABR in tumour and/non-tumor patient. Journal of Speech and Hearing Research, 30, 494-502.

Keith, W.J. and Greville, K.A. (l987): Effects of audiometric configuration on the auditory brainstem response. Ear and Hearing,8(1), 49-55.

Kevin, T.K. and William, D.D. (1987): High pass digital and analog filtering of the MLR. Ear and Hearing, 8(2), 101-109.

Kevin, T.K., William, D.D., Franks, R. and Hangin, E. (1988): Digital filtering and spectral analysis of the low intensity ABR. Ear and Hearing, 9(1), 43-47.

Kevin, T.K., Herbert, G., McComick, G. and Franks, R.(l989): Comparison of the identifi ability of the low intensity ABR and MLR in the mentally handicapped patient. Ear and Hearing, 10(2), 124-130.

Kileny, P.R. and Kripal, J.P. (1987): Test retest-validity of auditory event-related potentials. Ear and Hearing, 8(2), 110-114.

Kileny, P.R. and Magathan, M.G. (1987): Predictive value of ABR in infants and children with moderate to profound hearing impairment. Ear and Hearing, 8(4), 217-229.

Kraus, N. and Thearese, M.G. (1988): Color imaging of the human MLR. Ear and Hearing, 9(4), 159-167.

Lau,S.K., Weri, W.I. Choy, D., Shum, J. and Enazell, U.C.G. (1988): BAEPs after irradiation of nagopharyngeal carcinoma. Journal of laryngology and otology. 102(12), 1142-1148.

Lynn, G.S. and Michael, R.S. (1988): Response asymmetry and binaural interaction in the ABBR. Ear and Hearing, 9(2), 57-64.

Maiske, A. and Picton, T.(1989): Human AEPs to frequency modulated tones. Ear and Hearing, 10(3), 153-160.

Manrizi, M. Ottaviani, F. Paladetti, G., Almadori, G., Pierri, F. and Rosignoli, M (1988): Effect of sex on ABR in infancy and early childhood. Scandinavian audiology, 17(3), 143-146.

Michael, P.G., Kaminski, J.R. and Kathryn, A.B. (1988): ABR from graduates of an intensive care nursery using an insert earphone. Ear and Hearing, 9(3). 144-147.

Michael, P.G., Kamiski, J.R.,Kathryn, A.B. and Jesteadt, W. (1988): ABR to tone burst in normally hearing subjects. Journal of Speech and Hearing Research, 31, 37-97.

Michael,P.G., Kaminiski, J.R., Kathryn, A.B., Jesteadt, W. (1989): ABRs from children three months to 3 years of age, normal patterns of response. Journal of Speech and Hearing Research, 32, 281-288.

Michael, P.G., Reilord, J.K. and Kathryn, A.B. (1985): Auditory brainstem response in a case of high frequency conductive hearing loss. Journal speech and Hearing Disorder, 50, 346-350.

Michael, P.G. Reiland,J.K., Kathryn, A.B., Worthington, D.w. and Jesteadt, W. (1987): ABR from graduates of an intensive care mersery. Normal patterns of response. Journal of Speech and Hearing Research, 30, 311-318.

Michael, P.G., Worthington, D.W., Reiland, J.K. Kathryn, A.B. and David, E.G. (1985): Some comparisons between ABR thresholds latencies and the pure tone audiogram. Ear and Hearing, 6(2), 105-112.

Milford, C.A. and Birchall,J.P. (1989): Steady state auditory evoked potentials to amplitude modulated tones in hearing impaired subjects. British Journal of audiology. 23(2), 137-142.

Musiek, F.E., Johnson, G.D., Gollegly, K.M., Josey, A.F. and Michael, E.G. (1989): The ABR interaural latency difference (ILD) in patients with brainstem lesion. Ear and Hearing, 10(2), 131-134.

Musiek, F.E.,Josey, A.F. and Michael, E.G. (1986): ABR-interwave measurements in acoustic neuromas. Ear and Hearing, 7(2), 100-105.

Nancy, S. Christine, 0. and Jordan, R. (1986): ABR in the mentally retarded:Audiometrie correlates. Ear and Hearing, 7(2), 83-92.

Nowosielski, J. and Redhead, J. (1985): An improved technique for simulataneous recording of action potentials and ABR. British Journal of Audiology, 19(1), 13-18.

Osterlammel, P.A., Shallop, J.K. and Terkildsenk, (1985): The effect of sleep on the ABR and MLR. Scandinavian Audiology, 14(1), 47-50.

Paludetti, G., Ottaviani, F. Gollai, V. Tassom, A. and Maurizi, M (1985): ABR in multiple sclerosis. Scandinavian Audiology, 14(1), 27-34.

Paul, K. and Susan, L.S. (1986): MLR and 40 Hz. AER in normal Hearing subjects. Click and 500 Hz. threshold Journal of Speech and Hearing Research, 29, 20-28.

Poulsen, P. and Jensen, J.H. (1986): BRA and electronystagmographic findings in chronic toxic encephalopathy (Chronic painters syndrome). The Journal of Laryngology and Otology, 100(2), 155-156.

Prager, D.A., Stone, D.A. and Rosen, D.N. (1987): Hearing loss screening in the neonatal intensive care unit: ABR versus crib-o-gram: A cost effective analysis. Ear & Hearing, 8(4), 213-216.

Purmessure, M.N.S., and Singh, S.R. (1988): BERA in the diagnosis of deafness in children: A retrospective survey of its use in a district general Hospital, Journal of Laryngology and Otology, 102 (11), 981-989.

Randall, C.B., Beguwona, F.E. Mills, M.D. and Boyd, R.L. (1986): Latency and amplitude effects of electrode placement on the early AER. Journal of Speech and Hearihg Disorders, 51, 63-70.

Randal, C.B.G. Taggart, L.A.(l989): Electrode placement and mode of recording (differential vs. single ended) Effects on the early auditory evoked responses. Audiology, 88(1), 1-8.

Rawool, V.W. (1989): Speech recognition scores and ABR in cochlear impairment. Scandinavian Audiology, 18(2', 113-119.

Roaendo, R. Picton, T. Dean, L. Hamel, G. and Laframboise, G. (1986): Human auditory steady state responses: Effects of intensity and frequency. Ear and Hearing, 7(5), 300-313

Rosenhall, U.P., and Dotevall, M. (1986): Effect of presbycuais and other type of hearing loss on ABR. Scandinavian Audiology, 15(4), 174-185.

Rottenveel,J.J., Colon, E.J., Notormans, S. Stoelinga, G.B. Viscoy, and Graf, R. (1986): The central dudi-tory conduction at term date and three months after birth. Scandinavian audiology, 15(1), 11-19.

Rottenveel, J.J., Colon, E.J., Noterman, S., Stoelinga, G.B. and Visco, Y.M. (1985): The central auditory conduction at term date and three months after birth. Scandinavian Audiology, 14(4), 179-186

Rottenveel, J.J. Color, E.J., Stegeman, D.F., Viscoy, (1987): The maturation of the central auditory conditions in preterm infants until 3 months. Post-term:A composite group average of ABR, MLR, AER, Hearing Research, 26(1), 11-20.

Rotteveel, J.J., Color, E.J., Stegeman, D.F. and Viscox.Y.M. (1987): The maturation of the central auditory conduction in pre term infants until three months post term IV. Composite group averages of the cortical AERS. Hearing Research, 27(1), 85-93.

Rotteveel, J.J. Color, E.J., Stegoman, D.F. and Visco, Y.M. (1987): The maturation of the central auditory conduction in pre term infants until three months post term V: Composite group averages of the cortical AERS. Hearing Research, 27(1),95-110.

Samy, E.L. (1988): ABR in patients with acute severe closed head injury. Journal of Laryngology and Otology, 102(9), 755-763.

Schwarth, D.M.Robbert, E.P. and Schwarth,J.A. (1989): ABR in pre-term infants. Evidence of peripheral maturity. Ear and Hearing, 10(l), 14-22.

Smith, A.D. Picton. T. Edwards, C. Groodman,J.T. and MacMurray, B.(1985): The crib-o-gram in the NICU: An evaluation based on BSERA. Ear and Hearing. 6(1), 20-24.

Sorensen, M.Christensen, B. and Barving, A. (1988): Clinical application of BSERA. Scandinavian Audiology, 17(4),223-229.

Sturzebecher, E. and Webbs, M. (1987): Effect of age and sex. on ABR. Scandinavian Audiology, 16(3), 153-157.

Sturzebucher, E. and Werbs, M. (1988): Influence of age, sex, and hearing loss on ABR latencies. Scandinavian audiology, 17(4), 248-250.

Stypulkowski, H. and staller, S.J. (1987): Clinical evaluation of a new ECochG recording electrode, Ear and Hearing, 8(5), 304-310.

Suzanne, C.P., Houghton, J.M., Keith, W.J. and Greville, K.A. (1989): Frequency specific ABR. Audiology, 28(2), 82-91.

Thornton, A. R., Yardley, L. and Farrell, G. (1987): The objective estimation of loudness discomfort level using BERA. Scandinavian Audiology, 16(4), 219-225.

Vanden, H.C. and Stypulkowski, P.H. (1986): Characterization of the electrically evoked ABR in cats and human. Hearing Research, 21(2), 109-126.

Wilder, A. Pratt, H. and Rosen, G. (1987): Auditory brain stem evoked potentials in sudden deafness. Journal of Laryngology and otology, 101(7),652-659.

William, D.D. and Kevin, T.K. (1986): Analog and zero phase shift digital filtering of the ABR waveforms. Ear and Hearing, 7(6), 377-382.

Wilson, M.J., Ballweber,D.K. and Robert, A.D. (1985): Binaural interaction in ABR: Parametric studies. Ear and Hearing, 6(2),80-88.

Yang, E.Y. Rupert, A.L. and George, M. (1987): A developmental study of bone conduction ABR in infants. Bar and Hearing, 8(4),224-251.

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