AUDIOLOGY : ITS GENESIS AND METAMORPHOSIS

REG. NO. 9407

AN INDEPENDENT PROJECT WORK SUBMITTED IN PART FULFILMENT FOR FIRST YEAR MSc. {SPEECH AND HEARING) TO THE UNIVERSITY OF MYSORE.

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE - 570006

1995

FOR

PAPPA AND MUMMY

AND

PAPPA AND MUMMY

I AM SO GLAD GOD GAVE MB YOU

C E R T I F I C A T E

This is to certify that the Independent Project entitled: **AUDIOLOGY: ITS GENESIS AND METAMORPHOSIS** is the bonafide work done in part fulfilment for first year M.Sc. (Speech and Hearing), of the student with REG.NO. M9407.

MYSORE

MAY 1995

Director

All India Institute of
Speech and Hearing
Mysore 570006.

C E R T I F I C A T E

This is to certify that this Independent Project entilted: **AUDIOLOGY ITS GENESIS AND METAMORPHOSIS** has been prepared under my supervision and guidance.

MYSORE

MAY 1995

DR. (MISS) S. NIKAM

GUIDE

D E C L A R A T I O N

I hereby declare that this Independent Project entitled: AUDIOLOGY: ITS GENESIS AND METAMORPHOSIS is the result of my own study undertaken under the guidance of Dr. (MISS) S. Nikam, Director, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any university for any other Diploma or Degree.

MYSORE

MAY 1995. Reg. No M9407

A C K N O W L E D G E M E N T S

I would like to thank Dr. S.Nikam, Proffessor and Head of the Department of Audiology for her astute guidance and for finely honing this project to perfection.

I would like to thank Dr. S. Nikam, Director, All India Institute of speech and Hearing for granting me the permission and opportunity to undertake this project.

Thanks to Vanaja Ma'am and Manjula Ma'am for giving me guidelines along which to proceed and for putting up patiently with my tardiness.

Kiran and Jyothi M'aan I owe a lot to both of you. A large part of the credit for me being here goes to you.

Bobby (Priya.M) and Candy (Sang V.) - two seniors who helped when crisis struck and to all the other girls of II M.Sc. (Batch of '93)- I really enjoyed your company. Bhavani, Gayatri, and Niru, thanks for showing you cared.

Pearly and Laavanya, my cohabitants and fellow "Coshers", thanks for your support.

Nidhi, ray "Needy" friend- I am indebted to you in more ways than one, Thankyou.

To Lachoo (Lakshmi) for making me laugh, you really tried.

Reetha, Raksha, Annamma and Sneha, thanks for helping me out in my quest for information. Thanks to Pinto for never refusing help when asked.

To my parents who nurtured and brought me up. What I am today, is a tribute to your upbringing

Ani, Sam and Tali-my siblings. You are terrific. I couldn't ask for more.

To my Parents-in-law for their love and unconditional support. You have been really wonderful.

To my husband Aby, words are but shallow finite vessels and oh so very inadequate to couch the way I feel about you. I am bereft of words and grope in vain- the only word I can find which even only remotely describes you, is the word- WOW!.

To you ABY my 1ove and my life and the most wonderful person I will ever know - Thanks.

Above all I would like to thank my Lord JESUS CHRIST without whom nothing would have been possible.

TABLE OF CONTENTS

INTRODUCTION

What passed for a science of hearing - now called audiology - was restricted for centuries by such assertions as that of Plato in the seventh book of the Republic : "Men expend fruitless labour, just as they do in astronomy, in measuring audible tones and chords. " Yes, by heaven", he continued," and what fools they make of themselves, talking of densities and what not ".

The social and educational status of those with impaired hearing was directed for more than fifteen hundred years by Aristotle's pronouncement in the 'History of Animals' : "Those who are born deaf all became senseless and incapable of reason."

There are many references in the Bible (and probably in the Koran and in many other admonitions about the fundamentals of religion) to deafness and "the deaf". Only in modern times has a statement about "hearing impairement" been made. This is not a casual development, for only in modern times has it been possible to help those who do not hear well to function with a disability rather than with a handicap. Much of this state of affairs has to do with development and new insights in medicine and surgery. Much has to do with related development and insights in education. Development in technology particularly in the

area of electronics and computers has greatly influenced the current trend in the field of Audiology.

It is always fascinating to know how things began. To know when a particular phenomena was first observed and the manner in which this came about and who was responsible for this. It is also interesting to know when any established principle was developed and how it was done.

In short, mankind has always studied the historical aspects of various existing phenomena and we have always documented carefully,information regarding the same. This serves to highlight the landmark in development and also to guage the extent of current or modern day development of anything or phenomena since its origins. One we know the history we can predict the trend of development. We can also judge or evaluate the general focus of the field.

The emergence of audiology following World War II made possible the development of the present production era of otologic - audiologic interactions. The developments of tympanoplasty and stapes surgery and other advances in otology were acccompanied by advances in Physics, Physiology, Psychoacoustics, Engineering, Auditory neurophysiology and related neuro sciences. All of these factors were responsible for the development of modern audiology.

Audiology began as a necessary adjunctive audiometric skill within developing otology. At the present time, of course, audiology is a remarkable major scientific discipline and has also branched out into a number of sub specialities. Now one can appreciate the enormous expansion within the field of audiology, a far cry from the early audiometry, which was an outgrowth of primitive tuning fork testing techniques used by physicians.

Today audiology has its own laterfaces - with education, psychology, psychiatry, the hearing aid industry, vocational counselling and industrial medicine.

Audiology has now rapidly emerged as an important non medical profession, the members of which are now working side by side with otology in a fruitful collaborative relationship.

The two persons who are frequently viewed as being the first individuals to give this speciality its name are Norten Canfield and Raymond Carhart.

With regard to the beginning of audiology as a profession, Hoople (1951) stated that audiology developed out of work at the New York chapter of the League for the Hard

of Hearing. Holmgren reported that it grew out of the work of Mobley, Hughson, and Westlake. Others say that the early work of Goldstein, Newhart and Bunch was the forerunner of this new science.

The unifying force that bought ideas and personnel together was the group of aural rehabilitation programmes which developed during World War II.

The first organised meeting of individuals interested in Audiology in the United States occured in 1947 in Philadelphia. This involved persons working in the military aural - rehabilitation programmes. In 1948 the first International Conference in Audiology was held in Stockholm.

Over the next three decades various meetings, conferences were held which involved more personnel from an increasing number of countries. International standards in Audiometry, otology and physics and teamwork in Otology was discussed. International course in Audiology was also held during these conferences.

The growth of audiology as a civilian service and as an academic area has been great since 1949. In 1947 the term audiology appeared many times in a book edited by Davis

called Hearing and Deafness'. Since then there have appeared many publications in the field of audiology.

Audiology is the science of hearing. In other words, Audiology is undergirded by the competences and methods of many fields. Among the contributing fields are (1) physics, which studies acoustic events as one manifestation of matter and motion. (2) Medicine, which is concerned with human organism in sickness and health. (3) Pzychology, which deals with the response of the organism to stimuli . (4) Education, which seeks to modify and guide the behaviour of the organism ; and (5) Sociology, which attacks the problems of fitting the individual into his culture.

The development of equipment and methods for the measurement of hearing is a part of the field of audiology.

Long before the audiometer was constructed, there was interest in the measurement of human hearing. As far back as the 16th century there was an attempt to measure hearing level by those who were charged with the responsibility for educating the deaf. The methods were crude, using shouts, loud noises etc.

In the latter part of the 18th century more refined

approaches to measure hearing were used. They were the tuning fork tests.

In the first quarter of the 20th century the interest in audiometry continued and was helped along by the development of electronic instruments for measuring hearing level and by the development for electronic hearing aids to amplify sounds for hard - of - hearing individuals.

CHAPTER I

LANDMARKS OF THE EAR

EARLY ANATOMICAL WRITINGS

The Nei Ching Su Wen (Ca.2697 B.C) is the oldest medical book. It is a classic treatise on internal medicine and contains references to causes and cures of deafneas. Attributed to Huang Ti or yellow emperor. Described by Veath (1966).

The Ebers and Hearst (Ca. 1550 B.C.). It is an Egyptian medical papyri from the 18th dynasty. It presented prescriptions for ear diseases and deafness. As reported by Leake (1952).

Deafness and its cure, are referred to in the Holy Bible in Matthew 11:5 and Mark 7:11.

Author	Year	Finding
Vesalius, A.	1543	He provided description of the middle ear in De Fabrica Heumani Corporis.
Ingrassia, G.F.	15th century	Description of stapes.
Empedocles	490-435 B.C.	Discovery of inner ear.
Galen	138-201 A.D.	Discovery and naming of labyrinth.
Fallopio, G.	1561	Description of chorda tympani, auditory nerve and semi-circular canals.

Pyl, T.	1742	Noted existence of fluid in labyrinth.
Cotugno, D.	1777	Confirmed fluid in labyrinth and its role in transmission of sound.
Eustachi, B.	1562	Described Eustachian tube as the tube between the mouth and ear in a monograph entilted'De Audito Organis'.
Alcmaeon (reported by Boring in 1942)	6th century B.C.	Originally discovered eustachian tube.
Daverney, J.G.	1683	The first book on Otology "Traite de 1" Organe de 1" Ouie".
Itard, J.G. Modern pioneer of ear physiology	1821	First published a book or formal treatise on diseases of the ear called 'Traite des Maladies de 1' Oreille et de 1' Audition".

Chronicled below are discoveries related to the ear, according to historical period of occurrence.

PRE-SIXTEENTH CENTURY

Sumerian Cuneiform inscriptions	Ca.6000 to 3000 B.C	Ear referred to as organ of will.
Egyptian papyrus records	1500 B.C.	Ear referred to as organ of hearing and respiration.
Hippocrates	460-377 B.C.	Reported cases of deafness but differentiation of types was not done.
Empedocles	504-443 B.C.	Proposed that sensations required contact between object and perceiver.
Plato	427-347 B.C.	Suggested that "aer internus" (internal air to permit perception of sound) was implanted permanently during foeta1 deve1opmen t.
Aristotle	384-322 B.C.	Continued affirmation of implanted air concept.
Celsus	lst century A.D.	Described common causes of hearing loss and suggested

		maneuver which was later attributed to Valsalva in 18th century.
Galen	130-200 A.D.	Gave description of functional significance of auricle. Gave description of peripheral, neural and central causes of hearing loss.
Villanova	Ca. 1300	Employed inflation of middle ear by having patients sneeze while holding their nose.
Nicole	Ca. 1400	Suggested the use of suction tube in ear canal to inflate middle ear.

SIXTEENTH CENTURY

Da Capri, B.	Ca. 1514	Described malleus and incus.
Vesalius	Ca. 1546	Described stapes, oval and
Ingrassia	Ca.1543	round windows, cochlea and
Described Ossicles		semicircular canals.
Fallopius	Ca. 1561	Provided development of the ear from foetal to adult stage.
		Work included anatomical description of ear noises.

Eustachio	Ca 1564	Identified Eustachian tube and tensor tympani muscle.
Varolius	Ca. 1570	Described stapedius muscle.
Aquapedente	Ca. 1590	Described how middle ear muscle protected the tympanic membrane from intense sound.
Koyter	Ca. 1572	Reported improvement in bone conduction hearing when ear was occluded.
Caprivacci	Ca. 1580	Differentiated conductive and labyrinthine deafness.

SEVENTHEENTH CENTURY.

Willis	1664	Described helicotrema and described acoustic and facial nerves as being separate nerves.
Willis	1672	First to identify cochlea as primary structure of hearing.
Perrault	Ca. 1680	Supported view of implanted air within the cochlea.

Schelhammer	Ca. 1684	Felt air could not be both a conductive medium and sensory medium.

EIGHTEENTH CENTURY

Valsalva	Ca. 1707	Described ankylosis of stapes.
Scarpa	Ca. 1772	Described two paths of sound to the inner ear. a) via ossicular vibration of the oral window b) via air borne vibration of the round window.
Cotugno, D.	1760	Declared that fluid filled the entire cochlear space leaving no room for air.
Meckel,P.	1777	Proved the above.
Conti, A.	1851	Used the compound microscope and recognized the tiny hair cells that are the true sensory elements of the air.

CHAPTER II

ASSESSMENT OF HEARING

The first purpose of this chapter is to list the various contexts in which hearing assessment occurs and to highlight the principle area of present cencern within the general field of hearing assessment. The second purpose is to list the major tests currently used in the hearing assessment of adults.

Thomas Barr in 1886, established the principle of hearing assessment in an epidemiological study. He also established the occupational origin of NIHL.

Thomas Barr in 1887, initiated the first public health enquiry conducted on epidemiological principles of young peoples hearing.

Stragge in 1765, described the hearing impairment suffered by blacksmiths and coppersmiths.

Ramazzine in 1713, in his treatise on occupational disease noted similar cases.

Holt in 1882 in the U.S.A gave evidence of deafness among boilermakers.

However Barr 1886 study, is the first to establish the causal link between the degree of noisiness of the occupation and the resulting injury.

The three main sectors of contemporary hearing assessment practice are(a)screening of young children for early detection of hearing disorder,b) pre and post treatment evaluation of hearing in clinical and rehabilitative contexts. With an analogous function in the conservation of hearing in industry; and (c) evaluation of the degree of hearing impairment and handicap in compensation areas.

The audiometer is an electronic device for measuring hearing ability (on lack of it). In its simplest form it is a pure tone generator, an amplifier and an attenuator. A selection of different frequencies can be obtained by altering the o/p from the pure tone generator through manipulation of the frequency selector switch and the tone can be turned on and off by pressing or releasing the interruptor switch.

Although true diagnostic differentiation through various auditory measures did have its beginnings about half a century ago, attempts to test the power of hearing by use of Instrumentation were made by European workers much earlier in the 1870's, in fact more than a century ago.

Hartmann	1878	Developed Acoumeter which consisted of tuning forks that were the vibrating sources and which in turn activated an electrical unit.
Hughes	1879	He described an induction balance instrument which emitted tones from attached tuning forks to a telephone receiver using battery power. He called it a sonometer.
Cozzolino	1885	Developed induction coil audiometer using tuning forks as sound source.
Jacobson	1885	Developed audiometer using buzzer
Cheval	1890	as sound source.
Seashore	1899	Developed audiometer which was better than others because of Increased loudness in the receiver according to Weber-Fechner law.
Bunch, C.C	1922	First to commercially produce audiometer of vacuum tube type. Western Electric 1-A.
Bunch & Dean	1919	Developed pitch range audiometer which produced tones from 30 to 10,000 cycles.

Schwartz	1920	Introduced "Otaudion" electric audiometer.
Guttman	1921	Produced first vacuum tube audiometer
Fowler & Wegel	1922	Developed Western Electric 1-A audiometer which was not portable.
Jones S Knudsen	1924	Developed an audiometer which was battery operated.
Allison 8 Larr	1950	They also used warble tones to minimize effect of standing waves In the listening room.
Webster	1950	Developed an audiometer using phonodisks on which are recorded discrete warble frequencies. This was to minimize the effect of standing waves in the room.
Glorig & Wilke	1952	They developed a screening audiometer. It operates on the principle of pulse counting.
Brogan	1956	He developed the Air Force SAM Automatic Audiometer. The machine must be told how many presentations are to be made, how the stimulus

		intensity may be changed and how and when to make a threshold decision.
Ward	1957	Described an audiometer designed for group testing. He refers to this instrument as a single design audiometer.
Reger & Voots	1957	Developed the Randomized Pulse Tone Audiometer.
Rudmose Associate Company		Produced the Model RA 101 audiometer. It was a compromise between an automatic audiometer and a manual audiometer.
Grason Stadler Company		Model E 800 audiometer(Bekesy-Audiometer). All presentations are programmed and threshold hearing loss values are recorded automatically.
Rudmose Associates		Model ARJ recording audiometer. It was a group audiometer designed to operate a number of slave units.
Rudmose Associates		Group audiometer Model RA-108 is a modification of the ARJ audiometer

		adjusted so that it functions as a group audiometer.
Maic o Company		Developed the Maico Automatic Group Audiometer. It involves counting pulses a group presentation.
		Electro Nuclear Systems Automatic Audiometer. Model T-2 Automatic Audiometer is a pulse couting audiometer with descending and ascending levels.
Rosenblith & Colleaues	1959	They used cranial electrode signals to activate correlation computers (using of computer design to complete automatic threshold determination).
Weiss	1961	Reported that Bel tone Research Laboratories had developed an ingenous automatic audiometer. They modified a Model 15C Beltone Audiometer by attaching computer circuitry to the instrument.

ALTERNATE BINAURAL LOUDNESS BALANCE (ABLB)

The history of diagnostic audiometry can be divided very roughly into 4 eras.

(1) The era of loudness recruitment.

(2) The era of sensitized speech

(3) The era of impedance testing.

(4) The era of evoked potentials.

Fowler	1936	Developed the alternate binaural loudness balance test(ABLB) which was the earliest loudness recruitment test.
Reger.S.	1936	Developed monoaural loudness balance test(MLB) to assess recruitment in cases with bilateral hearing impairment.
Fowler	1939	He attributed presence of recruitment to a neurological mechanism.
Lorente de No	1937	He also attributed presence of recruitment to neurological mechanism.
Luscher & Zwislocki	1948	Gave diagnostic application of ABLB technique based on sinusoidal amplitude modulation.
Denes & Naunton	1950	Used the principle of ABLB to compare performance in the same subject at two different sensation levels.
Dix Hallplke & Hood	1948	Used ABLB test to differentiate between Menieres disease and Acoustic tumours of unilateral sensorneural hearing loss.
Dix et al	1948	Concluded that loudness recruitment,

		present in cochlear pathology and absent in eighth nerve pathology, resulted from disorders of the Organ of corti.
Hallpike & Hood	1951	They tried to evaluate the relation between loudness recruitment and auditory adaptation.
Hallpike & Hood	1959	They described the various loudness recruitment functions occurring in ears with Menieres disease.
Hallpike	1965	Confirmed the presence of loudness recruitment in cases of end organ pathology.
Jerger	1961	Also Confirmed the presence of loudness recruitment in cases of end organ pathol ogy.
Coles 8 Priede	1976	Also Confirmed the presence of loudness recruitment in case of find organ pa thol ogy .
Dix & Hallpike	1958	Confirmed the absence of loudness recruitment in eighth nerve pathology.
Hood	1969	Also Confirmed the absence of loudness recruitment in eighth nerve pathology.

Jerger,J.	1961	Alos Confirmed the absence of loudness recruitment in eighth nerve pathology.
Jerger, J.	1962	Decribed the methodology employed in administration of ABLB test. (Jerger method)
Hood	1969	Described the methodology employed in ABLB test administration. (Hoods procedure)

SHORT INCREMENT SENSITIVITY INDEX(S1SI)

Reisz	1928	Measured intensity DL(differece Limen) by asking the subjects to determine whether an amplitude modulated continuous tone was beating or steady. He employed a sinusoidal envelope for the continuous tone.
Doerfler	1948	He reported that intensity DL was most affected between 10 and 30 dBSL.
Luscher & Zwislocki	1949	Developed a test which was a modification of the one developed by Reisz. They used a tone that was amplitude modulated at a rate of 2/sec.
Luscher & Zwislocki	1949	Measured the critical percentage modulation at 40 dBSL since this is the level at which the intensity DL is independent of frequency.
Neuberger	1950	Found that intensity DL is reduced at high intensities and increased at low intensities in both recruiting and non-recruiting ears using the amplitude modulation approach.
Neuberger	1950	Reported that his patients with unilateral recruiting losses had reduced intensity DLS using the Luscher Zwislocki(1949) technique.

Liden & Nilsson	1950	Found larger inter-subject variability and overlap in the intensity DL's between normal hearing and hearing impaired persona.
Denes & Naunton	1950	They employed a relative measure of Intensity DL at comparison levels of 4 and 44 dBSL: in contrast with the intensity DL evaluated by comparing intensity DLS at 10 and 40 dBSL(Jerger,1953)
Denes & Naunton	1950	Used a different technique to measure Intensity DL. They used sequential presentation of two tones of same frequency to the same ear(memory method).
Luscher	1951	Modified the intensity DL test to employ a presentation level of at least 80 dBHL. This was employed in persons with hearing loss magnitudes exceeding 60 dBHL.
Luscher	1951	Reported that the IDL's (Intensity difference limens) were reduced in ears with cochlear impairnment, normal in ears with retrocochlear pathology

		and increased in ears with functional hearing.
Jerger	1952	Changed the presentation level for the Luscher Zwislocki test from 40-15 dBSL. This was based an Doenfler 1948 findings (literature shows that intensity DL was most affected between 10 and 30 dBSL.
Iverson, L.	1952	Failed to obtain agreement between the results of the ABLB test and the Luscher Zwislocki intensity DL.
Zollner & Hallbrock (1952a.b)		Found that musicians had smaller intensity DL's than other normal hearing listeners, (Effect of non auditory factors on intensity DL.)
Jerger	1953	Evaluated the relative measure of the intensity DL. by compairing the intensity DL's at 10 and 40 dBSL. This was to reduce overlap in various categories of loss like conductive, SN and functional hearing loss.
Hirsh et al	1954	Found that intensity DL obtained with memory method falls to differentiate

		among normal-hearing, non recruiting hearing impaired and recruiting hearing impaired ears.
Hirsh et al	1954	Contended that the intensity DL was not a measure of recruitment.
Hirsh et al	1954	Used a modification of Denes and Nauntons (1950) technique (memory method). This was because intensity DL obtained with memory method fails to differentiate among normal-bearing , non recruiting bearing impaired and recruiting heading impaired ears.
Jerge^J	1959	Developed SISI test.
Jerger et al	1959	Developed the SISI test using the principle that person with cochlear impairment might demonstrate hypersensitivity to small intensity increments superimposed on a sustained rather than interrupted tone.
Jerger et al	1959	Suggested representing the scores on a 'SISI-gram"
Jerger et al	1959	Investigated split half reliability of the SISI test. The Spearman-Brown

		correlation coefficient was moderately high at 250 HZ and very high at 1000 and 4000 HZ.
Jerger et al	1959	Suggested that the significances of intensity DL was the ability to hear small changes in sound intensity(which was a predictor of cochlear impairment) and not whether it was related to 1oudness recruitment.
Jerger	1961	Considered scores between 60-100 % = +ve (Indicative of cochlear pathology) 20-55 ? = questionable. 0-15 ? = Consistent with conductive or retrocochlear pathology.
Jerger	1962	Reported on test-retest reliability in SISI. This was poor at 250 HZ and moderately high at 1000 HZ and high at 4000 HZ.
Konig	1962	Supported the use of this modified Luscher-Zwislocki test.
Konig	1962	Obtained findings similar to Neuberger(1950)

Harris	1963	Compared the amplitude modulation and the memory method and obtained different results.
Thompson	1963	Suggested administering the SISI test at a presentation level of 75 dBHL. He reasoned that at this level only retrocochlear-impaired ears would obtain negative SISI scores.
Thompson	1963	Gave concept of "high level SISI". He proposed that comparison be made at an equivalent SPL rattier than at equivalent SL.
Owens	(1965a)	Reported that substantial number of his retrocochler impaired ears could hear 2 and 3 dB increments. Thus his findings argue against presentation of increments larger than 1 dB.
Hanley Utting	1965	Attempted to determine which SISI increment size{0.50, 0.75 and 1.00 dB) resulted in a SISI score equal to or exceeding 60%. Reported that the average SISI scores in SN subjects was significantly higher with 1-dB increment size.

Sanders a Simpson	1966	Concluded that the 1.00 dB increment was preferable to the 0.75 dB increment.
Young & Harbert	1962	Recommended administering the SISI test at 70 dBSPL or more if required for audibility. Because a negative score at ' this level indicates the presence of abnormal adaptation.
Young & Harbert	1967	Reported that positive SISI scores are obtained whenever the presentation level entering the cochlear exceeds 60dBSPL. Negative SISI scores are obtained in retro-cochlea impaired ears regardless of presentation level.
Blegvad & Terkildsen	1967	Reported that mean SISI score improved when contralateral masking with a broad band noise of 70 dBSL was employed.
Harbert et al	1969	Suggested using an increment size of 1.5 dB based on findings of Weiss, Harbert and Wilpezeski(1967)- that the minimum increment that could be detected in abnormally adapting ears exceded 1.5 dB.

Koch,Bartels & Rupp	1969	Observed that SISI scores of normal leaving 8 cochlear impaired subjects increased as carrier tone level increased. But this was not so in case of patients with retro cochlear pathology.
Blegvad	1969	Evaluated effect of masking with a broad-band noise at 80 dBSPL on the SISI scores of the affected ears. Masking did not alter the total number of positive scores, it caused a few negative scores to fall in the questionable range.
Swisher.Dudley Doehring	1969	Used contralateral, saw tooth and broadbrand noise masking in listeners with normal hearing' below 38 dBSPL, masking did not have an effect on differential intensity discrimination.
Pennington & Martin	1972	Reported that most audiologists consider positive SISI scores to be between 80 and 100%.
Fior	1972	Reported lack of developmental effect on intensity DL obtained with amplitude modulation technique.

Studebaker	1973	Asserted that contralateral masking for SISI is usually unnecessary.
Priede & Coles	1974	Suggested use of contralateral masking during SISI testing whenever possibility of cross hearing existed.
Martin	1978	Also Suggested use of contralateral masking SISI testing whenever possibility of cross hearing existed.
Fulton & Spradlin	1974	Employed modification of the SISI test in severely retarded children ranging in age from 16-19 years. Found that modified SISI yielded results similar to the standard SISI test in difficult-to-test children.
Martony	1974	Reported that intensity DL obtained with memory method decreased markedly with age.
Cooper 8 Owen	1976	Recommended a 20 dBSL presentation level or lower if 20 dBSL exceeded audiometric limits.
Sanders, Josey & Glasscock	1978	Recommended a presentation level of 75 dBHL as proposed by Thompson(1963). Since this level adequately seperated

		retrococh1ear from cochlear impaired ears.
Owens	1979	Suggested that SISI test could be used in children without mental impairement aged 6-7 years if play responses were used.
Buus, Florentine Redden	(1982a)	Suggested that a SISI score falling between 80-100% not be considered a positive score unless the patient has been given sufficient pre-test practice.
Buus,F1oren t ine		
Buus, Florentine & Redden	(1982b)	Suggested asking the patient what was heard before reporting the obtained SISI score.

TONE DECAY TEST(TDT)

Lord Raylelgh	1882	was the first to demonstrate tone decay by air conduction.
Corradi	1890	Was the first to demonstrate tone decay by tone conduction.
Gredanigo	1893	Observed that patients with VIIIth nerve pathology were unable to hear a tuning fork vibrating for more than a few seconds.
Schubert	1944	Was the first to develop a procedure for measuring auditory adaptation at threshold.
Hood	1955	First proposed the Tone decay test.
Carhart	1957	The threshold tone decay test was developed in 1954 at North Western University and described by Carhart in 1957.
Rosenberg	1958	Classified 0-5 dB tone decay as normal, 10-15 dB as mild,20-25 dB as moderate and 30 dB or more of tone decay as marked tons decay.
Rosenberg	1958	Gave Rapid clinical measurement of TDT.

Rosenberg	1969	Reported that mild to moderate tone decay was characteristic of pathology affecting the organ of corti whereas greater than 30 dB of tone decay was characteristic of retrocochlear pathology.
Carhart	1957	Gave Carharts tone decay test. (modified the procedure).
Yantis	1959	Suggested starting the test at 5 dBSL relative to pure tone threshold rather than at threshold.
Sorenson	1962	Developed another modification of Carhart tone decay test.
Owens	1964	Grave Owens TDT which is a modification of Hoods procedure. Tone decay can be classified as type I, II, III.
01sen a Noffsinger	1974	Proposed starting of TDT at an SL of 20 dB in camparison to 5 dBSL which was used earlier.
Jerger & Jerger	1975	Devised a procedure called Supra threshold adaptation test.

Hallpike & Hood	1951	Found loss of sensitivity in ear in response to continuous stimulation. They called this perstimulatory fatigue.
Hood	1955	Stated that abnormal adaptation was independent of stimulus intensity.
Hood	1955	Demonstrated presence of adaptation in cochlear impaired subjects by the technique of threshold determination using interrupted as opposed to continuous tones.
Carhart	1957	Cautioned against pointing a cochlear site for relapse or adaptation, observing that some normal hearing personse show abnormal auditory adaptation.
Harbert & Young	1964	Proposed that lesions of the eighth nerve causing partial damage to the axons manifest marked tone decay.
Gusselson & Sorenson	1959	Were unable to observe adaptation cochlear potentials of cats and guinea pigs. Implying that the site of auditory adaptation is the cochlear nerve.

Kiang & Peakes	1960	They also were unable to observe adaptation Peakes cochlear potentials of cats and guinea pigs. Implying that the site of auditory adaptation is the cochlear nerve.
Morales Garcia & Hood	1972	Found that marked tone decay is consistent with presence of VIIIth nerve pathology.
Parker & Decker	1971	They also found that marked tone ecay is consistent with presence of VIIIth nerve pathology.
Green	1963	Modified instructions to patients so that tonality and audibility could be assessed.
Wiley & Lilly	1980	Modified Hoods procedure to allow recovery period of 10 secs rather than 1 min.

SPEECH RECOGNITION TESTING

SPEECH RECOGNITION TESTING

Supra threshold speech recognition testing, has traditionally been done (a) to estimate the degree of hearing handicap or communicative functioning of the patiert, (b) to determine the anatomical site of lesion,(c) to monitor progress in aural rehabilitation and (d) to assess hearing aid performance. Supratheshold speech-recognition testing is applicable to differential diagnosis {peripheral or eig. nerve pathology) and is also useful in testing with respect to central pathology.

During World War II, research on suprathreshold speech recognition testing was centered upon the assessment of communication equipment such as the telephone using live- voice presentation.

Bryant	1904	First attempted to test speech understanding, using Edison phonograph in a "Sounds proof" box.
Campbell	1910	His was the earliest well controlled work concerning the measurement of speech intelligibility Purpose was to assess consonant intelligibility over the telephone.

Crandall	1917	Used consonant vowel (cu) and vowel cononant (vc) syllables to assess speech intelligibility
Dewey	1923	Reported the relative occurances of phonemes in the American English-speaking population He surveyed 100,000 words in newsprint.
Fletcher	1929	Recorded the first auditory test developed to determine an individuals threshold level for speech. This test was the Western Electric 4A developed at Bell Telephone laboratories (BTL).
French 6 Carten Koenig	1930	Studied the words and sounds of telephone conversation to find out the frequency of occurrence of the same.
Thorndike	1932	Gave a list of the 4000 most common English words.
Hughs on and Thompson	1942	They used sentences as materials to study SRT.
Hud gins et al	1947	Gave materials for developing the SRT at Harward Psycho-Acoustic Laboratories (PAL). They used spondaic words.

Egan 1948		Constructed 20 "equivalent" Haward phonetically balanced lists of 50 monosyllabic words (PAL PB-50s) from previously developed Harvard Psycho accoustic Laboratory speech lists.
Hirsh,Davis, Sibrman, Reynolds Eidert 6 Benson	1952	Developed a modified versian of the PALPB-50s, called the Central Institute for the Deaf (CID) W-22s.
Hirsh etal	1952	Recorded four W-22 lists each cataining 50 monosyllabic words, They were recorded with the carrier phrase "You will say" monitored on the Vu meter.
Fletcher	1922	Described the Standard Articulation lists, used at Bell Telephone Laboratories.
Fletcher 8 Steinberg	1930	Revised the Stardard Articulation lists and developed the New Standard Articulation Lists. They used only CVC syllables.
Egan	1948	Gave the Revised Monosyllabic word list at the Harvard PAL.

Eldert 6 Davis	1951	Reported on Clincal use of PALPB-50 and indicated a number of problems with them.
Tobias	1964	Indicated that phonetic balance is an interesting but unnecessary component in determining the world tests for SRT.
Lehiste & Peterson	1959	Developed a new monosyllabic word test for assessing speech discrimination. They developed phonemically balanced lists.
Lehiste & Petersan	1962	Revised their initial word list to eliminate unfamiliar words.
Tillman et al	1963	They developed and recorded the North Western University Auditory test number .4 (NU-4) word list.
Tillman & Carhart	1966	Expanded the NU-4 word list this list became known as Northwestern University Auditory Test Number 6 (NU-6).
Black	1957	Developed closed set discrimination test using multiple choice format.

Fairbanks	1958	Used lists of rhyming mono syllabic words in this 50 item rhyme test.
House et al	1965	Modified Fairbanks Rhyme test and this was known as the Modified Rhyme Test (MRT)
Kreul et al	1968	Altered the MRT to make it more clinically useful.
Griffiths	1967	Refined WtT. He used minimal rhyming contrasts.
Schultz 6 Schubert	1969	Used the mono syllables from CID W-22 to develop their mutliple choice discrimination Test (MCDT).
Mc Pherson Pang Chiag	1979	Reported development of a Distinctive Feature Discrimination Test (DTST).
Owens & Schubert	1977	Reported development of the CCT. This is a closed set response discrimination test using 100 CVC items. I terns selected were based on phoneme recognition errors of hearing - impaired subjects.
Haskins	1949	Gave 50 item phonetically balanced kindergarten word list (PBK-50) for use with children.

Rose & Lerman	1970	Gave the Word Intelligibility by Picture Identification (WIPI) test for use with children.
Fletcher 6 Steinberg	1930	Devised sentence intelligibility lists at BIL (Bell Telephone Laboratories).
Heedgins et al	1947	Gave the PAL Auditory Test Number 12 which may be adapted to speech recognition testing.
Davis & Silverman	1978	Developed a set of everyday sentences at CID.
Speaks & Jergar	1965	They introduced the synthetic sentence identification Test (SSI).
Kalikow et al	1977	Developed open set response sentence test called Speech Perception In Noise (SPIN) test.

BEKESY AUDIOMETRY

Bekesy	1947	Described automatic recording audiometer enabling subject to track his or her own threshold. (Bekesy audiometry).
Lundborg	1952	Said that amplitude of Bekesy tracing represented a tool for differential diagnosis of auditory site of lesion.
Lundborg	1952	Found that reduced amplitude was associated with ears having cochlear pathology.
Reger & Kos	1952	Found reduced amplitude in persons with retrocochlear pathology.
Kos	1955	Described abnormal adaptation in the "threshold tracking over time"
Zwislocki, Maire, Feldman and Reuben	1958	Found that practice and motivation influenced therehold of audibility in Bekesy audiometry.
Jerger.	1960	Categorized four basic types of Bekesy audiomety. Type I, Type II, Type III, Type IV, on basis of relationship between continuous and interrupted tracings.

Rose.D.	1962	Published first account of discrepancies between Bekesy tracings carried out in forward and backward direction.
Jergar.s and Jerger.J	1966	Reported on the "critical off time phenomenon.
Johnson	1968	Analysed findings in A coustic tumour pat ients and summarized hit rates associated with Bekesy audiogram and SISI.
Sanders and Josey	1974	Compared various test procedures like Bekesy type tracings and ABLE.
Stream and Mcconell Price Reger	1961 1963 1970	Thereshold is usually determined from midpoints of the excursions of tracings in Bekesy audiometry.

SPEECH RECOGNITION TESTING:

Suprathreshold speech recognition testing, had traditionally been done (a) to estimate the degree of heaving handicap or communicative functioning of the patient, (b) to determine the anatomical site of lesion, (c) to monitor progress in aural rehabilitation and (d) to assess hearing aid performance

Supratheshold speech-recognition testing is applicable to differential diagnosis (peripheral or eighth nerve pathology) and is also useful in testing with respect to central pathology.

During World War II, research on suprathreshold speech recognition testing was centered upon the assessment of communication equipment such as the telephone using live voice presentation.

Bryant	1904	First attempted to test speech understanding using Edisa phonograph is a "Sound proof" box.
Campbell	1910	His was the earliest well controlled work concerning the measurement of speech intelligibility. Purpose was to assess consonant intelligibility over the telephone.
Crandall	1917	Used consonant vowel (CV) and vowel consonant (VC) syllables to assess speech intelligibility.
Dewey	192 3	Reported the relative occurances of phonemes in the American English-speaking population. He surveyed 100,000 words in newsprint.
Fletcher	1929	Recorded the first auditory test developed to determine an individuals thershold level for speech. This test was the Western Electric 4A developed at Bell Telephone laboratories (BTL).
French,Carter Koenig	1930	Studied the words and sounds of telephone conversation to find out the frequency of occurrence of the sane.

Thorndike	1932	Gave a list of the 4000 most common English words.
Hughson and Thompson	1942	They used sentences as materials to study SRT.
Hudgins et al	1947	Gave materials for developing the SRT at Harward Psycho-Acoustic Laboratories (PAL) They used spondaic words.
Egan	1948	Constructed 20 "equivalent" Harward phonetically balanced lists of 50 monoxyllabic words (PALPB-50s) from previously developed Harvard Psycho accoutic Laboratory speech lists.
Hirsh,Davis Reynolds, Eidert Eldert 6 Benson	1952	Developed a modified version of the PALPB - 50s, called the central Institute for the Deaf (CID) W - 22s.
Sibarman, Hirsh et al	1952	Recorded four W-22 lists each containing 50 moanosy 11 able words. They were recorded with the carrier phrase'you will say' monitored on the Vo meter.
Fletcher	1922	Described the Standard Articulation

		lists used at Bell Telephone Laboratories.
Fletcher Steinberg	1930	Revised the Standard Articulation Lists and developed the New Standard Articulation Lists. They used only CVC syllables.
Egan	1948	Gave the Revised Monosyllabic word list at the Harvard PAL.
Eldert 6 Davis	1951	Reported on clincal use of PALPB - 50 and indicated a number of problems with them.
Tobias	1964	Indicated that phonetic balance is an interesting but unnecessary component in determining the word tests for SRT.
Lehiste Petersan	1959	Developed a new monosyllabic word test for assessing speech discrimination. They developed phonemically balanced lists.
Lehiste Peterson	1962	Revised their initial word list to eliminate unfamiliar words.
Tillman et al	1963	They developed and recorded the North Western University Auditory Test number 4 (NU-4) word list.

Tillman a	1966	Expanded the NU-4 word list. This Carhart list became known as Northwestern University Auditory Test Number 6 (NO-6).
Black	1957	Developed closed set discrimination test using multiple choice format.
Fairbanks	1958	Used lists of rhyming mono-syllabic words in his 50 item rhyme test.
House et al	1965	Modified Fairbanks Rhyme test and this was known as the Modified Rhyme Test (MRT)
Kreul et al	1968	Altered the MRT to make it more clinically useful.
Griffiths	1967	Refined MRT. He used minimal rhyming contrasts.
Schultz & Schubert	1969	Used the mono syllables from CID W-22 to develop their Multiple Choice Discrimination Test (MCDT).
Mcpherson & Pang ching	1979	Reported development of a Distinctive Feature Discrimination Test (DTDT).
Owens & Schubert	1977	Reported development of the CCT. This is a closed set response discri-

		mination test using 100 CVC items. Iterns selected were based on phoneme recognition errors of hearing impaired subjects.
Haskins	1949	Gave 50 items phonetically balanced kindergarten word list (PBK -50) for use with children.
Ross & Lerman	1970	Gave the Word Intelligibility by Picture Identification (WIPI) test for use with children.
Fletcher & Steinberg	1930	Devised sentence intelligibility lists at BIL (Bell Telephone Laboratories).
Hudgins et al	1947	Gave the PAL Auditory Test Number 12 which may be adapted to speech recognition testing.
Davis & Si1verman	1978	Developed a set of everyday sentences at CID.
Speaks & Jerger	1965	They introduced the Synthetic Sentence Identification Test (SSI).
Kalikow et al	1977	Developed open set response sentence test called speech perception in noise (SPIN) test.

IMMITTANCE AUDIOMETRY

The era of Impedance audiometer began nearly 100 yers ago. The first attempts at objective measurement of middle ear function using acoustic impedance measures were done by Lucace in 1867. There is substantial literature on the measurement of acoustic immittance measures dating back to early 1900's. Immittance measurements clinically employed today are based on the 1940's studies and technological creativity of Otto Metz.

As knowldege increased regarding immittance testing, microprocessing technology was advancing at a rapid rate. The technology available today has allowed this field to far surpass the vision of its creative predecesors. The days of manually balanced bridges gave way to microprocessor systems which today are able to rapidly analyze the amplitude and phase of reflected probe tone signals based on the immittance charateristics of the middle ear systems. It is now possible to store calibration data and test data in memory for recall. It is also possible to offer smaller more durable and affordable instrumentation which feature flexibility.

Lucae	1867	He made the first attempt at objective assessment of middle ear function.
Schuter	1934	Developed the first mechanical acoustic coupler.
West	1934	He described development of an electro acoustic device which was coupled to the ear with a telephone receiver cap.
Troger	1935	He gave description- of Trogers bridge.
Geffken	1938	Used Trogers bridge to calculate impedance at various frequencies.
Waetzman & Keibs	1939	They used thermophone method to calculate impedance at different frequencies.
Metz	1944	Modified the Schuster type bridge.
Schuster	1945	Developed a mechanical acoustic impedance bridge.
Otto Metz	1946	Used electromechanical bridge (Metz bridge) to measure acoustic impedance.

Zohansen	1952	Gave a theoretical discussion of the effects of mass, stiffness and resistance.
Metz in Denmark	1957	Developed the first commercially available electroacoustic impedance bridge.
Terkildsen & Nielson	1960	Gave electroacoustic impedance measuring bridge for clinical use. This was a proto type of ZO - 61.
Madson Company	1960's	Developed electroacoustic bridges Zo70 7o and ZO 72.
Zwislocki	1963	Produced the first commercially available mechanical impedance bridge capable of directly measuring the components of impedance at the eardrum.
Brooks, D.	1968	Gave the gradient concept of qualifying the "rounding off" of the tip of the tympanogram as an index oi differential diagnosis of pathology.
Anderson et al	1969	Published monograph on elevated reflex threshold and reflex decay in patients with acoustic tumour.

Liden, G.	1969	He delineated the basic types of tympanograms.
Grasar Company	1970	Developed an electroacoustic counterpart of Zwislocki's impedance bridge.
Griesen & Rasmussen	1970	Pointed out values of distinguishing ipsilateral and contralateral acoustic reflexes in brain stem disease.
Grasar - Stadler Company	1973	Commercially produced mechanical impedance instruments.
Nimeyer & Sesterharn	1974	Predicted hearing level from acoustic reflex threshold based on band width effect.
Lovette	1975	Described an objective otoscope which was a "compact admittance measurement device".
Onchi	1975	Developed electroacoustic instruments.
Onchi	1976	Developed electroacoustic device for detecting acoustic reflex thresholds.
Jerger & Jerger	1977	Gave patterns of abnormality in brain stem diseases based on relationship between two ipsilateral and two contralateral thresholds.

Coletti	1977	Gave concept of multifrequency tympanometry.
Hayes & Jerger	1982	Used signal averaging technique.
Starch & Jerger	1984	Used signal averaging technique to analyce supra threshold character-istics of acoustics threshold.
Shibahara.E. Takasuka.S. Okitsut.K.	1983	Conducted studies using mechanical middle ear model.
Wada, Kobayashi	1987	studied impedance using mechanical middle ear model.
Wada, Kobayashi, Suetake & Trachizakl	1989	Used a newly developed sweep frequency apparatus which measured middle ear dynamic characteristics.
Holke Margolis & Cavanaugh	1991	Described developmental changes in multifrequency tympanogram.
Hiroshima, Toshimaitsu, Kobayashi & Tachizaki	1992	Gave diagnosis of middle ear disease With ear drum perforation by a newly developed sweep frequency measuring apparatus.

E COCH G.

ELECTROCOCHILE OGRAPHY

Wever & Bray	1930	They were responsible for the earliest of the Auditory Evoked Responses discovered. They described cochlear microphonics in animals.
Kiang	1961	Reported the Auditory Late Response(ALR) which was a cortical evoked response in animal.
Adrian	1930	Confirmed Wever a Brays general observations in animal, and attributed the response to cochlear activity.
Saul & Davis	1932	Also confirmed Wever & Brays general observations in animal, and attributed the response to cochlear activity.
Fromm, Nylen 8 Zotterman	1935	Recorded cochlear microphonics from two patients with perforated tympanic membranes and replicated the findings in animal studies.
Adreev, Arapova & Gersuni	1939	Detected cochlear potentials from human subjects using cathode ray oscilloscope.
Perlman a Case	1941	Published the first figure showing a human & Ecoch G.

Perlman Case	1941	Published the first figure showing a human E Coch G.
Julius & Lenepert	1947	Recognized the optional site for E coch G. recordings and wisely predicted clinical value of E coch G.
Davis	1950	Described summating potential component of E coch G. in animals.
Nasaki	1954	Described the action potential component of E coch G, in single fibres auditory nerve in animals.
Clark	1958	Gave a description of the average response computer. This had an uprecedented effect on all Auditory Evoked Response measurement.
Reuben et al	1959	Reported Round window cochlear microphics in patients with hearing impairment.
Reuben et al	1960	Reported Round window action potential (AP) in humans with ear pathology.
Rueben , Hudsan & Chiang	1963	Recorded direct eighth nerve Action Potential in humans.
Kiang	1965	Published a classic monograph on discharge patterns of auditory nerve.

Yoshie, Ohashi & Suzuki	1967	Recorded promontory cochlear microphonic with transtympanic electrode. They also recorded AP with ear canal electrode.
Portmann et al	1967	Recorded promontory AP with transtympanic electrode averaged in human.
Sohmer & Fein Messer	1967	Recorded AP with ear lobe electrode. Response got was ABR but it was described as E Coch R.
Aran et al	1968	Recorded promontory AP in human with transtympanic electrode.
Yoshie	1968	Recorded promontory AP in humans with transtympanic electrode.
Aran et al	1969	Recorded promontory AP in children with transtymponic electrode.
Coats & Dickey	1970	Recorded AP in human with external ear canal electrode.
Cullen et al	1972	Recorded AP in human with TM electrode.
Coats	1974	CM, SP and AP recorded in human with ear canal electrode.

Eggermat	1974	Used E coch G. to give diagnosis of Menieres disease.
Berlin et al	1974	Frequency specific response with masking recorded from TM in human.
Gibson, Moffatt & Ramsden	1977	Gave E Coch G.application in diagnosis of Menieres disease. There was correlation b/w alterations of SP: AP ratio and Menieres disease.
Arlinger	1977	Recorded E Coch G.responses with bone stimulation.
Yauz & Dodds	1985	Improved ear canal electrode in human.
Ruth, Lamber 8 Ferraro	1988	Compared ear canal Vs TM electrode in human.
Schwaber S Hall	1990	Used simple trans tympanic electrode technique.

AUDITORY BRAIN RESPONSE(ABR)

Sohmer.H.& Feinmesser,M.	1967	Recorded waveforms that appeared to include what now would be recognized as the ABR, although they were only interested in recording the E Coch G.
Moor, E.J.	1960's	Conducted E Coch G research in human subjects. He attributed components observed immediately after the E Coch G to the auditory braInstem.
Jewett. D.	1960's	Credit for discovery of the ABR goes to him. This was discovered while pursuing his interest in higher level CNS function.
Jewett & Will is ton	1971	Published a paper on ABR. They identified major characteristics of the ABR and investigated many factors that influence the response.
Lev 6 Sohmer	1972	Independently described the ABR around the same time as Jewett and Williston.
Jewett	1970	First described the ABR in animals.
Jewett, Ramano & Williston	1970	First described the ABR response in humans.

Jewett & Wiliest on	1971	Conducted a systematic study of the ABR in humans.
Terkildsen, Osterhammel et al	1973	Conducted a series of studies an stimulus and acquisition parametres, in ABR.
Hecox & Galambos	1974	Described ABR in infants and children.
Schulman - Galambos & Galambos	1975	Described ABR response in premature infants.
Starr	1976	Described ABR response in patients with varied CNS pathology.
Salaney & Mckean	1976	Studied development of ABR response in neonates.
Greeberg & Becker	1976	Gave application of ABR in acute head injury cases.
Robinson & Rudge	1977	Described ABR response in multiple sclerosis.
Clemis & Mitchell; Selters 8 Brackmann; Terkildsen et al	1977	Applied ABR response in detection of acoustic tumours.

Stockard & Rossiter	1977	Studied ABR findings in patients with varied CNS pathology.
Arlinger	1977	Stimulation ABR responses with bone stumulat ion.
Stockard, Stockard a Sharbrough	1978	Published a monograph measurement techniques and variables in ABR.
Don & Eggermont	1978	Used high pass masking for frequency specific response in ABR.
Yamada, Kodera & Yagi	1979	Described effects of cochlear hearing impairment on ABR.
Chiappa, Gladstone & Young	1979	Studied normal variations in ABR waveforms.
Dobie & Berlin	1979	Investigated binaural response in ABR.
Jerger & Hail	1980	Studied effects of age and gender on ABR response.
Moller &	1981	Neural generators for ABR were studied with depth electrodes from human eighth nerve and brain.

Grundy, Lina Procopio Janetta	1981	Gave application of ABR in operative monitoring.
Rosenhamer, Lindstran & Lundborg	1981a,b	Conducted systematic study of peripheral auditory pathology using ABR.
Hall,Huangfu Gennarelli	1982	Used systematic application of ABR in intensive care unit monitoring.
Hall, MffkBT-Hargad & Kim	1985 ine	Used ABR for determination of brain death.
Gorga, Kamiski & Beauchaine	1987	Gave comprehensive neonatal and paediatric normative data.

CENTRAL AUDITORY DISORDER TESTING

Following are some of the major developmets in the field of central auditory assessment that have occured from the 1940's to the 1980's.

The beginning of central auditory testing can be traced back to the 1950's.

Bocca, Calearo & Cassinari	1954	First used monoaural distorted speech to assess the auditory function of patients with central lessions.
Bocca et al	**1955**	**Tested "cortical" hearing in temporal** lobe tumours. They developed a monoaural low redundancy speech test(low pass filterd speech).
Goldstein et al	1956	Applied CAD testing to patients with (R) hearing and left hemispherectomy.
Jerger	1960	Confirmed that performance was depressed on low pass filtered speech tests in the ear contralateral to the affected hemisphere.

Lynn et al	1972	
Lynn & Glhoy	1972	
Korsan & Bengsten	1973	Used low pass and band pass filtered speech tasks to assess CANS for in individuals with intracranial lesion.
Licklider & Miller		Did psychoacoustic research with normal subjects with regard to CANS testing.
Bocca Calearo & Antonelli	1958 1963	First investigated the use of interrupted speech test for assessing patients with CANS desorders.
Korsan & Bengston	1973	Used interrupted speech test and found that it is sensitive to lesions in both the temporal auditory area and the brain stem.
Beasley & Maki	1976	Described time and frequency altered speech. These include the accelerated or time compressed speech. This can be done by (1) having speaker accelerate speech rate (2) accelerating the recorded signal (3) removing segments of the signal electro mechanically.

Calearo Lazzarini Quarenta & Cervellers	1957 1977	Used accelerated speech and found that patients with localized lesions have reduced speech recognition in ear contralateral to lesion while those with diffuse lesion are likely to demonstrate reduced performance in both ears.
Fairbanks, Everitt & Jerger	1954	Gave method for time or frequency compression-expansion of speech (electro mechanic time compression).
Beasley et al	1972	Generated tapes of compressed speech stimuli(NU-6 word tests) at several different compression ratios using Fairbanks method.
Rintelman et al Kurdziel et al	1975 1976	Showed that patients with diffuse temporal lobe damage showed substantially poorer performance in centralateral ear on NO–6 auditory ward tests that were compressed by 60%
Baran et al	1985	Found that compressed speech is a moderately sensitive test for intracranial lesion involving the temporal lobe.

Sinha	1959	Was the first to use speech recognition in white noise task to assess central and audiotry function in group patients with cortical lesions.
Dayal et al	1966	Also used speech in noise test for the assessment of CANS disorders.
Morales-Garcia	1972	
Noffsinger et al	1972	
Olsen et al	1975	Demonstrated that lesions anywhere in auditory system, from cochlea to temporal lobe, can result in reduced speech in noise recognition scores.
Rintelman	1985	Talked about monoaural low redundancy speech test in the assessment of CANS
Jerger & Jerger	1971	Found that undistorted speech tests are sensitive to intracranial lesions if performance intensity functions are derived (PIPB).

CHAPTER III

HEARING AID HISTORY

The following table gives the different phases of development of hearing aids along with the progress of electronics and acoustics.

THE DEVELOPMENT OF HEARING AID TECHNOLOGY

PHASE I	Early 1940's	Mechanical Hearing aids.	Bulky in size. The desired features were not available.
PHASE II	1940's TO 1960's	Electronic Hearing aids. Valve version, Pocket types.	Bulky in size. Needed two cells i.e. high tension and low tension cells. Consumed large power. Amplification and tone control achieved to some extent.
PHASE III	1960' s to 1980's	Electronic Hearing Aids Transistor type,Pocket, Ear level and Spectacle models.	The size is reduced and the cosmetic valve was increased. The desired factor such as high gain A.V.C, compression loop are incorporated . It works on one cell at 1.5V and few M/s current flow.

PHASE IV	1980'S Onwards	Electronics Hearing Aids Hybrid version using IC'S and transistor's or using only IC[f]s Pocket, Ear level, Spectacle and in the Ear canal models are availble .	The size is further reduced. All requirements in the aid were provided The cosmetic, valve was very high.

At present technology is further advanced by providing the following additional features for better adaptability and discrimination of speech under different conditions.

Active and passive filter techniques for providing variable frequency response .

Powerful pushpull behind-the-ear type for children who are extremely hard of hearing. These aids provide very high gain with a peak at 900HZ. In this type full use of low frequency hearing capacity is used so that a maximum of

first and second speech fundamental frequencies can be transmitted.

Signal to noise ratio advantage of the supercompression concept. In this case numerous factors affecting the performance of hearing impaired listeners in noise such as environmental factors, psychoacoustic perceptual distortion built in the nature of sensorineural hearing loss, electro acoustic design of the hearing instrument and monoaural versus binaural amplification. The directional and pressure type microphone for certain advantages.

Few additional attachments to hearing aids for better benefits, such as external telephone coil, telephone shoe, audio attenuator and remote volume control.

With technology advancing in leaps and bounds and gargantuan effort being made in research and development in the area of hearing aids in developed countries, the goals of filling the gap of deficiency of hearing loss and regaining communication skills will soon be met. This is because biotechnology Is being given top priority with respect to man.

Mankinds first hearing "aid" was the hand cupped behind the ear.

The earliest historic references to hearing aids suggest that the animal horn and seashell were the first hearing and devices.

The first published scientific communications on hearing instruments were concerned with speaking trumpets and hearing trumpets.

The early speaking and listening trumpets were made of metal or glass. Ear trumpets for people with hearing impairments were most commonly made of then metal or tortoise shell, although a few economy models were cardboard cones or cubes. Ear trumpets were also made collapsible and could be carried more easily.

Small quite flat metal or tortoise shell trumpets were popular and were usually referred to as ear cornets.

The Banjo trumpet was a conical instrument with a rather small cross section which had a scoop or dish like collector attached to It.

The pipe trumpet resembled a large tobacco pipe. It consisted of a conical section which is bent and expanded to a larger collector area.

Acoustic fan for bone conduction.

The signal is transmitted from the collecting discs via the solid cylindrical handle.

Tube type hearing aids require two power supplies. A 1 1/2 volt battery was used for this purpose. A higher voltage battery was used for plate voltage. The lower bettery was called 'A' battery and the higher voltage battery the 'B' battery.

The microphones employed in the early vacuum tube hearing aids were of crystal type. Rochelle salt crystals were employed. The receivers were also crystal.

Athanasius Kircher	1673	Constructed one of the " first " Hearing aids called Ellipsis Otica. It was the result of an experiment in acoustics and was not intended to assist impaired hearing.
Dekkers, F	1673	Gave first illustration of an air conduction hearing aid. It was called the Vulgares Tubae.
She11hammer,G.C.	1684	Reffered to a different type of ear trumpet, called spherical trumpet.
Amiani, P.M.	17th Century	Cites Kircher and describes a hearing aid made by him which was a speculum suited to reflect the voice. It was made in a parabolic section.

DuQuet	1706	Designed an acoustic chair which was approved by the Royal Academy of Sciences. The chair was used with an ear trumpet.
Jean Itard	1773-1838	Used an actual seashell as a ear trumpet. He added a pipe extension for the ear tip and a cylindrical platform.
Aschendorf,W	18th Century	Invented a hearing aid held at the ear by means of an earmould.
F.C.Rein 8 Son	1800	Manufactured hundreds of different non-electric hearing instruments. Most of them in limited quantities.
Rein	1819	Made an acoustic throne for King Goa of Portugal. It had a resonant box and a hearing tube connected to a resonator.
F.C. Rein Company	1820	Developed the dome trumpet. It had good resonant characteristics for speech frequeueies.

The Rein firm also manufactured

acoustic urns.

ear trumpets on canes or partially folded fans.

collapsible ear trumpets.

ear trumpets with large silver resonators.

acoustic devices hidden in the hat or by the beard.

speaking tubes for churches.

Politzer.A	late 1800's	Designed an interesting ear insert device. It was made of vulcanite and shaped like an tiny alpine horn.
Paladino.G.	1876	Modified the rod device and called it a Fonifero. One end of the rod was curved and rested against the throat of speaker. The listeners end was placed against the teeth, forehead or mast old area.
Mcckeown.W	1878	Made an acoustic chair using large binaural ear trumpets mounted on the chair. He also used an ear tips made of molded India rubber in a spiral form.
Rhodes,R.	1879	Invented and patented a hearing fan which he called Rhodes Audi phone. This device consisted of a thin piece of pliable material shaped like a fan.
Hawksley.T.	1890	Manufactured ear level metal cups which connected to Custem ear-moulds. These-metal cups were the predecessors of our modern day receivers.
Hutchusan,M.R.	1895	Invented the Akoullallon. It was one of the first electric hearing aids. It was a table model instrument with a carbon

		microphone and up to three pairs of earphones.
Thornton,B.	1896	Used the "Thornton Telephone Aid". He used two telephones powered by dry cells and used earphones which were held by longnatte handles.
Hutchinson.M.R.	1898	Received patent to produce electric hearing aids. They were the predecessors of what became Acousticon instruments.
Chevalier Jackson Dr.Ferdinand Alt	1900	For having produced the first electric hearing device. The instrument is said to have consisted of a carbon microphone, a magnetic earphone and a battery.
Akouphone Company	1900	Modified the Akoulallion to produce the Akouphone.
	1903	The electronic hearing aid was first commercially produced. The early electric hearing aids used a carbon granule microphone and magnetic earphone powered by a battery.
Hutchinson.M.R.	1905	First patented Master Hearing aid devices. It was not marketed.

Hincks, E.T.	1913	Also patented Master hearing aids. It was also not marketed.
Western Electric Globe for Ear-Phone Company	1921	Produced the first vacuum tube hearing aid. It was a single tube amplifier in a box -which was portable but not wearable.
Hanson,B.C.	1921	Developed and patented the first vacuum tube hearing aid.
Western Electric	1920'&	Produced binaural vacuum tube aid. It was not portable. It required automobile type batteries.

Large vacuum tube aids were manufactured by

Gaumont of France Marconi of England Western Electric Company Radioear Corporation

Arthur Wengel	1938	Introduced his Wengel test Auditor which was a vacuum tube master hearing aid.
Wengel, A.M.	1937	Produced the first wearable aid and it was called the "Stanleyphone".
Telex Company	1938	Manufactured wearable vacuum tube hearing aids.

Ma icco Company	1939	Manufactured wearable vacuum tube hearing aids.
Aurex Company	1930's	It was the first to manufacture vacuum tube hearing aids on a large scale in the Unrited States. These aids employed four vacuum tubes of the company's own design.
Hayden, A.A.	1938	Was the first to use the term Master hearing aid' .
Lybarger.S.	1938	Patented the first master hearing aid to reach production. It was called Selex - A - Phone. The client could try three different air conduction receivers, an earphone and three different bone conduction vibrators.
Medical Research Council in England	1940's	Used instruments similar to those patented by ybarger. S. and their research resulted in the Medresco hearing aid.
Bel tone Compnay	1940	Designed the first one piece wearable vacuum tube aid. It was called Monopac.

New manufacturers of vacuum tube aids were -

1938	Paravok, Solopak, Vacolite
1939	Ontarion
1940	Beltone
1941	Alladin
1942	Goldfn Tone, Zenith
1946	Micronic, National
1947	Microtone

Companys manufacturing carbon type aids were -

Sonotone
Western Electric
Aurophone
Gem
Acoust icon
Radio ear

Watson & Tolan	**1949**	**During a period of 10 years. They were able to reduce current drain 4 1/2 times for the "A" battery and 8 times for the "B" battery.**
Bell Telephone Laboratories	**1947**	**Developed the first transistor which was of a point contact type and not suitable for hearing aids.**

	1952	The junction type of transistor was introduced and was used in hearing aids.
	1953	The first conventional transistor aids were manufactured by various manufacturers.
Audiotore Company	1955	Produced a behind - the - ear hearing aid. This being the earliest model was quite bulky.
Bel tone Company	1955	Introduced the "Hear -N - see" eyeglass hearing aid with the entire hearing aid in one temple.
Otar ion Company	1954	Produced the first CROS hearing aid. It was a headworn eyeglass hearing aid.
Zenith Company	1964	Produced tire first hearing aid with an integrated circuit. It was not an in-ear model but rather appeared in a behind - the - ear style.
Harford & Barry	1965	Suggested using CROS (centralateral routing of signal) hearing aids to overcome handicap of unilateral hearing.

Willco - a German affiliate of Maico Electronics Company	1969	Introduced the first hearing aid with a directional microphone.

BIBLIOGRAPHY

Berger, K.W. (1985) The Hearing Aid: Historical Footnotes. Audecibel Vol XXXIV, No:l, 19.

Berger, K.W. (1985) The Hearing Aid: Historical Footnotes. Audecibel, VolXXXIV, NO:2, 22.

Berger, K.W. (1985) The Hearing Aid: Historical Footnotes. Audecibel, XXXIV, NO: 3, 24.

Berger, K.W. (1985) The Hearing Aid: Historical Footnotes. Audecibel, XXXIV No:4, 38.

Berger, K.W. (1983) The Hearing Aid: Historical Footnotes. Audecibel, Vol XXXII, No:2, 33.

Berger, K.W. (1983) The Hearing Aid: Historical Footnotes. Audecibel Vol XXXII No: 3, 27.

Berger, K.W. (1983) The Hearing Aid: Historical Footnotes Audecibel, Vol XXXII, No:4, 25.

Berger, K.W. (1984) The Hearing Aid: Historical Footnotes Audecibal, Vol XXXIII, No:l, 14.

Berger, K.W. (1984) The Hearing Aid: Historical Footnotes Audecibel, Vol XXXI11, No: 3, 12.

Berger, K.W. (1984) The Hearing Aid: Historical Footnotes. Audecibel, Vol XXXI11, No: 4, 26.

Berger,K.W. (1975) History and Development of Hearing Aids. In Pollack,M.C.(Ed). Amplification for the Hearing Impaired; New York: Grune and Stratton.

Block,M.G. (1994) Overview and basic principles of acoustic immittance, In Katz.J (Ed 4), Handbook of Clinical Audiology; Baltimore: The Williams Wiley

and Wilkins Company.

Boothroyd.A. (1982J Impact of Technology on the Management of Deafness.
Volta Review, 92, 74-82.

Brunt.M.A. (1985) Bekesy Audiometry and Loudness Balance Testing. In Katz J (Ed 3), Handbook of Clinical Audiology; Baltimore: The Williams and Wilkins Company.

Davis (1966) Audiology: A meeting of varied Specialists. In Davis,H (Ed); Hearing and Deafness; New York: Holt, Rhinehart and Winston.

Dixon.W. (1973) Adaptation and Fatigue. In Jerger J (Ed); Modern Developments in Audiology; New York: Academic Press, Inc.

Feldman,A.S. (1975) Acoustic Impedance -Admittance Measurements. In Bradford,L.J(Ed). Physiological Measures of the Audio-Vestibular System; New York: Academic Press.

Glorig.A & Downs,M.. (1965) Introduction to Audiometry. In Glorig.A (Ed); Audiometry: Principles and Practices; Baltimore: The Willians & Wilkins Company.

Hall.J.W. 1992 Handbook of Auditory Evoked Responses.

Hiroshi.W. Kobayashi.T. Tachizak.H. (1992) Diagnosis of middle ear disease with ear drum perforation by a newly developed sweep frequency measuring apparatus. Journal of

auditory communication. Audiology 1992; 31:132-139.

Jerger.J. (1987) Diagnostic Audiology: Historical Perspectives. Ear and Hearing 8(4 supplement), 7S.

McConnell,F.E. (1987) Diagnostic Audiology: A Golden Anniversary, 1936-1986. Ear and Hearing 8(4 supplement), 4S.

Musiek.F.E. (1987) Baran.J.A. Central Auditory Assessment: Thirty Years of Challenge and Change. Ear and Hearing 8(4 supplement) , 22S.

Necol.J.C. (.1969) Lend an Ear To History. Audecibel, Vol XVII, No:3, 110.

Necol.J.C (1969) Lend an Ear To History. Audecibel, Vol XVIII NO:4, 178.

Necol.J.C. (1970) Lend an Ear To History. Audecibel 1970, 80 VolXIXNO:1.

Niemoller,A.F.(l970) Silverman.S .R. Davis.H. Hearing Aids. In Davis,H. and Silverman.S .R. (Ed) Hearing and Deafness. New York Holt, Rinehart and Wiston.

Noble,W.G. (1978) Assessment of Impaired Hearing; New York: Academic Press.

Olsen.W.O. (1987) Brief Tone audiometry: A Review. Ear and Hearing 8(4 supplement), 13S.

O'Neill,J.J. (1966) Oyer.H.J. Applied Audiometry; New York: Dodd, Mead & Company, Inc.

Price,L.L. (1978) Pure tone audiometry. In Rose.D.E. (Ed); Audiological assessment; New Jersey: Prentice-Hall Inc.

Reneau.J.P. (1975) Hnation.G.Z. Evoked Response Audiometry: A Topical and Historical Review; Baltimore: University Park Pres.

Rudmose.W. (1963) Automatic audiometry. In Jerger (Ed); Modern Development In Audiology; New York: Academic Press.

Shallop, J.K. 1976 The historical development of the study of middle function. In Feldman A.S. and Wiber L.A.(Ed). Acoustic Impedance and Admittance. The measurement of middle ear Function; Baltimore: The Williams and Wilkins Company.

Shwartz.D.M. (1987) NeuroDiagnostic Audiology: Contemporary Perspectives. Ear and Hearing 8(4 supplement) 43S.

Silman.S. (1991) a Silverman, C.A. Auditory Diagnosis Principles and Applications; San Dei go:. Academic Press, Inc.

Stach.B.A. (1987) The Acoustic Reflex in Diagnostic Audiology: From Metz to Present. Ear and Hearing 8(4 supplement) 36S.

Stevens,S.S. (1965) Warshofsky ,F. Sound and Hearing. Life Science Library; New York : Timeb-Life Books.

Watson,L.A. Tolan,T. (1949) Hearing Tests and Hearing Instruments; Baltimore: The Williams and Wilkins Company.

Willan.F.C. (1977) Development of the Hearing aid and Hearing Aid Industry. In Hodgson, W.R. and Skinner,H.P. (Ed). Hearing Assessment and use in Audiological Rehabilitation; Baltimore: The Williams and Wilkins Company.

VonTassel,D.J .(1972) Gain.R.T. Noise reduction Hearing Aids: Release from Masking and Release from Distortion. Ear and Hearing, 13, 114-121.