AUDIOVISUALS ON AUDIOMETERS AND AUDIOGRAMS

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

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CERTIFICATE

This is to certify that the Independent Project entitled: AUDIOVISUALS ON AUDIOMETERS AND AUDIOGRAMS is a bonafide work, done in part fulfillment for the First Year Degree of Master of Science (Speech and Hearing), of the student with Reg.No.M93i8.

Mysore
May, 1994

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CERTIFICATE

This is to certify that the Independent Project entitled AUDIOVISUAL ON AUDIOMETERS AND AUDIOGRAMS has been prepared under my supervision and guidance.

Mysore
May 1994

Dr.(Miss) S.Nikam
GUIDE

DECLARATION

This is to certify that the Independent Project entitled AUDIOVISUALS ON AUDIOMETERS AND AUDIOGRAMS is the result of my own study under the guidance of Dr. (Miss) S.Nikam, Director, and HOD-Audiology Department, 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 1994

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I am grateful to Ms. Manjula, Dept. of Audiology for having lent here patient ears and helping hands.

Dearest Amma, you are a v*ery*, very special person who has truly made a beautiful difference to my world.

Paddu, I am so glad that you are in my life cosed during low tides and you seem to know how I feel without me having to say anything. . . . . !

They are always there with a smiling face, a helping hand and a caring heart ! Though thanx is a v*ery* small word **for** everything, there is a whole world of meaning appreciated in it. . . . ."SATHYA AND NIRU" .

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INTRODUCTION

Asked to select the most precious of the five senses, few people would name hearing. Yet of all man's links to the outside world, hearing seems to be the essential sense, the one that makes man peculiarly human. Hearing is a late development in evolution but it has become the sentinel of our senses, always on the alert. The acquisition and monitoring of speech, the detection of potential danger, the elementary feeling of existing in a living universe - all depend upon the auditory modality.

Throughout waking life, the ear receives an uninterrupted stream of messages from the outside world ie audible messages which are screened, sorted and acted upon or filed away. How precious hearing is becomes clear when it is lacking. Ear, a sensitive organ may be damaged due to infection, exposure to noise, congenital malformations, ototoxic drugs, acoustic trauma, etc. All these factors and many more result in reduced auditory sensitivity and create special problems.

An audiologist is a scientist specialised in the field of hearing, habilitation and rehabilitation of people with impairment in auditory function. Audiometer, an electronic instrument is used by him. Through audiometry one can (a)

determine the degree of hearing loss (b) estimate the location of lesion within the auditory system that is producing the problem (c) estimate the extent of handicap produced by the hearing loss (d) help estimate the cause of the hearing problem (e) help to determine the clients habilitative or rehabilitative needs and the appropriate means of filling those needs.

It is needless to say that the experience provided through a combination of audio and visual media has distinct advantages. An attempt 1s made here to provide basic information through audiovisuals on Audiometers and Audiograms. Tape and slides are prepared for the same. It would basically cater to the needs of allied professionals, short-term refresher courses, and can be used as a self study for the beginners in the field of speech and hearing. They would facilitate retention of information, making learning and teaching task more effective and easy.

VISUAL	AUDIO
	An audiometer is technically defined as an electronic device that generates signals used to assess the hearing acuity of an individual.
	In the early 19th century some of the hearing testing devices used were :-
SLIDE N0.1 GALTON WHISTLE	GALTON WHISTLE: Compressed air was utilized in the production of various pitches. Two micrometer like settings enabled the tester to vary the aperture and plunger of the whistle. The micrometer settings allowed for accurate pitch production. Testing ranged from 4096 to around 25,000 Hertz.
SLIDE NO.2 TONOMETER	TONOMETER : Consisted of a series of 33 reeds which were blown by bellows. Each reed varied in

steps of 4 cycles. Produced tones of lower frequencies between 128 and 1024 Hertz.

SLIDE NO.3
CHART -> DEVPT. OF AUDIOMETER (1875-1899)
SLIDE NO.4
CHART -> DEVPT. OF AUDIOMETER (1904-1922)

These are charts depicting the important milestones in the development of Audiometer. Look at the contributions made by eminent scientists during each period. The major developments have been from turning fork audiometer to Electric generator vaccum tube audiometer to transistors. Presently microprocessor circuits and analog computers are being used widely making hearing evaluation more versatile.

SLIDE NO.5
CHART NO.5 -> DEVPT.OF AUDIOMETER (1924-1962)

SLIDE NO.6
AUDIOMETER
(FUNCTIONAL PARTS)

The main functional parts present in any audiometer are:

(a) ON-OFF POWER SWITCH: controls the power supply on the audiometer either 1n AC OR DC.

(b) OUTPUT SELECTOR SWITCH:

Determines how the stimulus will be delivered to the patient ie right ear, left ear or bone conduction.

(c) FREQUENCY SELECTOR DIAL: Allows the tester to choose **the** test tone for presentation to **the** listener.

Air conduction -> 125 to 8 KHz in octave and half octave intervals.

Bone conduction -> 250 to 4 KHz.

(d) HEARING LEVEL DIAL: Attenuator by which the intensity level of the signal is controlled' limits are previous set.varies from -10 to 120 dB.

(e) INTERRUPTOR SWITCH: Introduces tone with prescribed rise and fall time with no audible sound from the switch.

(f) MASKING LEVEL DIAL: Controls intensity of masking noise in the non-test ear. Spectrum and intensity range vary with manufacturer.

SLIDE NO.7
PURETONE AUDIOMETER
BLOCK DIAGRAM

This is a block diagram of a puretone audiometer. Let us see how it functions.

It consists of an audio-oscillator which generates puretones of different frequencies. Each tone is amplified to a maximum in the frequency range of 500 to 4000 Hz with less output above and below that range. The tones are then attenuated through the hearing level dial. The silent switch introduces or interrupts the tone. The signal is then routed via an output selection control to a right or left earphone or to a bone vibrator.

SLIDE NO.8
SPEECH AUDIOMETER
(BLOCK DIAGRAM)

This is a block diagram of a speech audiometer. The input signal can be through a microphone, Phonograph or tape recorder. The loudness of the speech signal is monitored by a

averaging VU meter (volume unit). The signal is amplified and attenuated as in a pure tone audiometer with the hearing level dial calibrated in decibels with reference to audiometric zero for speech. The output can be fed either through earphones or iuuuspeakers.

CLASSIFICATION OF AUDIOMETERS: ANSI (1951) S36 classified puretone audiometers into 3 types. They are -

SLIDE NO.9
WIDE RANGE AUDIOMETER

a) WIDE RANGE AUDIOMETER :- It covers major portion of the human auditory range in frequency and in SPL. It has facility for air conduction and bone conduction testing, used for clinical and diagnostic purposes.

SLIDE NO.10
LIMITED RANGE AUDIOMETER

b) Limited range audiometer is more restricted than a wide range audiometer. Produces tones of

500 1000, 2OOO. 3000, 4000, **and** 8000 Hz with levels from 10 to 70 dBHL. Bone conduction and masking facility is not available. Used in industries.

SLIDE NO.11
NARROW RANGE AUDIOMETER

C) Narrow range audiometer 1s more restricted than a limited **a** limited range audiometer. This 1s a simple two tone (2000 and 4000 Hz) narrow range audiometer with only two levels of output. Used in screening large populations.

SLIDE 12
IEC (1976) CHART (CLASSIFICATION OF AUDIOMETERS)

IEC 1976 classified audiometers as Type 1, Type 2, Type 3, Type 4 and Type 5. Type 1, 2, 3 are diagnostic types and have facility of both air conduction and bone conduction whereas type 4 and 5 are screening type having only air conduction facility.

Broadly speaking audiometers can be classified as manual, automatic and microprocessor based.

SLIDE NO.13

MANUAL AUDIOMETER (CIRCUIT)

Manual audiometers :- include manual control of signal parameters by the examiner, the responses are recorded manually on a audiogram.

Principle of operation involves on the left a number of oscillators which generate puretones at the frequencies F1, F2 etc. Each oscillator is followed by a potentiometer (R1, R2 etc) which is used to preadjust the exact level of each signal. S1 is a switch used to select frequency to be applied to the headset via the amplifier A1. S2 is used to calibrate directly in dB's of hearing loss.

Manual audiometers can be screening or diagnostic type.

SLIDE NO.14

MAICO MA 27 SCREENING AUDIOMETER

Screening audiometers are portable, used in camps, schools, etc to test large population. The amplitude and frequency ranges are limited. Bone conduction testing, masking facilities and special test provisions are not available.

SLIDE NO.15

DIAGNOSTIC AUDIOMETER

Diagnostic audiometers are versatile, meant for diagnostic purposes in clinical and medical settings. Designed to include special diagnostic (site of lesion) auditory tests. Two channel audiometer;is to be used in sound treated room. The parts are (a) Frequency dial -> 125-8 KHz (b) H.L. dial -> -10 to 120 dB in 5 dB steps (c) Programme switch -> for choosing stimulus mode: continuous, pulse tone,

special tests (d) Input switch - puretone, masking, tape, Microphone etc. (e) Reverse switch -> enables examiner between direct or Indirect presentation of the stimulus (f) Interrupter switch (g) Output switch.

SLIDE NO.16

SUPRAAURAL HEADPHONES, BONE VIBRATOR AND LOUDSPEAKER

The output of the signal can be fed through -

a) Standard supraaural headphones -> They are transducers used for air conducted sounds. There are indications for right and left ear. Transducers are mounted on a firm, adjustable spring steel bana and fitted with hard sponge and rubber pads.

b) Audiocups can be used to give extra attenuation in conditions of ambient noise too high for unsheilded earphones; they are noise excluding enclosures for standard audiometer headphones.

c) Bone vibrator is used for transmission of bone conducted sounds; vibrator is held firmly in place by a steel spring headband.

d) Loudspeakers are required for special freefield procedures like speech audiometry or while testing small children.

SLIDE NO.17

AUTOMATIC AUDIOMETER (CIRCUIT)

AUTOMATIC AUDIOMETER -> is an instrument programmed to present stimuli automatically. Princ ole of operation includes a numbe of puretone generators of frequencies F1, F2 etc. automatically selecte one after the other, for a ce, tain length of time, via the switch S1. S1 is switched by . motor M1 which also drives the recorder pen along the horizontal axis of the recordir. . paper representing frequency.

The level of the signal applied to the headset via the amplifier A is determined by the contact S2 on the potentiometer. S2 is driven by a second motor M2 controlled by the handswitch, operated by the patient. S2 is always in motion in either direction while the patient tries to maintain the tone continuously at the hearing threshold level. The motor M2 at the same time drives the recording in the vertical direction representing level.

SLIDE NO.18

AUTOMATIC AUDIOMETER

Frequency range may include 100-10,000 Hz, automatically pulsed or presented continuously (200 msec on /200 msec off). Subject alone controls the test with the help of hand switch and his hearing level is plotted; continuously as shown in the Fig. As long as the subject hears the

tone, he holds the handswitch pressed and the intensity is decreased, when he no longer hears the tone he releases **the** handswitch and the intensity increases again. Audiogram is saw toothed.

SLIDE NO.19
BEKESY AUDIOGRAM
-THRESHOLD TESTING

The Fig. shows the typical audiogram got in Bekesy audiometry. For threshold testing, interrupted tone is used at frequencies 500 Hz, 1 KHz **and** 2 KHz. 3 minute time is required for complete tracing at each frequency. Intensity changes at 2.5 dB/sec. The mid point **across** six excursions is the threshold.

SLIDE NO.20
BEKESY AUDIOGRAM (TYPES)
-Diagnostic procedure

For diagnostic procedures compare continuous and interrupted tracing for the **fixed** and sweep frequency mode. The amplitude of excursions (+ve / -ve traces) and the gap between

continuous and interrupted tone is noted. Type-I seen in normal and conductive hearing loss. Type II would be typical of cochlear loss. Clients with eighth nerve loss and sudden hearing loss present Type III and IV patterns.

Automatic audiometers can be individual or group.

SLIDE NO.21
AUTOMATIC AUDIOMETER
(GROUP TESTING)

The Fig. shows group testing with automatic audiometer, where a group of persons are tested simultaneously. Though it is not very reliable, it is definitely time saving.

SLIDE NO.22
GSI-10 MICROPROCESSOR AUDIOMETER

MICROPROCESSOR AUDIOMETER

Generally consist of a control panel with a table of functions, self explanatory keys, back lit LEDs, to read out test status and a computer programmed for management.

GSI-10 is one such instrument. The special features include ->

* 2 channel; Bekesy version available; speech testing possilable with MLV or aterao tape cassette, masking (WBN, NBN, Speech noise). Evaluation of cochlear vs retrocochlear dysfunction using ABLB, MLB, SISI, Bekesy, TDT, BTA, MLD, filtered speech, dichotic competancy test, binaural fusion test. Functional hearing tests include Lombard, Stenger, LOT, DS.

* Talk back and talk forward system facilitate communication between operator and individual being tested within a sound treated room.

* Auxiliary intercom permits the operator to speak to a test assistant in the sound room without the individual being tested hearing the conversation.

Monitor speakers for free field testing.

* The microprocessor instrument may be interfaced with an computer and aid in computerized audiometry.

SLIDE NO.23

CALIBRATION SET

CALIBRATION OF AUDIOMETERS:-

Refers to checking or correcting the output of audiometer either subjectively or objectively to ensure optimum functioning of the instrument and to make the results more reliable. Some of the parameters to be calibrated are intensity - output SPL and linearity. Frequency analysis and response of headphone. Harmonic distortion analysis, time analysis - rise and decay time, etc.

The slide shows a commercial audiometer calibrating device. This kit is used for earphone calibrat ion.

SLIDE NO.24

ARTIFICIAL MASTOID ASSEMBLY

An artificial mastoid assembly is shown here which is used for bone conduction vibrator calibration. The audiologist can maintain a calibration chart recording the functioning of the audiometer across various frequencies in air and bone conduction and make necessary correction in test results if needed.

PURCHASE OF AUDIOMETER: Purchase of an audiometer depends upon the purpose of use and the budget available. If only puretone testing is required it is good to buy the simple audiometers. In medical and clinical settings it is useful to buy clinical diagnostic audiometers with puretone, speech and special test facilities. To test children one should have the facility of free field audiometry. For research purpose more versatile audiometrs

may be needed. To screen large population screening audiometer would suffice.

SELECTION OF AUDIOMETER:

Remember that the audiometer selected should meet the specified standards. Manufactures should provide reliable maintenance and calibration services. Ask for operation and service manual of the instrument. While buying the spare parts the specifications of the accessories must be well noted.

AUDIOGRAMS

INTRODUCTION: An audiologist while doing Audiometry has to record the patients hearing thresholds and other test results. With the aid of this record the tester diagnoses the nature, type and amount of problem present. it is also useful for communication among professionals, and to plan rehabilitative measures.

An audiogram is a chart used to record graphically the hearing thresholds and other test results obtained in audiometry.

What does the audiogram form contain?

SLIDE NO.25
AUDIOGRAM
-BASIC INFORMATION

Almost all audiogram forms contain space for (a) Identification information such

as patients name, age, sex, case no., tester's name, audiometer used etc. (b) Response consistency of the patient. (c) Audiometric symbols. (d) Space for recording test results and remarks.

SLIDE NO.26

AUDIOGRAM-CONSTRUCTION OF GRAPH

The graph consists of grids with test frequencies in Hertz represented on the abscissa (X axis) by means of a logarithmic scale and the hearing level (HL) in decibels represented on the ordinate (Y axis) by a linear scale. The frequency scale has markings from 125 to 8 KHz. Hearing level scale ranges from -10 to 120 dB. 0 dB represents the average threshold of a large number of non-pathologic ears. One octave on the frequency scale shall be equivalent to 20 dB on the HL scale.

Grid lines of equal darkness and thickness should be used at octave intervals on the frequency scale and at 10 dB intervals on the HL scale. Grid lines used for inter octave frequencies should be finer and lighter in hue than those for octave frequencies.

SLIDE NO.27

AUDIOMETRIC SYMBOLS

All audiogram forms have standard symbols to be follows. Distinct symbols are present for air conduction, bone conduction, in masked and unmasked conditions for right and left ears. Denotations to indicate no response are also present.

SLIDE NO.28

AUDIOGRAM - PLACEMENT OF SYMBOLS

The AC symbols should be drawn on the audiogram so that the midpoint of the symbol centers on the intersection of the vertical and horizontal axes at the appropriate level.

The BC symbols should be paced adjacent to, but not touching the frequency axis and centered vertically at the appropriate HL. The symbol to the left ear should be placed to the right of the frequency axis and vice versa.

When BC thresholds occurs at the same level of AC thresholds, BC symbols should be placed adjacent to but not touching the AC symbols.

If BC masked, unmasked thresholds are at the same HL, unmasked symbol should be placed closest to frequency axis. Masked symbol should sorround but not touch unmasked symbol.

SLIDE NO.29

AUDIOGRAM - NO RESPONSE SYMBOLS

To indicate no response, an arrow should be attached to the lower outside corner of the appropriate symbol and drawn downward and about 45 outward from the

frequency axis to the right ear for left ear symbols and vice versa.

SLIDE NO.30
AUDIOGRAM - LINES CONNECTING SYMBOLS

Solid lines are used to connect AC threshold values. Dashed lines to connect BC threshold values. Symbols representing no response should not be connected. Colour coding is not mandatory but if employed red to be used for right ear and blue for left ear.

SLIDE NO.31
AUDIOGRAM FORM
ASHA 1990

Speech and Hearing Clinics modify the audiological assessment form to suit their clinical needs. However, every audiogram must contain the standard symbols, the reference hearing level, and the standard it follows.
ASHA 1990 has proposed these symbols which are not standardized universally.
Tympanogram is included in the

form and also abbreviations on the right bottom make the audiogram form more explicit.

What does the audiogram tell us

An audiogram provides information about the hearing status of any individual. Threshold is the lowest intensity at which the individual detects the signal 50% of the time.

SLIDE NO.32
SCALE OF HEARING IMPAIRMENT

To calculate the hearing sensitivity, compute the puretone average of 500 Hz, 1KHz and 2 KHz and compare 1t with the standard norms as shown in the figure. -10 to 15 dB is considered normal hearing. The severity of impairment is graded upon the degree of hearing loss.

SLIDE NO.33
CLASSIFICATION OF HL

Degree of hearing loss indicates the degree of difficulty

IN RELATION TO SPEECH HANDICAP	experienced in communication by the individual.
SLIDE NO.34 SOUND CONDUCTION PATHWAY	This fig. shows the sound conduction pathway through air conduction and bone conduction. It is helpful in understanding the type of loss present, In normal hearing the air and bone conduction pathway is normal. Shaded areas in the blocks represent hearing loss. Damage to outer or middle ear causes conductive hearing loss. Sensorineural hearing loss is illustrated by damage to the nerve as well as to the inner ear. A mixed hearing loss has both impaired AC and BC.
SLIDE NO.35 AUDIOGRAM - HEARING SENSITIIITY WITHIN NORMAL LIMITS	Let us try to interpret the audiograms based on the degree and type of hearing loss. This is an audiogram illustrating_____

hearing sensitivity within normal limits in both ears. The puretone averages for right and left ear are 7 dB. Note that no hearing level either by air conduction or bone conduction exceeds 15 dBHL.

SLIDE NO.36
AUDIOGRAM - CONDUCTIVE HEARING LOSS

IN CONDUCTIVE HEARING LOSS there is normal bone conduction hearing and hearing through air conduction is affected.
The audiogram illustrates mild conductive hearing loss in both ears. Bone conduction hearing is normal. Air conduction thresholds are affected and average 35 dB in each ear. There is an airbone gap of 35 dB (conductive component) in both ears.

SLIDE NO.37
AUDIOGRAM - SENSORINEURAL HEARING LOSS

IN SENSORINEURAL HEARING LOSS both air and bone conduction thresholds are diminished and the

airbone gap does not exceed 10 dB.

The audiogram illustrates mild sensorineural hearing loss in both ears. Air-bone conduction thresholds are affected and average 35 dB in each ear. The air-bone gap is 0.

SLIDE NO. 38

AUDIOGRAM - MIXED HEARING LOSS

IN MIXED HEARING LOSS both air and bone conduction thresholds are affected and the air-bone gap exceeds 10 dB.

The audiogram illustrates moderately severe mixed hearing loss in both ears. The AC thresholds average 60 dB and BC thresholds average 35 dB (sensorineural component). There is an air-bone gap of 25 dB.

SLIDE NO.39

AUDIOMETRIC CONFIGURATION - CLASSIFICATION

Generally there are certain distinct patterns of hearing loss seen. The table shows the criteria for the classification

of audiometric configuration. The primary frequencies considered in describing the audiometric configuration are 500 through 4000 Hz.

SLIDE NO.40

AUDIOMETRIC CONFIGURATION - TYPICAL PATTERNS

Most of the audiogram configurations can be distinguished and are unique in the sense they are typically seen in certain ear pathologies. Flat loss is seen in serous otitis media, conditions of collapsed canal and moderately advanced cases of Menier's disease. Sloping loss is seen 1n presbyacusis, ossicular discontinuity etc. Rising loss is seen in early stages of Menier's disease. Notch audiogram is seen in otosclerosis, noise induced hearing loss. Saucer shaped is found in some sensorineural

conditions such as rubella and also in malingerers.

Let us describe a few typical audiograms seen in various ear pathologies.

SLIDE NO.41

AUDIOGRAM - CONGENITAL HEARING LOSS

Congenital hearing loss : Also called corner audiogram. Response to air-conduction and bone-conduction seen only in low frequencies is 250 **and** 600 Hz, At other frequencies there is no response even at the maximum output of the audiometer.

SLIDE NO.42

AUDIOGRAMS - MENIER'S DISEASE

In Menier's disease triad of symptoms are seen. They are tinnitus, vertigo and hearing loss. In the early stage audiogram contour is rising with greater loss 1n low frequencies than in mid and high frequencies.

In moderately advanced stage there is a flat sensorineural

hearing loss. In advanced stage there is downwardly sloping configuration with greater loss in high frequencies than in low frequencies.

SLIDE NO.43
AUDIOGRAM - OTOSCLEROSIS

Otosclerosis is a condition wherein there is deposition of new bone in the annular ligament of stapes, leading to fixation of stapes. Characteristic (Carhart notch) dip is evident at 2000 Hz in bone conduction.

SLIDE NO.44
AUDIOGRAMS - PRESBUACUSIS

Presbyacusis is a sensory-neural hearing loss due to degenerative changes of aging. Sensory prescbyacusis involve **the sensory** cells of cochlea and characterized by abrupt high frequency loss and is bilateral. Neural prescbyacusis is primarily due to neural degeneration, gradual high frequency hearing loss is seen.

SLIDE NO.45 AUDIOGRAM - NOISE INDUCED HEARING LOSS	Noise induced hearing loss is caused if a person is exposed to continuous noise of high intensity for a long duration. Dip is evident at 4 KHz.
SLIDE NO. 46 AUDIOGRAM - FUNCTIONAL HEARING LOSS	In functional hearing loss cases or malingerers saucer shaped audiogram is seen. Reduced hearing in mid frequencies but surprisingly good hearing ability in low and high frequencies.
SLIDE NO.47 AUDIOGRAM - OTOTOXICITY	This is an audiogram of a person who received large doses of neomycin, producing subsequent sensorineural hearing loss of profound nature.

CONCLUSIONS

Through these audiovisuals we have tried to provide the basic information about audiometers and audiograms. In hearing evaluation an audiologist always uses a battery of tests like puretone, speech, impedance audiometry etc. to be

more accurate in the diagnosis of hearing disorders. In case our viewers are interested to enrich their knowledge and learn more about hearing evaluation, audiometers etc, please contact ALL INDIA INSTITUTE OF SPEECH AND HEARING, MANASAGANGOTHRI, MYSORE 570 006.

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