

AN AUDIO VISUAL ON TESTS WHICH DIFFERENTIALLY DIAGNOSE
COCHLEAR AND RETROCOCHLEAR PATHOLOGIES

Reg. No. M 9308

An Independent project submitted as part fulfillment for the first-year MSc (Speech & Hearing) to the University of Mysore.

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DEDICATED TO

Amma & Appa - Thanks for being so understanding
supportive & loving.

My friends - Anu, Mona & Ritu
The time we have spent together has been 'The time of my
life.

Thanks for adding spice to my life as only you know how
to.

CERTIFICATE

This is to certify that this independent project
entitled.

**An Audio Visual On Tests Which Differentially Diagnose
Cochlear and Retro Cochlear Disorders.**

Is a bonafide work done is part fulfillment of the first
year degree of the Master of Science (Speech & Hearing) of
the student with Reg No. M 9308

Mysore

1994



Director
All India Institute
Of Speech & Hearing
Mysore

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**"An audio visual on tests which differentially diagnose
Cochlear and retrocochlear pathologies".**

has been prepared under my supervision and guidance.

Mysore

May 1994


Dr. (Miss) S. Nikam
Guide

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AUDIO VISUAL ON TESTS WHICH DIFFERENTIALLY
DIAGNOSE COCHLEAR AND RETROCOCHLEAR PATHOLOGIES

VISUAL

AUDIO

Slide - 1
Audio Sequences

Introduction: The site of lesions resulting in hearing loss is of more than a casual interest to audiologists.

Through the use of some basic pure tone and speech measurements it is possible to separate hearing disorders into broad categories conductive and sensory neural.

Slide - 2
Audiogram in
Sensory neural
hearing loss case

This is a relatively easy task but the distinction between sensory hearing loss and neural hearing loss is more difficult to determine.

Slide - 3
Diagram of Cochlea

Lesions of the auditory portions of the inner ear are said to be cochlear or sensory and neural lesions beyond the inner ear are often called retrocochlear.

There are several audiometric tests which differentiate between the sensory and the neural kinds of hearing loss.

For the sake of convenience we can group these tests under the categories of pure tone tests, speech tests & objective tests.

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PORE TONE TESTS

Slide - 4
 Flow chart of
 Alternate Binaural
 loudness
 Balance test

The characteristic feature of cochlear pathology is recruitment or abnormal growth in loudness. One of the earliest tests proposed for cochlear pathologies is a direct test of recruitment & Measures recruitment.

The test is Alternate Binaural Loudness balance test.

This test was proposed by Fowler in 1928 and is administered 11 to unilateral SN loss cases.

In this test tones are presented to the two ears alternately and the subject is required to make a judgement whether the two tones are equal in loudness.

The test is started by presenting a 1kHz tone at 20 dBsL to the better ear and achieving a loudness balance in the poorer ear.

Then the procedure is repeated with 20 dB increments in the better ear. The results are plotted on a ladder gram or a graph.

Following Jerger's suggestions, the interpretation is based on the most intense level in the reference ear while the overall pattern is of value in viewing the loudness function.

Slide - 5
 Ladder grams in
 cases with
 complete recruit-
 ment and no
 recruitment

Complete recruitment is present when reference and variable ear are judged equally loud at equal HL \pm 10 dB.

If equal loudness judgements are made at equal SL's \pm 10 dB it implies No recruitment.

VISUAL

Slide - 6
Ladder grams in
cases with partial
recruitment and
decrement

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Partial recruitment is observed if equal loudness judgement fall between those of partial and No recruitment.

Decruitment is said to be present if the poorer ear needs an ever increasing amount of intensity for a signal to sound equally loud to the good ear.

Cochlear pathology is suggested if partial or complete recruitment is observed.

No recruitment or decruitment suggests -
No cochlear pathology.

Monaural loudness balance test this test was proposed by **larger** in 1936. The test is similar to ABLB except that it is done on cases with bilateral SN hearing loss with atleast one frequency which has normal thresholds.

While ABLB is a direct test of recruitment an indirect measure of recruitment is the difference Limen for intensity or **DLI 'test,**

Slide - 7
Luscher and
Zwislkis Difference
Limen of intensity
test

The difference limen for intensity is the smallest detectable change in intensity.

Lusher and Zwisllocki developed a **DLI test in 1949** which enjoyed popular use for a time. In this test the patient listened to a puretone presented 40 dB above threshold and was asked to indicate when amplitude modulation of the steady state signal resulted in a pulsating sound. Those patients who could detect small intensity changes were assumed to have cochlear pathology.

This ' test led to the development of another test which also involved detection of very small increments in intensity. This test was proposed by Jerger, Harford & Shedd in 1959 & is called Short increment sensitivity Index.

VISUAL

Slide - 8
Flow chart of
SISI

Slide - 9
Schematic of
stimulus
presentation in
short increment
sensitivity index
test

Slide - 10
Modifications of
SISI

AUDIO

The test is done at 20 dBSL at 500Hz, KHz
2 KHz & 4KHz.

The task is to detect 1db increments
which are super imposed on a 20 dB SL
carrier tone, the increment is given
every 5 sec for 200 msec. Interpretation
is based on the percentage scores of
correct identification.

Scores of 0-70 indicate non cochlear
lesion and scores between 90-100 indicate
chchlear lesion.

- SISI may be performed in at least 5 ways.
- 1) One dB increments at 20 dBSL (the
classical SISI test) high scores
suggest a cochlear lesion.
 - 2) 2-5 dB increments at 20dBSL low scores
suggest a retrocochlear lesion.
 - 3) One dB increments at high sound levels
(eg 75dBHL) low scores suggest a
retrocochlear lesion.
 - 4) Increment sizes varied from 1 to 5 dB
at 20 dBSL - poorer scores in one ear
than the other (when thresholds are
approximately equal) suggests X@
central lesion opposite the ear with
the lower scores.
 - 5) One dB increments at SLs ranging from
20 dB to high levels (about (75 dBHL)
in 10 dB steps for both ears.
Difference in the rate at which scores
increase suggests a retro cochlear
lesion.

Abnormal adaptation is a feature seen in
the retrocochlear pathologies.

VISUAL

Slide - 11
 Procedure in tone
 decay test

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Tone decay test is a test to detect abnormal adaptation. Tone decay test was, first proposed by Schubert in 1944. since then many modifications have been proposed by various researchers of these methods the Olsen & Noffs TDT which was proposed in 1974, has enjoyed popular use.

In this test the tone is presented at 20 dBSL for 1 minute. Case has to respond to the tone as long as he hears it. If case hears the tone for 1 minute at 20 dBSL test is negative. If the case stops responding then intensity is increased in 5 dB steps without interrupting the tone till the case hears for 1 minute or till 35 dBSL is reached, time for which the person hears at each level should be noted. If case doesn't hear the tone for 1 minute at 35 dBSL also it indicates retrocochlear pathology.

Olsen and Noffsinger's TDT is done at 500 Hz, 1Khz & 2Khz. A modification of this test which is done at suprathreshold levels is the supra threshold Adaptation test.

Slide - 12
 Suprathreshold
 adaptation test

This test was developed by Jerger & Jerger in 1975.

It is same as TDT except in this test tone is presented at 110 dBSL at 500 Hz, 1KHz & 2KHz for 1 min to the test ear and white noise at a level of 90 dBSL to the non test ear.

The test is scored positive if the patient fails to respond for the full 60 sec. In which case it is indicative of retrocochlear pathology.

These are few of the puretone procedures used to locate the cochlear and retrocochlear lesion. Automatic pure tone audiometry has also been used for this purpose.

VISUAL

Slide - 13
Bekeesy Audiometer

Slide - 14
Type 1 & Type 2
tracings in Bekeesy
audiometer

Slide - 15
Type 3 and Type 4
tracings in Bekeesy
audiometry

AUDIO

This procedure was first described by Von Bekeesy in 1947 and was modified by Jerger in 1960's.

A special audiometer is required for testing. Test frequencies range from 125 Hz - 8 KHz and are presented to the patient in 2 modes- The Sweep frequency mode & the fixed frequency mode.

The intensity of presentation is controlled by patient through a response button, subject presses the button, when he hears the tone & hence reduces the intensity & releases the button when he stops hearing hence increasing the intensity. Rate of intensity change is 2.5 dB/second. 4 types of tracing are obtained which can be used to differentiate cochlear pathology and retrocochlear pathology.

Tracings are obtained through both interrupted and continuous tracings.

Type 1 tracing. In this type the pulsed and continuous tones are superimposed at all frequencies. Amplitude of excersion is roughly 10 dB. This type is typical of conductive hearing loss and occasionally in sensory neural hearing loss & presbycusis.

Type 2 tracing - The pulsed & continuous tones are superimposed at the low frequencies from roughly 1 KHz onwards the continuous trace falls below the pulsed trace by about 20 dB and the gap remains parallel for the remaining frequencies. This trace is typical of cochlear disorders such as Meniere's disease.

Type 3 tracing - The pulsed trace is normal but the continuous trace falls way below the pulsed trace at an early stage e.g. less than 500Hz, sometimes disappearing altogether. This trace is typical of retrocochlear disorders such as acoustic neuroma.

VISUAL

AUDIO

Type 4 tracing - There is a wide gap (greater than 25 dB) between the pulsed and continuous traces. The separation takes place at a fairly early stages and remains stable over the whole frequency range. This trace is typical of retrocochlear disorders.

Modification of the conventional Bekesy audiometry have also been used to detect cochlear and retrocochlear lesions.

Slide - 16
Comparison of
forward reversal
tracings

Karja a Palva observed in 1970 that in retrocochlear disorder comparison of forward and reverse tracings of the continuous tone shows significant difference in threshold obtained through these 2 tracings i.e., greater than 10

Slide - 17
Critical off time

Critical off time This test was proposed by Herbert and young (1962) critical off time is the off time when the interrupted tracing behaves like continuous tracing. The normal on-off time is 200 ms. If off time is reduced to 125 ms it indicates retrocochlear pathology and if off times reduced to 75ms and type 1 tracing is seen then it indicates cochlear pathology. Due to tone decay I tone is perserved as continous tone.

Slide - 18
Continuous tone
masking

Continuous tone masking: Here tone is presented at either 10 dB SL or 20 dB SL and patient is asked to trace his threshold for pulsed tone. The threshold for pulsed tone is found in the presence and then in the absence of a continuous tone. There will be a large threshold shift in case of retrocochlear pathology with the threshold of pulse tone in the absence of continuous tone being less. Another modification of the conventional Bekery audiometry is brief tone Bekesy audiometry.

VISUAL

Slide - 19
Brief Tone
Audiometry

AUDIO

Hughes in 1946 was the first to show that, as the stimulus duration decreased, the pure tone threshold increased. Barner and Miller in 1947 showed that this effect occurs for stimulus below 200 ms and is referred to as temporal integration or summation function. Sanders, Josey and Kemker in 1971 showed that the slope of this function in retrocochlear pathology was similar to that in normals and steeper than that found in cochlear pathology cases. Thus, brief tone audiometry differentiated between retrocochlear impaired ears and cochlear impaired ears but not between retrocochlear impaired and normal hearing ears.

These were a few pure tone procedures used for differentially diagnosing sensory and neural hearing loss cases.

Slide - 20
Articulation curve
PI - PB function

Speech tests are also useful in this. One such useful test is the PI-PB function and the roll over index.

The articulations curve was obtained by Jerger and Jerger in 1971.

In this test the speech discrimination is recorded on a graph in which the intensity of presentation in decibels is plotted against the percentage of correctly identified items.

The following patterns are seen for various pathologies. In normal ears type(a) is seen in conductive hearing loss type(b) is seen.

Type(d) in which the intelligibility is not improved beyond a certain dB SL i.e. 100% discrimination is not reached is seen usually in cochlear disorders and is due to recruitment.

Type (e) slope in which beyond a certain point intelligibility is reduced by further increase in intensity i.e., roll over seen is typical of advanced cochlear disorder or an VIIIth nerve lesion.

VISUAL

Slide - 21
Roll over Index

AUDIO

To find the significance of roll over the formula.

$PB \text{ Max} - PB \text{ min}$ is used

$PB \text{ Max}$

Where PB max is the highest SDS at which the subject reaches the plateau and PB min is the lowest point to which the discrimination drops after further increase in intensity.

If this function is greater than 0.45 it indicates retrocochlear lesion.

Another useful parameter which is routinely used in detecting cochlear pathology is the dynamic range.

Slide - 22
Dynamic range

Dynamic range is found by deducting the speech reception threshold from uncomfortable loudness level.

In normals the dynamic range is 90-100 dB if the dynamic range is less in a case it is suggestive of cochlear pathology.

These tests were subjective in nature, one can also make use of objective procedures i.e., where the voluntary response is not required to come to a diagnosis.

The procedures which are most widely used are reflexometry and evoked response audiometry.

Slide - 23
Block diagrams of
the reflex arc

Reflexometry

A stimulus which is sufficiently loud elicits a reflexive contraction of the stapedial muscle when the reflex arc is intact.

The reflex can be elicited by both ipsilateral and contralateral stimulation.

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Depicting the right and left ear reflexes both for crossed and uncrossed stimulation yields the Jerger box pattern. Jerger proposed use of box patterns in 1979. The Jerger box pattern is an important indicator of site of lesion. 3 types of boxes clear boxes indicate reflexes within normal blackened boxes indicate that reflexes are absent, hatched boxes indicate reflexes present but abnormal.

Slide - 24
Jerger box patterns in
(a) subject with normal hearing in right ear and mild cochlear loss in left ear
(b) subject with severe unilateral cochlear loss

Jerger box pattern in a subject with normal hearing in right ear and mild cochlear loss in left ear. All reflexes are present the reflexes in left ear are present at low sensation level because of recruitment.

Jerger boat pattern in a case with normal hearing in the right ear and severe cochlear loss in left ear. Reflexes are normal when the right or the normal ear is stimulated and elevated in the case where the left ear is stimulated.

Slide - 25
Jerger box patterns in
a) Subject with profound unilateral cochlear loss
b) unilateral retrocochlear loss

Jerger box pattern in a case with normal hearing in " right ear and profound cochlear loss in left ear. A diagonal pattern where the right contralateral and left ipsilateral reflexes are absent.

Jerger ox pattern in a case with normal hearing in right ear and retrocochlear pathology in the left ear in this case too an diagonal pattern which is similar to the one seen when the case has normal hearing in right ear and profound cochlear loss in the left ear.

Slide - 26
Jerger box pattern a case in unilateral lesion left ear

Jerger box pattern in a case with normal hearing in right ear and brainstem lesion in the left ear. Two types of patterns might be seen depending on the site of lesion.

VISUAL

AUDIO

In case of extraaxial lesions a diagonal pattern is seen and in case of intraaxial lesion horizontal pattern is seen where the crossed reflexes are absent.

Slide - 27
Reflex decay test

A test used widely in clinical practice is the Reflex decay test. This test was first described by Anderson et al in 1969. This is a test of retrocochlear lesion here a tone is presented 10 dBSL with reference to acoustic reflex threshold for 10 seconds. A 500 Hz or 1KHz tone is used as stimulus. The amplitude of the reflex is monitored. In normals, normal amplitude is maintained throughout stimulation. If there is a reduction of amplitude of 50% or more within 5 secs it indicates the presence of a retrocochlear lesion.

Slide - 28
Metz recruitment test

A test of recruitment using reflexes is the Metz recruitment test. This consists of comparison between the puretone threshold in the contralateral ear and the reflex levels in the test ear. If the gap is less than 65 dB, then recruitment is present. The same procedure is carried out for all frequencies where cochlear dysfunction is suspected.

Slide - 29
Differential ratio quotient (DRQ)

Fitzland and Balkery gave a formula to compute the amount of recruitment this is called the differential ratio quotient or DRQ.

$$DRQ = \frac{(A-x) - (B-Y)}{x-y}$$

Where 'A' is the ART of better ear 'B' is the ART of poorer ear. 'X' is the pure tone threshold of better ear. 'Y' is the pure tone threshold of poorer ear.

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DRQ less than 0.5 suggests no recruitment
 DRQ equal to 1 indicates complete recruitment. If DRQ is between 0.5 and 1 it indicates partial recruitment.

DRQ greater than 1 is seen when there is hyper recruitment.

Slide - 30
 Reflex intensity
 function

Another index of recruitment may be seen in the abnormal growth of amplitude for successive increases in stimulus intensity. Where as in normal subjects after threshold has been established, the amplitude grows regularly in proportion to stimulus levels, in recruiting subjects there is sometimes evidence of disproportionate growth of amplitude even for a 5 dB increase in stimulus intensity.

Slide - 31
 Reflex relaxation
 index

Like DRQ another parameter which studies the temporal alterations of acoustic reflex is the reflex relaxation index. This was proposed by Norris et al in 1974. To measure RRI, a pulsed tone of 500 Hz, 1KHz and 2KHz is presented at 10 dB above acoustic threshold level. The width of the pulsed component is divided by the total reflex amplitude to get Reflex relaxation index. An RRI of less than 30% was considered indicative of SN loss. Besides reflexometry the other procedure useful in locating site of lesion is the Brain stem evoked response audiometry.

These responses were first recorded by Jewet and Willis ton in 1971. The stimulus used to evoke brainstem response are clicks. The Brainstem response is an early response whose latency is 4-6 sec.

Slide - 32 The shape of the wave or morphology shows Morphology of Jewet seven peaks.
 Wave

VISUAL

AUDIO

Slide 33
Origin of different
peaks in Jewet Wave

The peaks have different origins
Peak I - originates from cochlear nerve.
Peak II- originates from Cochlear Nuclear
Peak III - originates from Pons
Peak IV - originates from Pons
Peak V - originates from Mid Brain
Peak VI & VII undetermined.

Slide - 34
Abnormal wave
morphology

For differentially diagnosing
sensorineural hearing loss cases the
qualitative measure used is the wave
morphology and the quantitative measures
used are latency and amplitude measures.

Slide - 35
Measures used for
differential
diagnosis in ABR

Latency - Latency is the interval between
the presentation of the stimulus and the
response. Absolute latency is the
latency of each peak.

Inter peak latency is the latency between
two peaks interpeak latency of peak I,
peak III and Peak V are usually used for
diagnostic purposes.

Absolute latency is affected in cases of
conductive loss, sloping high frequency
loss and unilateral high frequency
profound hearing loss. But interpeak
latency is not affected by these
conditions.

In case of retro cochlear pathology the
interpeak latency is prolonged i.e.,
greater than 2 msec.

If amplitudes are considerably reduced
even at high intensity level when the
conventional audiometric threshold is 30
to 40 dB retrocochlear pathology can be
suspected.

If amplitude ratio of V & I peak is
greater than 1 one can suspect
retrocochlear pathology.

VISUAL

Slide - 36
Latency - Intensity
function

AUDIO

By plotting the latency of wave V at different intensities (the latency intensity function), general site of lesion information of a hearing loss may be inferred. If conductive hearing loss is present, the intensity required to produce ABR is increased. Threshold is elevated and latencies of all waves are prolonged but interwave intervals are normal and the slope of the latency intensity function is similar to one showing normal hearing. If the lesion results in a high frequency loss in the cochlear, wave V shows a normal latency at high sensation levels but i.e., prolonged near threshold, resulting in a steeply sloping latency intensity function. When the lesion affects the auditory nerve, as in the case of tumors, all waves subsequent to wave I are often delayed or absent at all intensities.

These tests are just a few of the many procedures used in locating the site of lesion.

Slide - 37
sensitivity
specificity and
efficiency of tests

Jerger and Jerger in 1983 and Turner and Nielen in 1984 have suggested that audiological tests for site of lesion can be subjected to a set of mathematical models by means of clinical decision analysis CDA asks questions about each tests sensitivity (how well it correctly identifies a lesion site or true positive), its specificity (How well it rejects an incorrect diagnosis or true negative), its predictive value. (The percentage of false positive and true negative results) and its efficiency (The percentage of true positive and true negative results) Review of the sensitivity, specificity and efficiency of 7 popular site of lesion tests shows that none of the tests are infallible some tests like Bakesy audiometry and STAT have high specificity but low sensitivity where as others like PI-PB have high specificity and moderate sensitivity, still other tests like ABR

VISUAL

AUDIO

are both highly specific and highly sensitive and are both efficient and possessive of high predictive value.

The trends pointed out by Martin and Morris (1989) suggest that the older psychophysical tests are giving way to newer electrophysiological procedures. No site of lesion test is infallible for any individual loss, it might be necessary to use the entire test battery before a diagnosis can be made. All results of special diagnostic tests must be compared with pure tone and speech results and above all to the patients history.

BIBLIOGRAPHY

- Ballantyne, D. Handbook of Audiological techniques, Butterworth-Heinemann Ltd, 1990.
- Jeffrey H. Owen and Charles D. Donhoe (ed) Clinical Atlas of Auditory Evoked potentials Grune and Stratton, Inc. Harcourt Brare Jovanich, 1988.
- Jerger, J and Northern, L.J. (ed) clinical Impedance Audiometry edn 2. American electromedics corporation, Massachnsetts, 1980.
- Katz, J (ed) Hand Book of clinical audiology ed. 2nd Williams and Wilkins, Baltimore, 1972.
- Martin, N.F. Introduction to Audiology Edn. 3rd Prentice Mall Inc. Englewood Cliffs, New Jersey 1986, 1981.
- Newby and Popelka R.6 Introduction to Audiology, Edn 5th, Prentice Hall, New Jersey 1985.
- Sataloff. T.R. and Sataloff T.J. Hearing loss Edn. 3rd Maxel Dekker, New York, 1993.