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.

ALL INDIA INSTITUTE OF SPEECH AND HEARING

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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

All India Institute
Of Speech & Hearing
Mysore

CERTIFICATE

This is to certify that the independent project entitled.

"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 RETROCQCHLEAR 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 Abroad 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 recruitment 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.

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Slide - 6 Ladder grams in cases with partial recruitment and decruitment	**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 larg**er** 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 Zwislocki 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.

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Slide - 8 Flow chart of S1S1	The test is done at 20 dBSL at 500Hz, KHz 2 Khz & 4Khz.
Slide - 9 Schematic of stimulus presentation in short increment sensitivity index test	The task is to detect ldb 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.
Slide - 10 Modifications of SISI	S1S1 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.

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Slide - 11 Procedure in tone decay test	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, lKhz & 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.

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Slide - 13 Bekesy Audiometer	This procedure was first described by Von Bekesy 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.
Slide - 14 Type 1 *&* Type 2 tracings in Bekesy audiometer	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.
Slide - 15 Type 3 and Type 4 tracings in Bekesy audiometry	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.

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	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 cochlearpathology. 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 dBSL 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.

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Slide - 19 Brief Tone Audiometry	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 retro-cochlear 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 dBSL 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 Vlllth nerve lesion.

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Slide - 21 Roll over Index	To find the significance of roll over the formula. PB Max - PB min is used PB 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	<u>Reflexometry</u> 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 paaterns 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 bones 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 retrococchlear 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.

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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.

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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 with in 5 sees 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 of Jewet Wave	shows seven peaks.

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Slide *33* Origin of different peaks in Jewet Wave	The peaks have different origins Peak I - originates from cochlear nerve. Peak II- originates from Gochelar 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 is 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 I one can suspect retrocochlear pathology.

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Slide - 36 Latency - Intensity function	By plotting the latency of wave V at different intensities (the latency intensity function), general site of lesion information of a bearing loss may be inferred. If conductive rearing 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 ie., prolonged near threshold, resulting in a steeply sloping latency intensity function. When the lesion affects the auditory nerve, as in the case of turmors, 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 le0sion site or true positive), its specificity (How well it rejects an incorrect diagnosis or true negative), its predictive valve. (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

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

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.

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