The Effect of Test Tone Levels And Contralateral Masking Noise Levels on the S.I.S.I. Scores for Normal and Sensori-Neural Loss Cases

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CERTIFICATE

This is to certify that the Dissertation entitled: "The effect of test tone levels and contralateral masking noise levels on the SISI scores for normal and sensori neural loss cases" is the bonafide work in part fulfillment for M.Sc., Speech and Hearing, carrying 100 marks of the student with Register Number: 21.

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CERTIFICATE

This is to certify that the dissertation has been prepared under my supervision and guidance.

GUIDE

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Dr. M.N.Vyasamurthy, Lecturer & Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore.

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CONTENTS

CHAPTER I

INTRODUCTION

"As new tests are developed and old ones refined the audiologist finds himself with more and move tools at his disposal for determination of locus of auditory lesion," (Martin, 1970).

Since the observation of Dix, Hallpike, Hood (1948) relating recruitment to cochlear pathology the audiologist has been able to determine with some degree of certainty that the presence of recruitment is an indicator of a cochlear disorder.

Many procedures have been devoted to the determination of the presence of loudness recruitment. Difference Limen for Intensity (DLI) was used as an indirect measure of Recruitment. DLI is the smallest change in the intensity of a pure tone which the ear can just detect. Persons with normal hearing have difficulty in detecting small changes in intensity close to their auditory thresholds. There is a positive relationship between the ability to detect small intensity changes at relatively low sensation levels (SLS) and the presence of Auditory Recruitment.

Luscher and Zwislocki (1949) developed a DL test in which the patient was presented with a pure tone 40 dB above his threshold and was asked to indicate when he heard a wobbulating sound resulting from amplitude modulation of a steady state signal. Patients who could detect small intensity changes in comparison with Lusoher's normative data were considered to have cochlear lesion. Denes and Naunton (1950) required their patients to report a difference in loudness of two tons presented at two presentation levels of 4 and 44 dB SL. Normal subjects had large differences between the two levels while those with cochlear lesions showed very small differences between their two DL's. Jerger (1952) modified Luscher-Zwislocki DL Test and used 15 dB SL presentation. Jerger (1953) used a DL test similar to Denes and Naunton but compared at 10 and 40 dB SL.

In 1959, Jerger, Shodd and Harford described a test which was a relatively simple task called the Short Increment Sensitivity Index (SISI). A pure tone was presented to a patient at 20 dB SL and a small increment in intensity varying from 5 to 1 dB was superimposed upon the steady state tone at periodic intervals. The subject had to signal to the examiner if he heard that increment. After presentation of 20 such increments, the SISI score is derived by multiplying the number of increments detected by 5. Practice is given before the scoring starts. The possibility of false positive and negative responses are reduced by the interseparation of either no increment or 5 dB at every five test presentation depending upon the character of the previous responses.

Since first introduced by Jerger SISI has found wide application in the topical diagnosis of hearing loss. It has become part of the audiological test battery for site of lesion testing. Several studies are now available on the reliability of the SISI test and on a range of variables which are of significance for the results of SISI. However discrepancies between SISI results and ontological diagnosis have been reported in the literature. (Johnson 1965). Several variations in the normal procedure outlined above have been introduced. Some like Yantis and Decker (1964) have indicated that the procedure yields results that are dependent upon sound pressure level (SPL) of the stimulus reaching the cochlea and the sensation level (SL) at which the tone is presented i.e. Standard 20 dB SL.

It has become a standard clinical procedure to exclude the participation of the non-test ear during SISI testing with appropriate masking in those cases of unilateral hearing loss of suspected cochlear and Retro cochlear pathology. However, it is entirely possible that the slight changes in the test condition produced by the contralateral masking may alter the SISI results. As reported in the preliminary communication Blegvad (1966) in some patients with unilateral sensori-neural loss the results of investigation was influenced by the use of masking noise. Recently Blegvad and Terkildsen (1967) investigated the effect of contralateral masking noise i.e., white noise on SISI scores on ten normal hearing subjects. White noise at 50, 70, 90 dB SPL and the intensity of constant SISI signal was 20 dB SL. Only at 4 KHz did 50 dB SPL noise result in improvement of the SISI score. With 70 dB SPL of contralateral noise five subjects attained positive scores (60% higher) 3 subjects questionable (20% to 50%) and two negative scores. In a lateral study Blegvad (1969) investigated the effect of contralateral masking 80 dB SPL of white noise on SISI scores of 32 subjects with sensori neural loss. There was an increase in the mean SISI scores at 1 K and 4 K under this condition. They have reported that the relationship between the intensity of the test tone and the masking undoubtedly deserves further study.

STATEMENT OF THE PROBLEM

The aim of the present study was to check whether there was any effect of noise on the SISI scores and to study the varying effects of noise if any, at different intensity levels of the test tone. Further it was proposed to investigate the effect of the test tone level on the SISI scores on the normal and the clinical subjects and secure and normative data for 100% SISI results.

So for no studies being available on the experience of Indian listeners on different audiological test batteries, the present study was undertaken. The routine audiological tests were administered and also the special audiometric tests like SISI, ABLB and TDT were performed on sensori neural loss cases and the results were analyzed in detail.

HYPOTHESES

1) a) There is no effect of contralateral masking noise on SISI scores in normals and clinical subjects. (Unilateral Sensori Neural Lose).

   b) There is no significant difference between the different intensities of noise on their SISI scores.

   c) The effect of noise does not vary significantly at different intensities of the test tone.

   d) There is no significant difference in SISI scores between normals and the clinical group (Unilateral Sensori Neural loss cases).

2) There is no significant difference in SISI scores at different levels of intensity of the test tone.

BRIEF PLAN OF THE STUDY

Thirty normal subjects were taken for the study and 10 unilateral S.N. loss cases comprised the clinical group as well as thirty S.N. loss cases. SISI test was administered to all at different levels of the test tone at 40, 50, 60 db HL and under three noise condition vis. 60, 70, 80 dB masking noise in the non-test ear. The test was administered as described by Jerger (1959) in his original procedure only with slight modifications to suit the present study. The test was administered to randomly selected ears, and at different random levels and frequencies between 4 K and 2 K, male and females all of which were randomly chosen. The whole testing was divided into two settings for the sake of subject's convenience.

DEFINITION OF SOME OF THE TERMS USED IN THE STUDY

1. Recruitment – Abnormally rapid loudness growth with the increase in intensity of the sound.
2. Contralateral masking noise – noise presented to the non-test ear.
3. Difference limen – Just noticeable difference or differential threshold – the smallest change in a given physical property of stimuli that produced an observable change in sensation.

CHAPTER II

REVIEW OF LITERATURE

Abnormally rapid loudness growth has been the subject of interest and investigation for many years. There were early reports of persons with hearing loss whose threshold deficit 'disappeared' at higher intensity levels (Pohlman & Krans, 1924). Fowler named this abnormal growth is loudness with the increase in intensity as Recruitment, when he first described his alternate binaural loudness balance test. He originally through it would help him diagnose early sub-clinical otosclerosis (Fowler 1936). But later found recruitment in unilateral sensori neural patients. Lorente de No (1937) commenting on Fowler's 1937 paper on recruitment theorized that recruitment was due to either hair cell damage or nerve fibre loss. Since then many procedure have been devoted to the determination of the presence of loudness recruitment.

The phenomenon of recruitment is measured by having the patient compare the loudness of the tone which is heard within normal limits with a tone for which the patient has an impaired threshold. The loudness comparisons are done at suprathreshold levels and the patient is required to 'balance' or match the loudness of these two tones. The tones are made to alternate so that the patient may listen to each tone alone and make judgments on the relative loudness of the two tones. If this loudness matching is done in the same ear using different tones then it is MLD (Monaural Loudness Balance) (Reger, 1936) and between ears with same frequency tone it is alternate loudness balance or ABLB (Fowler 1936)

Dix et al. (1948) reported that loudness recruitment was characteristically present in end organ cochlear cochlea hearing loss and absent in cases of VIIIth nerve tumor. The importance of this observation encountered difficulties in obtaining definitive measurements of loudness of recruitment by tests commonly used at that time, notably ABLB and NLB. Attention was thus turned to intensity difference limen as possible indicator of loudness recruitment on the assumption that recruiting ear compared to a non-recruiting ear "compressed" more loudness unite into a given range of intensity. It was believed that intensity increment would accordingly involve more loudness units and thus would be more noticeable. By extension, the intensity increment needed for just noticeable difference in loudness would be smaller for recruiting ears than for non-recruiting ears. However the phenomenon of recruitment appears to be controversial. It may be an artifact (Jagadesh, 1970). Two major tests emerged the Luscher Zwislood and Denes Naunton tests making use of this relationship between the ability to detect small intensity changes at relatively low sensation levels and the presence of auditory recruitment.

Luseher and Zwislocki (1949) developed a DL test in which the patient was present with a pure tone of 40 dB above his threshold and was asked to indicate when he heard a wobbulating sound resulting from the amplitude modulation of the steady state signal. Those patients who could detect small intensity changes were assumed to have cochlear lesions. Those having impaired hearing loss i.e. patients who could not detect small changes in loudness were assumed to have non-cochlear lesions. It was therefore a test of loudness discrimination.

Denes and and Naunton (1950) asked their patients to report a difference in loudness of two tones presented one after the other at signal presentation levels 4 and 44 dB SL. The test was to find out the difference between DL's at the two levels. Normal hearing subjects had large differences between the two levels while those with cochlear lesions showed very small differences between their two DL's

Jerger (1952) using a modification of the Luscher Zwislocki test i.e. 15 dB SL presentation level showed parrallelism of abnormally small intensity difference limen and recruitment. Lund Iverson (1952) confirmed Luscher Zwislocki technique. While Liden and Nilsson (1950) indicated that Luscher-Zwislocki technique did not always differentiate clearly between recruiting and non-recruiting ears. Jerger's (1955) second DL test was similar to Denes and Maunton's but compared the rise of DL's at 10 and 40 dB SL. Here the signal used was one which was wobbulated in intensity requiring the patient to indicate the smallest level at which he could barely near changes in loudness. Hirsh, Palva and Goodman (1954) found no clear differences between recruiting and non-recruiting ears with respect to their ability to judge small changes in loudness during the use of modification of Denes Naunston test.

By the late 1950's disappointment in the applicability of DL tests for indicating recruitment was great enough that many abandoned them. There were difficulties in administration and response on the test. Harris (1963) indicated that subjects take more time in learning the DL task and many would not perceive the 'beats'. Others gave false positive responses.

Jerger in 1959 introduced SISI, a test technique designed to differentiate subjects who wore able to detect very small amplitude changes presented periodically in a pure tone signal. Having observed that may ears with a sensitivity loss due to abnormal cochlear function appear to have extremely keen discrimination for all changes in tonal intensity, these authors defined a relatively simple task called Short Increment Sensitivity Index (SISI).

A pure tone was presented to the patient 20 dB above his threshold and a small increase in intensity was superimposed upon the steady state tone at periodic intervals. The size of the increment would be varied from 5 to 1 dB. The subject is asked to signal the examiner would be varied from 5 to 1dB. The subject is asked to signal the examiner each time he gets the increment. After presentation of twenty such 1 dB increments, the SISI scores are computed by multiplying the number of detected increments by 5%. Initially 5 dB increments are presented five times for practice. The possibility of false positive and false negative is reduced by introducing either no increment or 5 dB increment after every 5 test presentation depending upon the character of previous responses.

The SISI score is derived by determining the number of correct identification of the 1 dB increment out of 20 presentations. This number multiplied by 5% gives SISI score. Jerger et al, found the ability to detect 1 dB increment was largely restricted to patients with cochlea pathology. Therefore they indicated that scores between 70% and 100% as positive, indicative of cochlear lesion. While the ability to detect increments being absent in cases of normal hearing and conductive losses and Retro-cochlear scores between 0% to 70% was considered by them as SISI negative. In the study by Jerger et al. (1962) SISI test was given to 27 subjects of normal hearing, 95 patients with cochlear lesions and 15 patients with VIIIth nerve lesions. Test scores for cochlear lesions were typically 60% or higher (often 100%). Those of VIIIth nerve lesions 0%, VIIIth nerve lesions other than tumor had 60% scores, 3 patients 0% scores despite negative nerve lesion findings.

Jerger, comments that they were not particularly concerned with whether it measures recruitment or not. The question was whether it relates to site of lesion within the auditory mechanism or any kind of meaningful pattern of diagnostic categories. Apparently only pathological cochleas give rise to this ability to respond to a transient signal of small amplitude whereas lesions elsewhere in the auditory system do not. Findings of such diagnostic tests for cochlear functions on ABLB, DLI, acoustic reflex, performance intensity functions, on word discrimination tests, as well as SISI test may correlate highly in cases of cochlear lesion since they spring from the same parent disorder.

Since the description of SISI by Jerger (1959), the investigation of sensitivity of ear to changes in intensity has found wide application in the topical diagnosis of hearing loss. Several studies are now available on the reliability of the SISI test and on a range of variable which are of significance for the results of SISI.

Yantis & Decker (1964) did a detailed study on the various aspects of SISI test i.e. the relationship between the sound pressure level (SPL) at which SISI test is administered and scores. They found SISI scores become progressively greater with increased intensity of the automatic tone pulse and the average normal ear is least sensitive to the 1 dB increment. Relatively consistent increase in average SISI score was found by them for each of the intensity categories, as a function of higher frequency of the test tone.

While Stevens et al (1941) using a instrumental pure tone stimulus and quantal method similar to that employed in SISI found that the relative sensitivity to the increment improved when the intensity of stimulus was increased. Harris (1963) reported subjects responding to the same kind of stimulus as used in the Stevens study were able to hear increasingly smaller increments as the sensation level was raised. Thus as the loudness of tone increase the normal cochlea improves in sensitivity to detect incremental stimulus. Luscher (1957) sates difference limen is dependent upon intensity as such and comes out smaller at greater intensities, which happens equally tot eh normal hearer and the persons who ha shearing loss. The difference limen is therefore, he says, a measure of intensity and becomes smaller, the louder the tone is subjectively perceived. Recently Young & Harbert (1967) found that if the inner ear receives a signal 60 dB SPL or greater there is a positive score in all ears except those with abnormal adaptation. Lack of SISI responses were noted in cases with abnormal adaptations regardless of the intensity of the carrier tone. High SISI scores indicate that the ear is functioning as a normal ear would with an equivalent SPL. And a negative score at 60 dB SPL indicates abnormal adaptation.

Swisher (1966) determined IDL for a 2000 Hz tone at a number of hearing levels ranging from 0 to 100 dB HTL for 20 subjects of normal hearing and 20 subjects with cochlear pathology. The median DL of the group with cochlear pathology tended to be smaller when the results were plotted in SL. However, the HL curves of the two groups were similar. These results show that when DL tests are expressed in SL, then the standard tone should be taken into consideration. A physiological explanation by Katsuki & Kanno (1962) is that the rate of increase in nerve impulses with stimulation at increased SPL tended to be smaller in neurons with low threshold than those with high thresholds. Further, Swisher refers to the work of Davis (1957) suggesting that inner hair cells have higher thresholds than outer hair cells and once they have reached the ability to detect the small changes in intensity is markedly increased. May be in cochlear lesions with high SISI scores the inner hair cells are somehow spared or are affected later than the outer cells, Hallpike and Hood (1959) have questioned this with their Histological evidence in several cases of Nenier's Disease.

Swisher, Stephens and Doehring (1966) did two experiments which were concerned with the relationship between the hearing threshold level of a standard tone and the sensitivity to an intensity changes on the SISI test. The results indicated that the SISI score is influenced by both the hearing threshold level of the carrier tone and normal variability in differential sensitivity. Martin (1970) compared SISI test scores in cochlear impaired ears at 4000 Hz with scores at the same subjective loudness in the opposite ear using 20 dB SL as reference level. Scores were not same here for both the ears. He tested again at 20 dB SL at normal ear and equal loudness level in poorer ear. Again scores were not same in both the ears. However, when the test was performed at the same SPL in the normal ear as 20 dB SL in pathological ear, scores were identical.

so, the conclusion drawn was when SPL's of 55 or 65 dB are generated at the cochleas of either normal or cochlear involved cases, high SISI scores results at 4000 Hz regardless of the sensation of loudness.

Hanley & Utting (1965) attempted to find whether SISI increment size was of sufficient challenge. They found more than 20 of the 48 normal hearing population could score as high as 60% with increment size of 1 dB to 0.75 dB and 0.50 dB. Many subjects with cochlear pathology could hear changes as small as 0.5 dB. They recommended that SISI test be done with an increment size of 0.75 dB for all subjects in order to make the task more difficult for normal hearing persons. Yet possible for the cochlear subject to pass. Sanders and Simpson (1966) performed the SISI test at 1.0, 0.75 and 0.50 dB increment on 24 subjects with normal hearing and 9 with cochlear lesions. He found 1.0dB increment is large enough to reveal cochlear pathology when it exists, yet small enough to prevent spuriously high scores in ears with normal hearing. Their conclusion was SISI test should be continued using 1 dB increment.

Yantis and Deoker (1964) found tendency of SISI scores to cluster at extremes of the continuum and concluded that the test may be safely reduced to 10 increments in many cases. They found in 80% of the cases no significant change in scores obtained on the first ten presentation and on the later ten presentations. The split half reliability correlation coefficient was high at three frequencies especially at 1 K and 4 K. Owens (1965a) confirmed this and he stated this as possible owing to the strong tendency toward all or none type of responses on the test. Griffing and Tuck (1963) using ten increments instead of 20 found that the reliability of the test was reduced only slightly. This procedure not only conserves time but also reduces fatigue and loss of attention of the subject.

Yantis & Decker (1964) reported that while testing SISI at 4 K the first increment was not heard significantly more times than at other frequencies. They attributed this to the sudden transition of the increment presentation from 5 dB to 1 dB. They suggest 5 dB should be introduced at various points of the testing to reinforce the subject and also there should be gradual transition from 5 dB to 1 dB.

Fulton & Spradlin (1972) reported that SISI results are subject to practice affects. They found that SISI scores may be increased by giving feed-back for correct SISI signal detections ad also SISI scores increased with practice even if no feed-back is given. The practice effect, they say, cannot be attributed to a learned temporal response in view of the variable presentation schedule used in the experiment.

Owens (1965) suggests a slight departure from the recommended schedule of withholding an increment after every five 1 dB test presentation when the patient is responding to majority of the stimuli. It is seen patients are quick enough to observe the regular rhythm of 1dB increment presentations, so that to avoid this, control events should be introduced as often as thought necessary. Similarly when patient is not responding properly a 2 or 3 dB increment should be inserted so as to keep him alert.

Hughes (1968) discussed 18 subjects who achieved high SISI scores 80 to 100% and reported that 1 dB increment emerged from silence. This situation was brought about by abnormal tone decay which caused adaptation to the carrier tone. Despite this fact the high scores they yielded were quite consistent with the diagnosis of auditory pathology. Thus SISI test retains its validity even in cochlear cases with unusual pathological adaptation. He also states that confirmed cochlear lesions can also yield high SISI scores despite excessive tone decay.

Thompson (1963) studied two cases of surgically confirmed acoustic neuromas without appreciable hearing less. Using the normal ear as control, he gave SISI test at 20 dB and 75 dB SL at 1000 Hz to the proper ear. Even at high sensation levels the poorer ear was unable to detect small intensity increments inspite of the hearing loss being slight. Thus modified SISI technique provided useful information in these two cases.

Young & Heubert (1967) state negative SISI scores for audible signals of 60 dB or grater are indicative of abnormal adaptation. They conclude this as a much more significant finding then a positive score.

Hodgson cited a case of unilateral hemisperectony who showed reduced SISI scores on the ear opposite to the side of lesion.

Koch, Rartels and Rupp (1969) compared a normal hearing group with a sensori neural group on SISI at the standard 20 dB SL and at higher intensity levels. They found both the groups raised their SISI scores consistent with the increase in intensity. While 5 subjects with Retrocochlear lesions continued to have low scores even at higher levels. Thus the current view is that a modified

SISI test should be carried out at high sensation levels in order to completely over-rule the possibility of a Retrocochlea lesions.

Johnson (1965) analyzed 110 cases of surgically confirmed Retro-cochlear lesions, in terms of various auditory findings, like pure tone loss configurations, speech discriminations, auditory adaptations as evidenced in the MTDT and in Bekesy audiometry, SISI test scores, ABLB results. It was found nearly 60% produced the expected auditory responses to the various types of tests. Jerger (1962a) while discussing the differential diagnosis by auditory tests states, the diagnosis is most accurate when a multiple test battery is used rather than when relying on single test. The fallibility of relying on SISI test as a single diagnostic tool is also pointed out by Mensel (1966) who concluded that SISI test is useful diagnostically in that it "supplements" other auditory test which can be performed. Sanders (1965) and Tillman (1966) also concluded entire battery yields more useful information than individual tests alone. Owens (1965 b) found evidence of recruitment from ABLB tests on 85 subjects with positive SISI scores. He concluded SISI test reflects recruitment and both the tests are duplicative.

Jerger & Allen (1961) studied 12 cases of unilateral S.N. hearing loss of cochlear origin and 12 cases of unilateral retrocochlear lesion. Both groups showed the expected results on the tests. Rosenberg & Brand (1963) found the SISI scores ranging from 0 to 100% on a number of patients with cerebello-pontine angel tumors. Johnson (1966) analyzed 163 cases of confirmed retrocochlear lesions and found that 70% had positive findings in the audiological battery.

Naunton (1967) in his 18 cases of surgically confirmed acoustic neurinomas found that tests failed to reveal any pattern consistent with that expected in the case of retrocochlear cases. When both cochlear and retrocochlear lesion coexist the trend of results were to show a picture of cochlear involvement. He thus stresses a need for complete battery of auditory, radiologic, vestibular and laboratory tests. Later Johnson (1968) showed that 37 cases out of 156 retrocochlear lesions showed a typical SISI scores ranging from 75 to 100%.

Prat & Egan (1968) studied SISI scores on 88% of patients who benefited from stepedectomy. All of these had negative pre-operative SISI scores with no significant discrimination loss and no tolerance problem. While those 12% who did not have good functional result with discrimination loss & tolerance problem had positive SISI scores.

Isolation of the test stimulus to the ear under test is a frequent problem in audiometry. This is generally accomplished by the application of noise to the non-test ear. It is well know that when a test signal is presented by ear phone to one ear of the patient the signal also arrives at the opposite ear at an attenuated level, usually about 50 to 60 dB lower. With bone conduction vibrator presentations the signal level at the opposite ear is probably only 1 to 10 dB less than at the test ear. The difference between the presentation level and the level of the opposite ear is referred to as IA (Interaural attenuation). Whenever the presentation level minus IA is greater than the threshold of the non test ear, then the non-test ear has significant influence on the test results.

Now if the carrier tone on the SISI test can be heard b y the non test one, the audiologist may need to take care to isolate the nontest ear. A precise procedure should beundertaken, which avoids the pitfalls of undermasking and overmasking in the vast majority of cases (Studebaker, 1967). His formula for this level of effective masking to be used in non-test ear: The hearing level dial setting used for SISI test minus 40 dB (IA) plus the airbone gap of the masked ear. This would be minimum level of noise high enough to avoid contralateral participation in the SISI test.

When to mask --- SISI HTL - IA = BC_{nte}.

Effective Masking level --- EM = SISI HTL – IA + $AB_{nte.}$

This masking is very necessary, for without appropriate masking it is possible to obtain a pattern of special auditory test result consistent with cochlear pathology in a ear with sensorineural loss actually due to VIIIth nerve tumor.

It has become a standard clinical procedure to exclude the participation of the non-test ear during SISI testing with appropriate masking in those cases of unilateral deafness of suspected cochlear pathology. However, it is entirely possible that the slight change in the test ear condition produced by contralateral masking may alter the SISI results.

Ward (1967) states, if a steady high frequency noise whose intensity exceeds 85 dB SPL is presented to one ear of the normal listener then the threshold for low frequency tone in the other ear is elevated. This he calls contralateral remote masking. Jerger defines CRM as masking without any direct masking effect on the test ear through physical cross over of the sound.

Ward (1961) through extensive investigation concluded that CRM is largely as a result of the acoustic reflex which is accompanied by unilateral high frequency noise. Bilger (1966) showed that there was no significant difference in CRM between two groups; normal control subjects and those whose stapedius muscles were cut off. Thus CRM was not accounted by acoustic reflex.

Ward (1967) suggested CRM may be due to (1) an attenuation of test signal caused by reflex contraction of middle ear muscles, (2) direct masking by physiological noise from these muscles, (3) some from of contral making; an inter action between neural events originating at the respective cochleas.

Studies by Dirks and Malmquist (1965) and Dirks and Norris (1966) explored the contralateral threshold shift for discrete pulsed and continuous tones as a consequence of pulsed and continuous masking stimulus. When the masker and test stimulus were presented in the same mode (either both pulsed or both continuous) the contralateral threshold shift was longer than when masking noise was steady and the test tone pulsed. Sheriek found central masking greater at higher frequencies. Threshold shifts of 1.5 dB, 3.5 dB, 6.5 dB, for 250, 1K and 4 K were obtained for 40 dB SPL noise when both were continuous. Studies on the effect of contralateral noise on pulsed tone air conduction thresholds show an elevation in the threshold by about 3 dB. In the case of bone conduction tests the influence of a unilateral masker on the threshold is somewhat larger, particularly more if the bone conductive vibrator is placed at forehead. Studebaker (1962) and Dirks & Malmquist (1964) observed about 4 or 5 dB threshold shift with mastoid vibrator placement and around 7 or 8 dB with forehead placement.

Sherriek (1954) investigated the effect of random background noise on the DLI for pure tones of three sensation levels 20, 40 and 60 dB SL for frequencies 250, 1000 and 4000 Hz with varying signal to noise ratio – 15, -10, 0 and 10. They concluded that S/N ratio was a very significant factor affecting DLK and as S/N ratio increased DLI become smaller. He also states that DLI was not affected by sensation level at which stimuli was presented.

Young & Werner (1968) studied five subjects on SISI test at 80 dB SPL test tone level introducing white noise monaurally increased at 5 dB stops to get different S/N ratios. Same results were obtained with narrow band noise. They found dramatic changes in SISI scores i.e. from 35% to 80% with as much as + 5 dB increase in the S/N ratio, the effect being same for all intensity levels 60 dB SPL to 100 dB SPL and at all frequencies 250 to 4000 Hs. while unilateral noise condition did not affect below 60 dB SPL test levels. The authors warned against testing SISI in very noisy surroundings.

With the exception of several works by Blegved, remarkably little published work is to be found on the influence of contralateral noise on typical audiomerty tests. Blegvad and Terkildsen (1966) found that masking the non-test ear exerts an influence on auditory procedures when a sustained stimulus is involved. In the case of SISI test they found the scores were improving at high frequencies. Blegvad and Terkildsen (1967) tested ten normal hearing subjects at 250, 1000, 4000 Hz in the presence of contralateral noise at 0, 50, 70 and 90 dB SPL, in the opposite ear with modified SISI procedure. With normal listener the contralateral noise increased the size of DLI at 250 Hz possible due to acoustic reflex which probably reduces the input to the cochlear at this frequency. A decrease in DLI was noted at 1000 Hz and 4000 Hz of about 0.5 dB with 70 and 90 dB contralateral noise levels. A 0.5 dB DLI change should have a substantial influence on the outcome of SISI test. Belgvad (1969) studied 32 patients with unilateral hearing loss on SISI test with the tone presented at 20 dB SL without masking and in the presence of 80 dB broadband noise. All patients taken had recruitment with positive ABLB results. DLI in these case improved significantly at 1000 and 4000 Hz when the good ear was masked. No change was seen at 250 Hz.

Swisher and Dudley (1969) tested 3 groups of normal hearing subjects with contralateral white noise, saw tooth noise and both type of noise under different intensity levels of the test tone 38, 58, 78 dB SPL and at different noise levels 17, 37, 57 dB SPL. On the whole there was hypersensitivity in the presence of noise at 4K the effects of noise was seen at 50, 70 and 90 dB SPL of the tone while with 1K even at 20 dB SPL the effect was seen for 70 and 90 dB noise. While at 250 dB SPL the effect was seen for 70 and 90 dB noise. While at 250 Hz there was decrease in sensitivity. They conclude, since the noise was not of sufficient intensity to affect the test ear, the effect of hyper sensitivity may be because of interaural interdependent. Contralateral noise could interact centrally with test tone of effectively increase the SPL of the test tone, thus producing decrease of DLI.

Grimes and Feldmen (1969) compared the Bekesy tracings of 5 normal hearing subjects with no masking and under three conditions of contralateral continuous masking noise. (1) White noise. (2) narrow band noise with band width of ± 300 Hz. (3) Narrowband noise with a constant band width of ± 150 Hz. They observed that when narrow bands were narrow enough to approach the critical band width, some subject confusion resulted. This confusion produced substantial elevation in the continuous tone thresholds (as much as 40 dB). They strongly recommended against using narrow band masking noise which approached the critical band width at any test signal frequency in continuous tone Bekesy auditometry.

Hurley and Rupp (1971) studied the effect of narrow band masking noise on SISI scores. They gave SISI test to 25 normal hearing subjects at 50 dB SPL for the frequencies 2K and 4 K. Then they testd again in the presence of contralateral narrow band noise of two widths 425 and 750 Hz centered at 4000 Hz. The mean values under no masking condition was 80% or higher. But not much difference was observed by them under masked condition. They conclude that the nearer the masking noise reached the critical band width it results in significant change in SISI score of normal subjects. In the present study it was decided to investigate the effect of intensity of the tone on the SISI under different tonal levels which actually served as control unmasked conditions, with which the effect of different narrow band noises at 60, 70, 80 dB HL were compared under each setting. This was done both for normal as well as the clinical group comprising of unilateral S.N. loss cases.

CHAPTER III

METHODOLOGY

The study constitutes the following parts:

1) To find out the effect of the intensity of the test tone in SPL (Sound pressure level) on SISI scores for the normal subjects, as well as the clinical group (S.N. loss cases)

2) To study the effects of contralateral masking noise on the SISI scores at varying intensity levels of the test tone for different intensity levels of the noise in normal space subjects as well as in clinical group of unilateral sensori neural loss cases.

3) To find out the validity of the SISI scores at 20 dB SL of the clinical subjects (Sensori-neural loss case) and compare the results with ABLB tone decay test and speech and pure tone audiometric results.

SUBJECTS:

Thirty college student of mean age 19 years were chose for participation in this study. There were 22 males and 8 females. All had bilateral normal hearing and they were free from any otologic complaints.

2) The clinical group comprised of ten unilateral sensorineural loss cases with essentially one normal ear and the other ear with S.N. loss. Care was taken to include cases only with pure S.N. loss with no conductive component.

3) Thirty sensori neural loss cases were taken up for the third part of the study.

GENERAL PROCEDURE

Measures obtained for each normal subject:

1) Pure tone average for each ear.

(2) SISI scores for different intensity levels of test tone. vis. at 40 dB HL, 50 dB HL and 60 dB HL. And with different intensities of contralateral masking noise viz. 60 dB HL, 70 dB HL, 80 dB HL at all the three tonal levels.

GENERAL PROCDURE FOR

(A) CLINICAL GROUP 1.

(Unilateral S.N. loss cases)

Measures obtained for each unilateral S.N. loss case:

1) Pure tone audiogram
2) SISI tests as in normal subjects.

(B) CLINICAL GROUP 2

(Sensori - neural loss cases)

Measures obtained for each S.N. loss cases:

1) pure tone audiogram.
2) speech reception threshold and discrimination scores
3) SISI test
4) ABLB test (unilateral S.N. loss cases)
5) TDT.

Pure tone audiometry by Hugson Westlake method was done for all the subjects. Ten dB threshold criteria was observed for selecting the normal subjects. SISI test was then administered to normal subjects at test tone levels of 40 dB HL, 50 dB HL and 60 dB HL without contralateral masking noise. Further the intensity of the test tone was increased and SISI test was continued until 100% SISI scores were obtained. The test was repeated with contralateral masking noise at different intensities viz. 60 dB HL, 70 dB HL and 80 dB HL. All the testing levels, the ear and the frequency 4K Hz and 2K Hz were randomly chosen. The whole testing procured was divided into two settings. A pilot study was conducted in which SISI test was administered to 3 subjects under 15 test conditions. The whole testing was done in more than one hour. It was observed that there was a lack of concentration of fatigue on the part of the subjects, by the end of the testing. With the same subjects when the testing conditions were split in to two settings, the results were different. In the first type of testing procedure there were many false positive and false negative responses; when the testing session was half an hour, there was considerable reduction in the number of false negative responses. Thus SISI test involves a lot of concentration as the part of the subject and also the task of detecting the increments is quite monotonous. Added to it, the presence of noise made it quite difficult for the subject to undergo testing for more than half an hour. To avoid fatigue and further loss of concentration, five minutes rest period was given between two test presentations. The SISI test was administered as originally described by Jerger (1959).

AUDIOLOGICAL PROCEDURE

A continuous tone was presented at the test frequency 4K Hz or 2K Hz at a level which was chosen randomly. At regular intervals a short 1 dB increment was superimposed over the continuous tone for approximately 200 m secs. Each increment had a rise time of 50 m.sec. and a duration at full length of 200 m. sec. and a decay time of 50 m.sec. The subject was simply asked to signal to the examiner each time he heard the increment by means of pressing a button provided to him. After presenting 20 such increments the SISI score was derived by multiplying the number of increments detected by the subject by 5 to get the score terms of percentages. Initially 5 dB increments were presented to familiarize the subject with the response task. Five such dB increment were given for a practice run. Then next five increments were 1dB in size. If the subject responded to 3 or more of these, the size of the sixth increment was set at 0 dB as a control presentation for checking up the subject's responses. If the patient responded to two or less of the first five 1 dB increments, the size of the sixth increment was set at 5 dB to enable him once again to respond positively.

Thus the possibility of false positive or false negative responses were reduced by the interspersion of either no increment or a 5 dB increment after every five one dB increments depending upon the character of previous responses. If the subject responded during a control presentation (increment of 0 dB) the test was discarded as invalid because the subject was probably responding to the rhythmic presentation of increments rather than to an increase in intensity.

A slight departure was made from the recommended schedule of withholding an increment after every 5 increments of 1 dB. It was observed that many subjects were quick to observed the rhythmic event of the test increment presentation. So to overcome the rhythm effects and guessing, increments were with-held as often as though necessary. Similarly when the patient was not responding a 2 dB or 3 dB increment was used for maintaining the listening set of the test stimulus. 5 dB increment was found to be too large a departure from 1 dB test stimulus. Sometimes when it was quite obvious that the score would inevitably be 100%, last five of the 20 increments were omitted. This was done especially when intensity masking noise was used. Yantis & Decker (1964) conclude from their studies that SISI test can be safely reduced to 10 presentations, for it not only conserves time but also reduces fatigue and loss of attention of the subject. Moreover they found that the split half reliability correlation coefficient is quite high especially at 4 K Hz i.e. there was correlation between scores obtained in the first ten presentations and the later ten.

Instructions given to the subject:

"You will now hear a continuous sound in one of your ears. Sometimes you will hour jumps in loudness. Every time there is a jump indicate by pressing the button."

The same procedure was repeated on ten cases with unilateral hearing loss. Test tone levels below the threshold of the patient were omitted.

In the third part of this study sensori neural loss cases were taken and were given SISI test at 20 dB SL. For all these subjects P.T.A. and discrimination scores were taken. Further ABLB was administered on some of the cases wherever it was possible. But tone decay test was given for all the S.N. loss cases.

AUDIOLOGICAL PROCEDURE USED FOR A.B.L.B.

After finding the thresholds at 4K in both the ears the tone (4K Hz) was presented to the poorer ear at 30 dB SL or a higher level and the same tone was presented to the better ear. The intensity was adjusted in the better ear while the subject reported equal loudness. The interaural intensity difference at the point of balance was determined. When the interaural intensity difference

.

at the point of balance was less than the interaural intensity difference at threshold by more than 10 dB it was considered that the recruitment was present and ABLB positive.

Instructions

The subject was asked to match the loudness of the tone presented to the poorer ear with loudness of the tone presented to the better ear. He was asked to indicate when the two tones were equal in loudness. The intensity of the tone in the poor ear was kept constant but the better ear tone was varied.

Audiological produced used for TDT.

Screening TDT i.e. Rosenberg's test was administered to all the subjects. A continuous tone was presented at 5 dB SL for 60- seconds. If he failed to hear within one minutes, the tone was raised by 5 dB without interrupting the stimulus and without stopping the watch. Whenever the tone faded the intensity of tone was raised by 5 dB steps. After testing for full one minute the tone was turned off and the amount of tone decay was computed.

Instructions given to the subject:

"You will now hear a continuous tone. Keep your finger raised as long as you hear the tone. The moment the tone fades away drop your finger and the moment you hear again raise your finger."

Equipment and test environment:

A calibrated diagnostic Audiometer, Arphi model 700 mark IV which satisfies the ISO standards was used in this study. The audiometer was calibrated using Bruel and Kjaer equipment (artificial ear B and K type 4152, SPL meter B and Type 2203, octave filter B and K type (1913) in a sound treated room. The noise dial was found to be in calibration. The intensity of the noise in SPL at 40 dB HL of the noise dial was 48 dB SPL and at 100 dB Hl it was 106 dB SPL. The audiometer was provided with TDH 39 earphone with Max 41 ear muffs. The 1 dB increment required for the SISI test was calibrated both interms of intensity and duration time, by means of Tetronix Oscillosocpe type 564 A and was found to be in order. After every 20 days the audiometer was rechecked for calibration.

The study was conducted in sound treated environment. The audiometer room was located in an area away from the noisy localities.

Table gives the noise levels in the test room by B and K SPL meter type 2203 with B and K octave filter set 1613.

TABLE

Sound pressure levels in the sound treated room at various frequencies.

Sr. No.	Central frequency of octave band in Hs.	SPI values in the test room in Db re .0002 dynes/cm^2	ISO specifications SPL values in Audiometric room in dB.
1	125	19	31
2	250	14	25
3	500	12	26
4	1,000	12	30
5	2,000	10	38
6	4,000	12	51
7	8,000	9	51

Sound Pressure Level in sound treated room using weighted scales

Sr. No.	Scale	SPL value in ref to .0002 dynes/cm^2
1	A	22
2	B	22
3	C	34
4	L	45

From Kerlinger, 1967, A 3x4 factorial research design was made use of in the present study. Randomisation procedures were used in the selection of subjects and in the application of various test conditions to the subjects. Since the results of the study tended to show the variance in the subjects were not homogenous it was decided to apply non parametric statistics to the raw data.

CHAPTER IV

RESULTS AND DISCUSSION

The investigation was divided into the following parts:

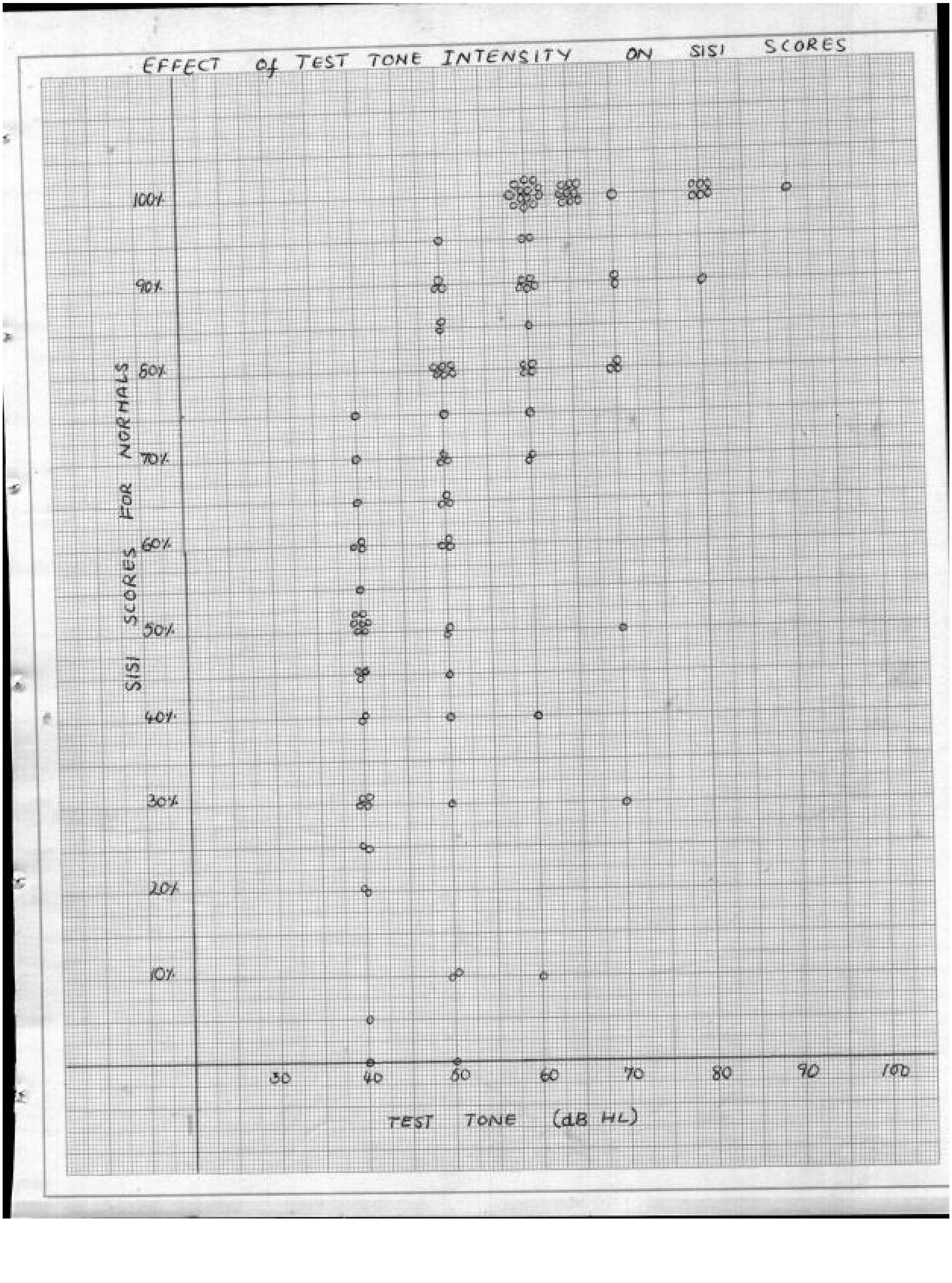
Part I:

(A) to find out the effect of intensity of the test tone in SPL (Sound Pressure level) on SISI scores.

The sample tested for this study consisted of 30 normal hearing subjects (22 males and 8 females) constituting a large sample according to Garrett (1967). A majority of the subjects were naïve listeners. Table A in the Appendix gives the raw data of (PTA) pure tone Average, age, sex, ear and frequency which was tested for each subjects.

A null hypothesis was formulated for this problem: there is no effect of the intensity of the test tone on SISI scores. SISI test was administered to the subjects at 40 dB HL, 59 dB HL, 60 dB HL and further the testing was continued until 100% scores were obtained. Table 1 gives the scores obtained by these subjects.

Friedman's two way analysis of variance test was used to test this hypothesis. Table II (a) gives the results of the test. Null hypothesis was rejected by the test at .01 level indicating that there was a significant difference in the scores under the different intensity levels of the test tone 40, 50, 60 dB HL. It was seen as the intensity of the test tone was increased, the SISI scores also increased significantly, so that at about 65 dB HL nearly 73% of the normals showed 100% SISI scores. The remaining subjects reached this 100% score level by about 80 dB HL. Graph A gives the results obtained in this study.

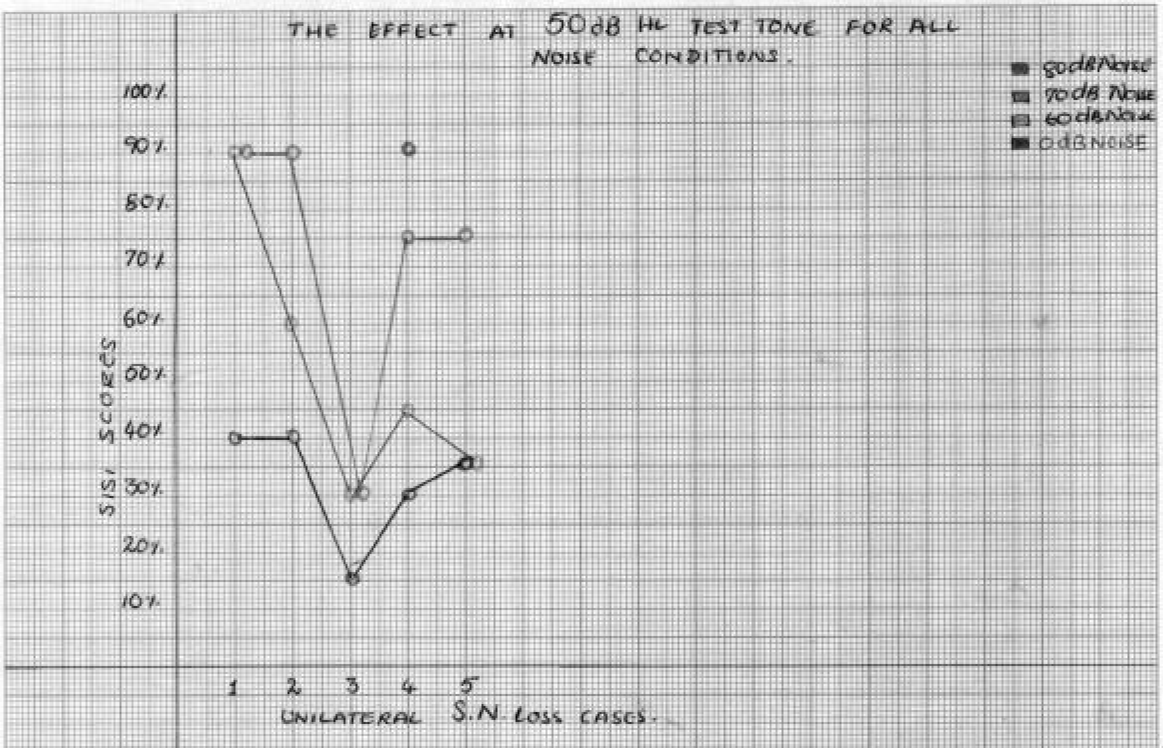


EFFECT of TEST TONE INTENSITY ON SISI SCORES
SISI SCORES FOR NORMALS
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
30
40
50
60
70
80
90
100
TEST TONE (dB HL)

B) The effect of intensity of the test tone on SISI scores was investigated on the clinical group (Ten sensori neural loss cases). Table III gives the score obtained by the ten subjects for the varying intensity levels of the test tone. The null hypothesis was, there is no effect of the intensity of the test tone on SISI scores. Friedman's test was used. The test rejected the null hypothesis at .001 level. There was increase in the SISI score as the tonal level was increased even in the sensori neural loss cases. Results of the test are given by table II (b). Graph B gives the results obtained.

Further, nearly 97 percent of the 30 S.N. loss cases (described in Part III of the study) tested, reached a 100% criteria for the SISI score at80 dB HL. The result show that the test tone level is a significant factor during SISI testing. The study is in good agreement with Swisher et al (1966) who have shown that in Sensori neural hearing loss, SISI scores determined above 20 dB SL increase systematically with the increasing HL. No significant differences was seen by them between the clinical group and normal hearing subjects on SISI scores where the basis of measurement was HL at which comparison was made.

In the present study the effect of tonal level on the SISI score was compared between the normals and the clinical group. Mann Whitney u test was used to test the null hypothesis formulated for this problem; there is no significant difference between normals and clinical group in the effect of tonal level on their SISI scores. Test accepted the null hypothesis at .05 level. At 80 dB HL the SISI scores obtained by the normals and clinical, subjects were same. Table IV gives the results of the test.


THE EFFECT AT 50dB HL TEST TONE FOR ALL NOISE CONDITIONS.
80dB Noise
70dB Noise
60dB Noise
0dB NOISE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
SISI SCORES
1 2 3 4 5
UNILATERAL S.N. LOSS CASES.

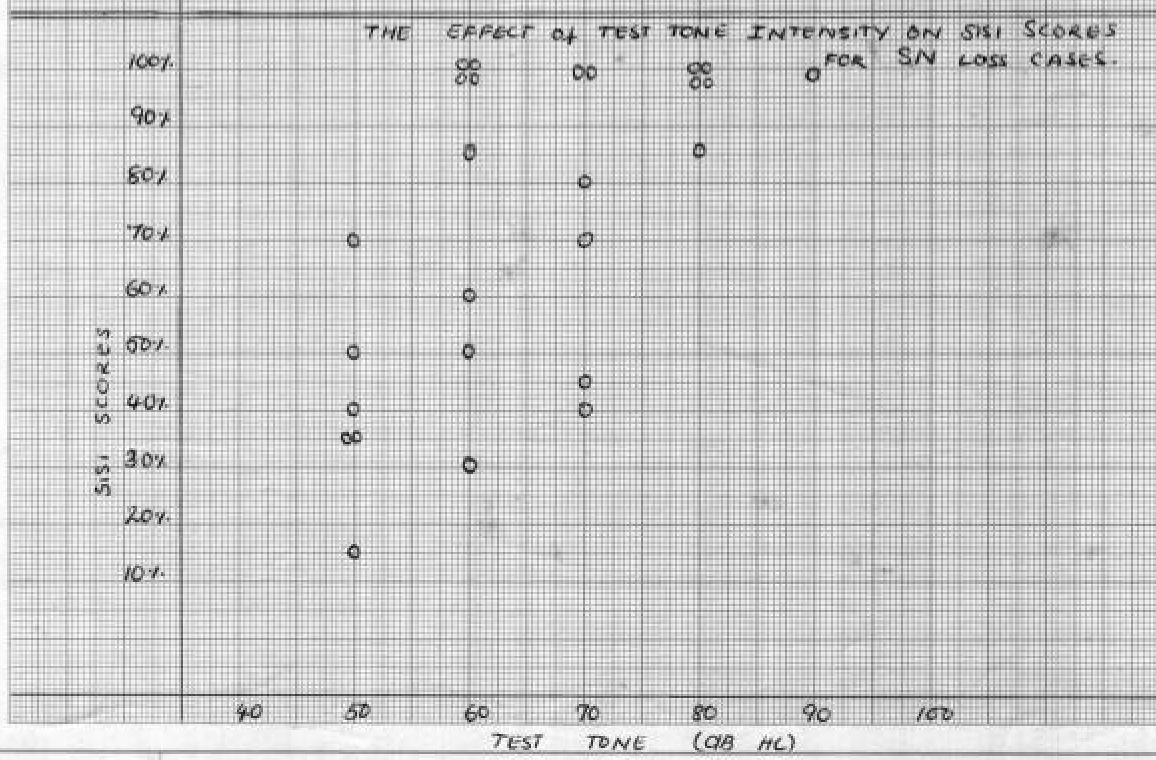

THE EFFECT of TEST TONE INTENSITY ON SISI SCORES FOR SN LOSS CASES.
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
SISI SCORES
40 50 60 70 80 90 100
TEST TONE (dB HL)

Table I – SISI scores of Normal subjects with no noise condition at 40, 50, 60 dB HL test tone.

Sr. No.	40	50	60	65	70	80	90
1	50%	85%	100%				
2	55%	90%	95%	100%			
3	45%	90%	100%				
4	25%	65%	40%		30%	100%	
5	60%	65%	90%	100%			
6	75%	90%	100%				
7	65%	80%	100%				
8	45%	80%	100%				
9	30%	50%	90%		100%		
10	50%	85%	90%	100%			
11	30%	30%	80%		80%	100%	
12	30%	40%	80%		80%	100%	
13	20%	10%	80%		80%	100%	
14	50%	70%	100%				
15	50%	50%	90%	100%			
16	50%	65%	75%	100%			
17	60%	80%	90%	100%			
18	5%	70%	100%				
19	50%	70%	100%				
20	0%	0%	10%		50%	90%	100%
21	20%	10%	70%		90%	100%	
22	45%	60%	100%				
23	60%	95%	100%				
24	25%	80%	100%				
25	30%	60%	80%		90%	100%	
26	40%	80%	100%				
27	40%	60%	85%	100%			
28	50%	45%	100%				
29	70%	80%	70%	100%			
30	50%	75%	90%	100%			

TABLE II

Ten Results of Friedman's 2 way analysis of Variance test. Test rejected the Null hypothesis "There is no effect of test tone on SISI scores" for both normal subjects and clinical group (Semsori neural loss cases) at .001 level of significance.

Tone Level on SISI scores	X_r^2 values	Table values
A. Normals	83.58	16.27
B. Clinical Group	120.5	16.27

TABLE III

SISI Scores of S.M. los cases with increasing test tone level

Sr. No.	50	60	70	80	90	100
1	35%	60%	80%	100%		
2		30%	100%			
3	40%	100%				
4				85%	100%	
5			45%	100%		
6	15%	85%	100%			
7			40%	100%		
8	35%	100%				
9	50%	100%				
10		50%	70%	100%		
11	70%	100%				

TABLE IV

The result of mann whitney u test. Test accepted the null hypothesis; there is no significant difference between the normal and clinical group upon the effect of test tone on SISI score. At 80 dB HL this was tested and found significant at .05 level.

Tone level on SISI Scores	Z value	Table values
Normal-clinical group	.0	.50

From the above results we know that 75% of normals reach 100% SISI scores at 65 dB HL and the remaining 25% by 80 dB HL so also, 97% of the Sensori neural loss cases in this study with signs and symptoms of Cochlear lesions secured 100% scores at 80dB HL or at a higher level (some who had loss grater than 80 dB) Luscher, (1957) found at 80 dB HL the difference limen in intensity (DLI) in patients of Cochlear loss to be equal to that of normal hearing subjects. The observation suggests the sound pressure level entering the cochlea is decisive for the magnitude of difference limen. Luscher, (1957) explains this by saying that difference limen is a measure of intensity and it becomes smaller, the louder the tone is subjectively perceived.

In the light of the these evidence, a modified SISI procedure seems appreciable to the extent, it provides a simpler easier procedure to rule out the retrocochlear lesion. Just by screening each case at about 80 dB HL or above, a clear cut differential diagnosis can be made, for a negative SISI score between 0 to 20% at this test tone intensity level is very highly significant with relevance to Retrocochlear lesion. In support to this, SISI results obtained by a case described in the part III of this study can be mentioned. Ten cases with symptoms of giddiness, headache and Tinnitus, obtained only 5% SISI scores even at 100 dB HL, with tone decay results positive in that ear, while the other normal ear obtained 100% scores at 60 dB HL. The case was suspected of having Retrocochlear lesion. Further follow up is necessary to confirm it.

Part II of the study:

(A) Thirty normal subject were tested to study the effect of contralateral masking noise on the SISI scores. SISI tests were administered at varying intensity levels of the test tone i.e. at 40 dB, 50 dB and 60 dB HL. Table V gives the SISI scores of all these subjects, at all the test condition. A null hypothesis was formulated for this problem; there is no significant effect of noise on the SISI scores. Friedman's 2 way analysis of variance test was used to test this hypothesis. The test rejected the null hypothesis at .01 level. Table VI gives the results of this test. Results show that contralateral masking noise influences the SISI scores.

Table VI

The results of Friedman's 2 way Analysis of variance test. The test rejected the null hypothesis; there is no effect of contralateral masking noise on SISI scores at .001 level for the normal subjects, both at 40 dB HL tone with 60 and 70 dB HL noise and at 50 dB HL tone with 60, 70 and 80 dB HL noise.

	Noise on SISI scores	**X_r^2 values**	**Table values**
A	At 40 dB HL tone 0 – 60 – 70 dB HL N	43.4	16.27
B	At 50 dB HL tone 0 - 6 - 70 - 80 dB HL N	46.34	13.82

TABLE V (a)

The SISI scores obtained for normal individual at 40 dB HL tone with 60 dB noise, 70 dB noise and no noise condition

Sr. No.	0 dB Noise	60 dB Noise	70 dB Noise
	Percentage		
1	75	90	100
2	60	75	80
3	20	70	
4	45	70	80
5	55	75	100
6	50	80	90
7	70	100	
8	50	45	
9	40	80	
10	40	60	40
11	30	50	
12	25	60	60
13	60	85	90
14	45	90	100
15	20	0	
16	0	0	0
17	50	70	75
18	5	30	80
19	60	75	90
20	50	70	90
21	50	80	80
22	50	60	65
23	20	30	
24	30	0	
25	50	95	100
26	30	50	
27	65	70	70
28	45	65	100
29	30	70	80
30	50	90	

TABLE V (b)

SISI scores obtained for normal subject at 50 dB HL test tone with no noise condition and 60, 70, 80 dB noise condition.

Sr. No.	**0 dB or no noise**	**60 dB Noise**	**70 dB HL noise**	**80 dB HL noise**
	P e r c e n t a g e			
1	50	85	100	100
2	65	80	90	100
3	80	80	90	95
4	70	100	100	100
5	70	65	90	90
6	0	20	0	0
7	10	100	40	
8	60	75	95	100
9	95	100	100	100
10	80	80	80	85
11	60	60	70	100
12	80	80	90	
13	60	85	80	90
14	45	60	60	85
15	80	80	100	100
16	85	90	90	90
17	90	95	100	100
18	90	90	100	100
19	65	90	100	100
20	65	80	90	80
21	90	90	90	100
22	70	70	80	80
23	10	30	50	100
24	40	40	50	100
25	85	100	100	100
26	30	40	50	
27	80	70	80	100
28	80	90	100	100
29	50	50	80	100
30	75	85	90	90

TABLE V (c)

SISI scores obtained for normal subject at 60 dB HL test tone with no noise condition and 60, 70, 80 dB noise conditions.

Sr. No.	**No noise**	**60 dB Noise**	**70 dB HL noise**	**80 dB HL noise**
	Percentage			
1	90	100	100	100
2	85	95	100	100
3	90	100	100	100
4	100	100	100	100
5	100	100	100	100
6	10	20	30	
7	70	60	90	100
8	100	100	100	100
9	100	100	100	100
10	100	100	100	100
11	80	90	100	100
12	100	100	100	100
13	85	100	100	100
14	100	100	100	100
15	70	100	100	100
16	100	100	100	100
17	95	100	100	100
18	100	100	100	100
19	30	80	100	100
20	90	90	100	100
21	100	100	100	100
22	100	100	100	100
23	80	60	80	80
24	80	60	95	100
25	90	100	90	100
26	80	70	80	100
27	100	100	100	100
28	100	100	100	100
29	90	90	100	100
30	90	100	100	100

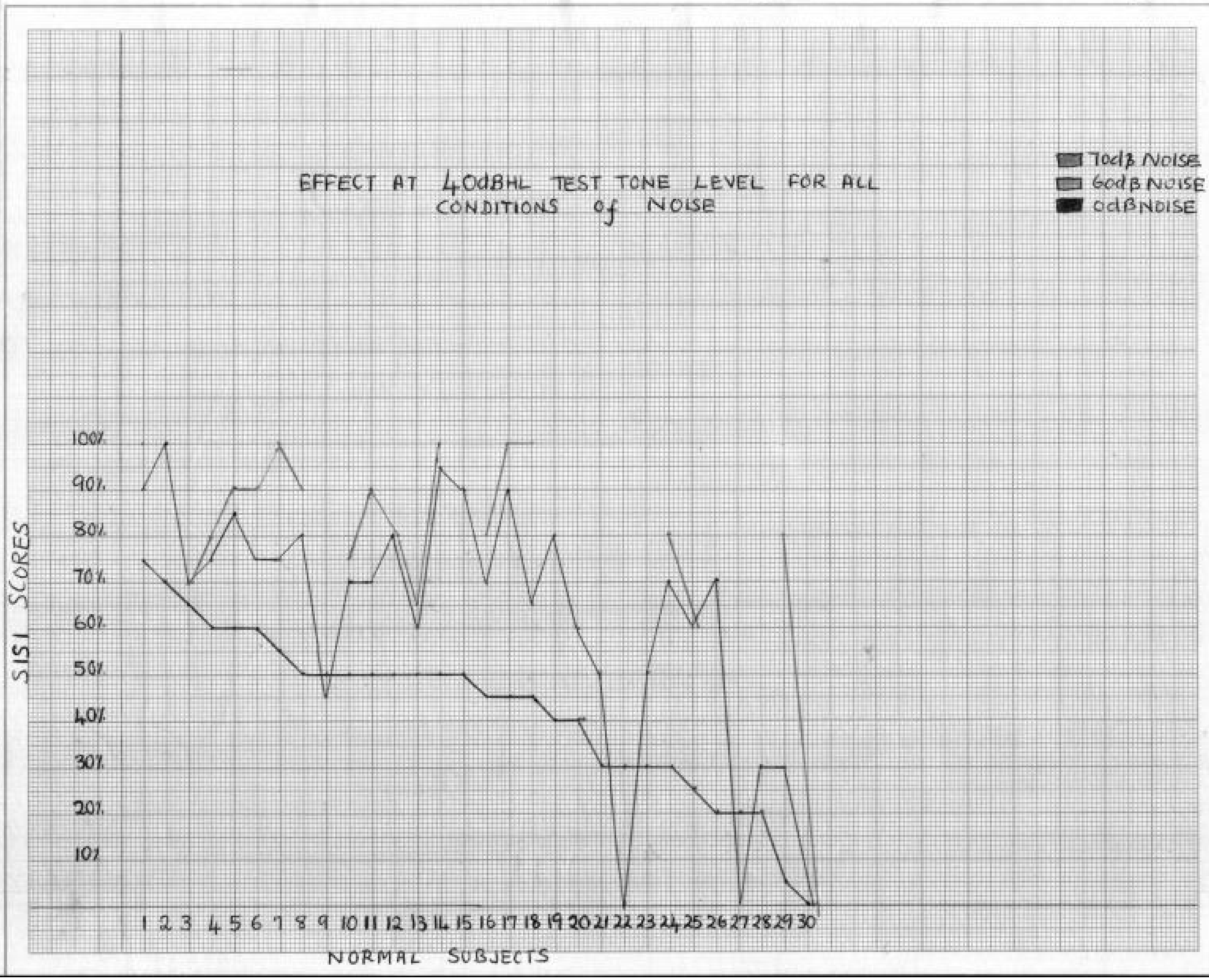
It was decided to investigate the effect of noise at each of this contralateral noise condition i.e. at 60, 70, 80 dB HL for all the test tonal levels namely 40, 50 and 60 dB HL. Hypothesis formulated for this was, SISI scores at the noise condition were grater than at no noise conditions. Wilcoxon matched pairs signed Ranks test was used. The test accepted the hypothesis for all these conditions at .001 level. That means the SISI scores in the presence of contralateral noise of 60, 70, and 80 dB HL was very significantly grater than at the no noise condition for all the tonal levels at 40, 50, 60 dB HL. Table VII gives the results of this test. Graph C gives the results of this study

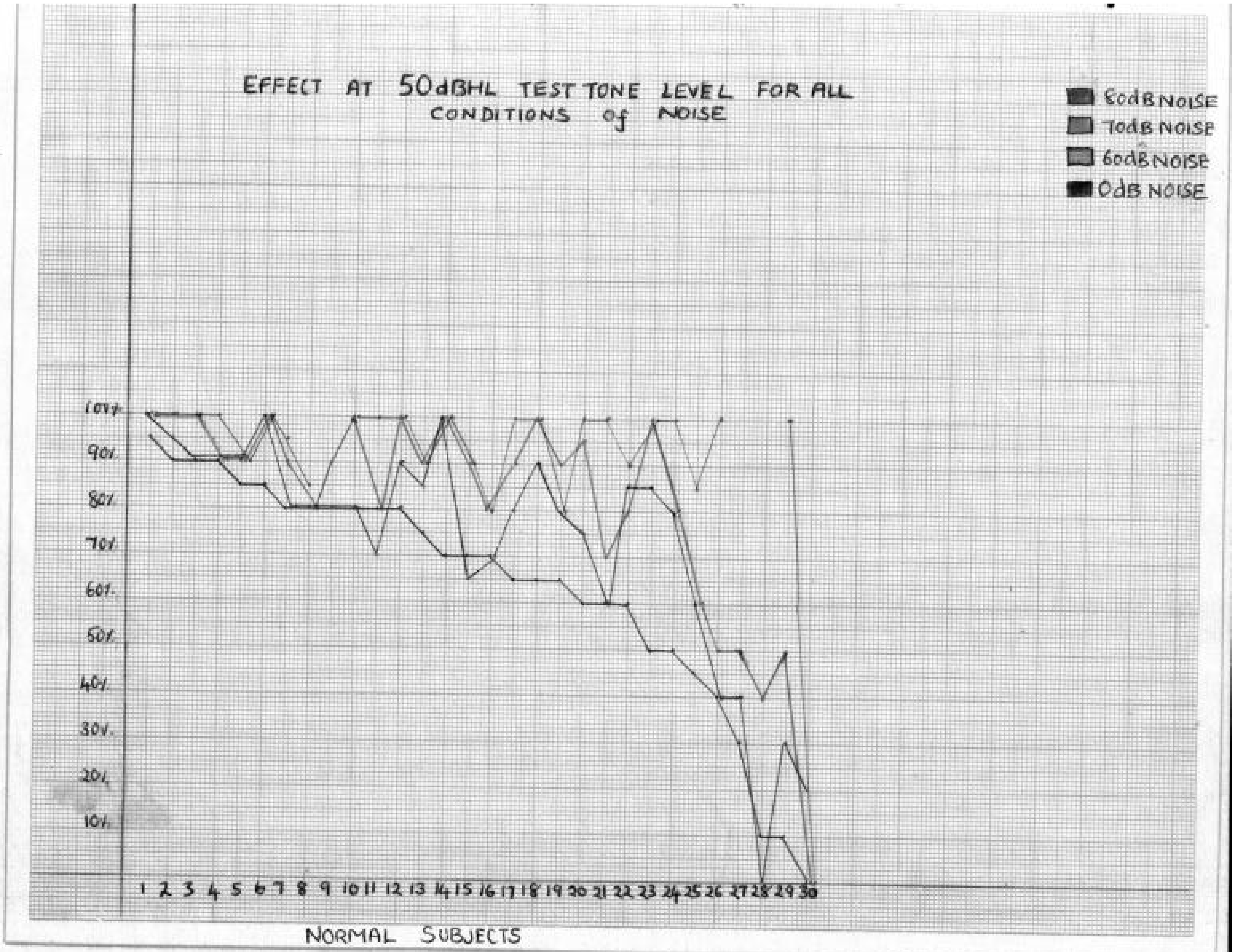
TABLE VII

The results of Wilcoxon matched pairs signed Ranks test at the varying intensities of noise levels i.e. 60, 70, 80 dB HL for the different test tone levels i.e. 40, 50 and 60 dB HL. Test accepted by Hypothesis; the SISI scores at noise conditions are grater than at no noise condition at .005 level.

	Noise on scores	**S values or T values**	**Table values**
	At 40 dB HL tone		
A	odBN and 60 dBN	4.012	.00006
	odBN and 70 dBN	0	28
	At 50 dB HL tone		
	odBN and 60 dBN	19.5	43
B	odBN and 70 dBN	0	68
	odBN and 80 dBN	3.916	.0001
	At 60 dBHL tone		
C	odBN and 60 dBN	11	16

Further, effect of different intensities of noise within the same tonal level and at different test tone levels was studied. Friedman’s test was used to test the null hypothesis which was stated as “there is no significant difference between the noises


EFFECT AT 40dBHL TEST TONE LEVEL FOR ALL CONDITIONS of NOISE
70dB NOISE
60dB NOISE
0dB NOISE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
SISI SCORES
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
NORMAL SUBJECTS


EFFECT AT 50dBHL TEST TONE LEVEL FOR ALL CONDITIONS of NOISE
80dB NOISE
70dB NOISE
60dB NOISE
0dB NOISE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
NORMAL SUBJECTS

upon their effect on the SISI scores". This was tested at each of the test tone levels namely 40, 50 and 60 dB HL. Test rejected the null hypothesis at .001 level. Table VIII gives the results of this test. Thus varying intensities of the contralateral masking noise produce varying effects on the SISI scores. This was seen at 40, 50, and 60 dB HL of tone.

TABLE VIII

The results of Friedman's 2 way analysis of variance test at the different intensities of test tone levels 40, 50, 60 dB HL for the different intensities of noise. Test rejected the null hypothesis; There is no significant difference between the noise levels upon their effect on SISI scores at .001 level of significance.

		X_r^2 values	Table values
A	At 50 dB HL tone 60 dBN-70 dBN-80 dBN	19.75	13.82
B	At 60 dB HL tone 60 dBN -70 dBN-80 dBN	9.62	9.2

To test the hypothesis that the effect of noise at 70 dB HL is grater than 60 dB noise at 40 dB HL test tone, Wilcoxon test was used. The test accepted the hypothesis at .01 level. The same test was applied to test the hypothesis that the effect of 70 dB HL noise was grater than 60 dB HL noise and 80 dB HL nose has an effect on SISI scores which is grater than 70 dB noise at 50 dB HL test tone. Test accepted both the hypothesis at .01 level Table IX gives the results of this test. Thus the results show that with the increase in their influence upon the SISI scores, 80 dB noise had the maximum facilitating influence on the SISI scores at all tonal levels.

TABLE IX

The results of Wilcoxon matched pairs signed Ranks test. Test accepted the hypothesis the effect 70 dBN is grater than 60 dBN at 40 dB HL tones and at 80 dB HL and also the effect of 80 dBN is grater than 70 dBN for 50 dB HL tone", at .005 level of significance.

		T Values	**Table values**
	at 40 dB HL tone		
A	70 dBN and 60 dBN	12.5	23
	At 50 dB HL tone		
B	70 dBN and 60 dBN	20.5	49
	80 dBN and 70 dBN	5.5	10

The effect of each intensity of noise at 60, 70, 80 dB HL was studied at all the test tone levels 40, 50, 60 dBHL. Wilcoxon test was used to test the hypothesis stating that the effect of 60 dBNL noise is grater at 40 dB HL test tone than at 50 dB HL tones and the effect of 60 dB HL noise at 50 dB HL tone is grater than at 60 dB HL tone. And there is no difference in the effect of 60 dB HL noise at 50 dB HL and 60 dB HL tone. Test accepted former hypothesis in the later the test accepted only the null hypothesis that there is no significant difference between 50 and 60 dB HL at .01 level. Table X gives the results of the test.

TABLE X

Results of Wilcoxon method pairs signed Ranks Test. The test accepted the hypothesis the effect of noise at 40 dB HL tone is grater than 50 dB HL tone with 60 dB noise and 70 dB noise at .005 level. Test also accepted the accepted the hypothesis that the effect of noise at 50 dB HL tone is grater than at 60 dB HLT with 70 dB noise and 80 dB noise at .005 level. This hypothesis was rejected for 60 dBN and the null hypothesis that there is no significant difference between 50 dB HLT and 60 dB Hlt with 60 dB noise was accepted at .005 level.

		S Values or T values	**Table values**
	At 60 dB HL noise		
A	40 dB HLT and 50 dB HLT	2.95	.0032
	50 dB HLT and 60 dB HLT	94.5	55
	At 70 dBHL noise		
B	40 dBHL T and 50 dB HLT	22.5	38
	50 dB HLT and 60 dB HLT	35.5	43
C	At 80 dB Noise		
	50 dB HLT and 60 dB HLT	11.5	61

At 70 dB noise condition, Wilcoxon test accepted the hypothesis stating that the effect of noise at 40 dB HL tone is grater than at 50 dB HL tone and the effect of noise at 50 dB HL tone is grater than at 60 dB HL tone at .01 level. So also at 80 dB noise condition the test accepted the hypothesis that the effect of contralateral masking noise on SISI scores at 50 dB HL tone is grater than at 60 dB HL test tone. Thus the results show the overall effect of noise is grater at lower test tone levels than at the higher ones. This is quite deductible from the observation that at 40 dB HL test tone level there was a wider range for the improvement to be seen on the SISI score while at 50 dB 60 dB HL the scores being already high at the no noise condition, facilitating influence could be shown only until the scores reached 100% and no more.

Upto now, the 2nd part of the study can be summarized as follows:-

1) Increase in intensity of tone increase thus SISI scores.
2) Contralateral noise increase SISI scores.
3) Increase in intensity of the noise increase the SISI scores. 80 dB HL noise has maximum effect on SISI scores.
4) Maximum effect of noise seen at 40 dB HL. Then at 50 dB HL and then at 60 dB HL.

Mann Whitney U test was used to test whether there was any significant difference on SISI scores between males and females, right and left ear and 4 K Hz and 2 Hz frequencies used for the SISI testing. The test accepted the null hypothesis formulated to test this problem stating that there is no significant difference between males and females on the SISI scores under all the test conditions used in this study at .01 level. Test scores for males and females were quite similar for all the conditions of noise at different test tone levels. The test also accepted the hypothesis, that there was no significant difference between test conditions at .01 level. The hypothesis that there was no significant difference between the frequencies 4 K HZ and 2 K HZ on SISI scores under all the testing conditions was accepted at .01 level. Table XI gives the results of this test.

TABLE XI

The results of Mann Whitney U test. Test accepted the null hypothesis that there is no significant difference between Males and Females on SISI scores for all test conditions, right and left ear and 4 K Hz and 2 K Hz at .05 level.

		n values	Table values
A.	Right-left ear.		
1.	For males at 4 K Hz		
	50 HLt with 60 dBN	25	.253
	50 HLt with 70 dBN	23	.191
	50 HLt with 80 dBN	24	.221
	at 40 HLt with 60 dBN	21	.139
	40 HLt with 70 dBN	24	.221
2.	Female at 4 K.		
	40 dBHLt with 60 dBN	8	.607
	50 dBHLt with 70 dBN	6	.393
	50 dBT with 70 dBN	7	.5
	80 dBT with 80 dBN	5	.286
3.	Males at 2 K.		
	40 dBHL with 60 dBN	3	.4
	50 dBHL with 60 dBN	0	.067
	50 dBHL with 70 dBN	0	.067
	50 dBHL with 80 dBN	2	.267
B.	Males & Females		
	60 dBN at 40 dBHL T	61.5	15
	60 dBN at 50 dBHL T	42.5	15
	70 dBN at 50 dBHL T	43	15
C.	2k and 4k		
	60 dBN at 40 dBHL T	48.5	8
	60 dBN at 50 dBHL T	43.5	8
	70 dBN at 50 dBHL T	36.5	8

Test-retest reliability of the scores were verified in the following way:

The SISI tests were again administered under the different settings for randomly selected subjects from the original sample for a second time, 2 weeks after initial testing. The results were compared with results obtained in the first test. No significant differences were observed between the two. The correlation coefficients obtained were, .79, .80 and .84 at 60 dB HL tone, 50 dB HL tone with 70 dBN and at 40 dB HL tone with 60 dBN. All ware significant at the .05 level. Results of the Rank correlations test is given at table:

TABLE FOR

TEST RETEST RELIABILITY

For 8 subjects at 3 conditions of the SISI tests used in the study. The rank correlation coefficients obtained were significant at .05 level.

	Ist Test Scores	Retest Scores	Rank correlation coefficient
1. at 60 dB HLT With no noise	1. 100% 2. 100% 3. 100% 4. 100% 5. 100% 6. 95% 7. 100% 8. 90%	1. 100% 2. 100% 3. 100% 4. 100% 5. 100% 6. 100% 7. 100% 8. 90%	.79
2. At 50 dB HL T With 70 dB noise.	1 95% 2. 100% 3. 90% 4. 100% 5. 100% 6. 100% 7. 100% 8. 100%	1. 100% 2. 100% 3. 100% 4. 100% 5. 100% 6. 100% 7. 100% 8. 100%	.80
3. At 40 dB HL T With 60 dB noise	1. 90% 2. 85% 3. 80% 4. 70% 5. 30% 6. 75% 7. 80% 8. 75%	1. 80% 2. 85% 3. 85% 4. 85% 5 30% 6. 80% 7. 80% 8. 75%	.84

(B) A similar effect of the contralateral noise on SISI scores was seen in the unilateral sensori neural loss cases. Ten unilateral S.N. loss cases were tested at several sensation levels under all the condition of contralateral masking noise i.e. at 60, 70, 80 dB noise. The HL tested varied with the subjects depending upon their hearing loss. Table XII gives the scores of these subjects under all the testing conditions.

TABLE XII

With no noise, 60 dB, 70 dB and 80 dBN at 50 dBHL tone SISI scores obtained in case of Unilateral S.N. loss.

Sl.No.	**0oBN**	**60 dB Noise**	**70 dB Noise**	**80 dB Noise**
1.	40%	90%	90%	
2.	40%	60%	90%	
3.	15%	30%	30%	
4.	30%	45%	75%	90%
5.	35%	35%	75%	
6.	at 60 dBHL tone 60%	75%	85%	100%
7.	75 dB HL tone 85% 80%	90% 100%	100% 100%	
8.	80%	100%	100%	
9.	at 85 dB HL tone 85 %	90%	90%	100%
10.	at 100 dB HL tone 100%	100%	40%	100%

Friedman's test was used to check the null hypothesis; there is no effect of contralateral masking noise on SISI scores. Test rejected the hypothesis at .01 level. Table XIII gives the results of the test.

TABLE XIII

Results of Friedman's 2 way analysis of variance test. The null hypothesis; there is no effect of contralater noise on SISI scores was rejected at .001 level for the clinical group (U. S. N. loss cases)

	Xr^2 values	Table values
On clinical group 0 – 60 dBN – 70 dB	21.62	13.82
C. at 60 dB HL tone 0 dBN and 60 dBN	11	16

Mann Whitney u test was made use of to check the hypothesis, there was no significant difference among the normals and the clinical group upon SISI scores under the contralateral masking noise condition. The hypothesis; was accepted by the test at .01 level. The results of the test are shown in table XIV.

TABLE XIV

Results of Mann Whitney u test. The null hypothesis that there was no significant difference between normals and the clinical group upon the effect of noise an their SISI scores was accepted at .0001 level.

	Z Values	Table Values
Effect of Noise at 50 dB HLT Normal – Clinical	.3156	.3783

The present study corroborates the Blegvad and Terkildsen (1967) and Belgvad (1969) and Swisher and Dudley (1969) giving support to the hypothesis that contralateral masking noise at the non-test ear has an increasing influence on the SISI scores. Further in the present study it was seen that the facilitating effect produced by this contralateral noise increases with the increase in intensity of the noise.

The effect of 80 dB HL noise was grater than the effect of 60 dB HL, 70 dB HL noise used in the study. At lower levels of the intensity of test tone the effect of noise is grater than at the higher levels of test tone. However this needs to be further studies in the case of Retrocochlear lesion where the effect of test tone. However this needs to be further studied in the case of Retrocochlear lesion where the effect of test tone intensity is minimum on the SISI score results.

The possible explanation put forth this effect of noise is the central masking phenomenon. In the present study the possibility of the practice effect influencing the SISI scores was reduced to a minimum by strictly adhering to a random schedule of treatment to the test conditions. Moreover the fact that facilitated SISI scores were observed under the masking even at the initial testing situations, eliminates this possibility (practice effect).

Regrading central making phenomenon Deatherage (1966) states if two sounds however different otherwise occur at ears within some brief tome of one another they will interact i.e. “Binaural interaction”.

In his investigations of acoustic altenuation between ears, Zwislocki (1967) reports an apparent contralateral masking effect an physiological interference” amounting to about 5 dB when pure tones of 1,000 and 1,110 cps were used.

Bilger (1966) reports CM appears even for relatively low levels of contralaterally presented maskers and is greatest in the frequency of the masker and is dependent upon the temporal sequence of signal and masker. Ward reports of CRM which may be due to a central interference between the massive neural activity in the noise ear channel and the test tone at the other test ear at any centre receiving apparent innervations from both sides.

Van Bergeik points out that accessory nucleus of the superior olivary complex is the earliest place in the Auditory system where the outputs of the two ears combine. Until electro physiological studies on CRM at higher intensities are undertaken we can only speculate on the exact locus of interference whether it occurs at the accessory nucleus of the superior olivary complex, though at present to the most peripheral center that receives apparent innervations or at higher centers such as inferior colliculus or medial geniculate or perhaps at all of them.

Thus masking of one ear changes the threshold of pure tones in the other ear in the absence of physical cross over of the sound, to an effect amounting to about 15 dB even in patients with inactive middle ear muscles (Liden et al). Thus noise and tone interact at the higher central Nervous System level and increase the SISI scores. DLI (Blegvad 1967, 1969) and SISI scores (Rupp) Crimes and Feldman (1969) have reported that contralateral masking noise very much influences. The Bekesy tracings, Blegvad's study (1968) on normals and unilateral S.N. loss cases showed marked increase in the separation between continuous and interrupted amounting to about 25 dB or more especially in the hearing loss group. Mills (1972) reports Temporary Threshold shift reduction as a function of contralateral noise level even with as brief expostures, as 2 minutes in the non-test ear.

Thus Ward (1963) states with regards to contralateral masking "perhaps now the central effects and reflex attentions will usually be the second order effects, they have been thought to be". Studies now show conclusively that stimulation of the Non test ear cases changes in the Auditory test results which are of both theoretical and practical clinical significance.

Jerger (1973) says as there is extremely little information which hears directly on the point of the effect of contralateral noise on different clinical audiological results. But the amount of evidence presented so far are sufficient enough o warrant a grate caution in the clinical application of masking procedures.

PART III Study:

30 sensori neural loss cases were taken up for the study, which was to obtain SISI results at 20 dB SL and compare its results with other audiological test results like ABLB and T.D. tests. Table XV gives the results of all these tests obtained for each subject and the age, sex, symptoms and PTA and discrimination scores. In all 45 ears were tested in these 30 subjects. It was seen that 33 ears out of the 45 ears secured 100% SISI results at 20 dB SL out of these subjects who scored 100% SISI scores irrespective of the severity of hearing loss 20 showed the symptoms of tinnitus, and in 8 of them Tinnitus was accompanied by Giddiness, Vertigo an head ache. Tone decay was negative in all 17 of these subjects, further in 9 or those cases where ABLB testing was possible showed positive results.

Now with the remaining 12 ears SISI scores were less then 80%. In one ear with symptoms of head ache tinnitus and vertigo, SISI scores were 5% at 90 dB HL tone decay test positive with grater than 40 dB tone decay, another five ears whose SISI scores ranged between 60% and 70% had nearly normal pure tone average ranging between 10 to 25 dB HL only 2 of them had high frequency loss at 6 K (50 to 60 dB above). In the rest, the other ear was poorer with cochlear symptoms. Then the SISI scores in these 5 ears can be considered as essentially a normal response in comparison to the results obtained in the first part of the study. Only in 3 more ears it was seen that SISI results were negative i.e. ranging between 50% to 60% and tone decay results positive. ABLB could not be administered in those 3 ears. In two of these ears SISI results were obtained with 80 dB contralateral masking noise in the non-test ear. Thus high scores with positive tone decay may be attributed to the facilitating effect with contralateral noise thus increasing the SISI results.

The finding were positive consistent with the diagnosis of cochlear lesions for all the 45 ears expect 5 ears (30 subjects). Thus in the present study there was good agreement between SISI results and TDT results and ABLB findings.

However there are many reports supporting inconsistencies in the audiological results between these two tests. Yantis and Decker, (1964) report that the two tests are felt to reflect the functional integrity of two separate systems. There is a possibility of pathological factors to exist either primarily or secondarily in both cochlear and Retro Cochlear lesions. Johnson (1965) after analyzing 40% of his cases with a typical results., in the audiological battery reports that inconsistencies to tests appeared to be related to the size and probably the site of lesions./ In many of these surgically confirmed Retrocochlear cases he reports a (1967) predominance of cochlear sighs in the absence of Retro cochlear sign. Dix and Hallpike's (1960) suggestion may explain this phenomenon. They say the tumor might interfere with cochlear blood supply, thus creating a second cochlear lesion. To support this they cite two instances in which recruitment disappeared after the removal of tumour. He also says if both cochlear and retrocochlear co-exist, it is the cochlear findings which predominate Hughes (1968) in his report on typical responses to SISI says that high SISI scores in 15 of his 18 cases despite the fact the carrier tone was decayed, were consistent with the diagnosis of cochlear Auditory pathology. There fore the diagnostic value of SISI remains undiminished. He quotes Owens who reports investigators who decline the use of SISI procedure because a subject demonstrates excessive tone decay, obviates its value as a diagnostic tool.

Thus in support with Ownes (1965) it appears that SISI is highly useful in providing Auditory information regarding the site of lesion. However many audiologists view SISI as not infallible, as high SISI scores are seen with excessive tone decay in confirmed Retrocochlear lesion. But the evidences and explanations given by Johnson (1967) Hughes (1968) speak in favour of SISI results for it exactly depicts what is happening in the auditory mechanism, we still need a better understanding of a cochlear and Retrocochlear lesion and their related phenomena. Until then, an approach with a basic battery of audiological tests is considered to be important in the differential diagnosis of cochlear Vs Retrocochlear lesions, for no test in itself is conclusive. The presence of positive findings in a number of these tests should be taken into account for a decision regarding the site of lesion. An in these battery of tests SISI test shows good relative consistency.

TABLE XV Data of Audiological Results obtained for 30 S.N. Loss cases

Sr. No.	Age	Sex	Sign & Symptoms	P.T.A.		Discrimination Scores		SISI scores		A. B. L. B.		T.D.T.	
				R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
1	40	Male	Tinnitus	40	20			100%	40%			-ve	-ve
2	52	Male		20	55				100%		+ve		-ve
3	24	Male		30	50	84%	92%	50%	90%			R 15 dB	+ve C.
4	38	Male	Tinnitus Giddiness	45	55			100%	100%			-ve	-ve
5	38	Male	Tinnitus	48	53	45%	76%	40%	70%				
6	67	Male		15 H.F. bse	15			69%	70%			-ve	-ve
7		Male	Tinnitus	60	55	70%	65%	100%	85%			-ve	-ve
8	48	Male		40	65	100%	68%	100%	68%				+ve
9	40	Male		70	65			100%	100%			-ve	-ve
10	42	Male	Tinnitus giddiness	70	10			100%	50%		+ve	-ve	
11	37	Male	Head ache	10	45				100%		+ve 40dB		-ve
12	30	Female		50	60	76%	88%	100%	100%				-ve
13	43	Female	giddiness H.A., Tin.					100%	5%				+ve
14	73	Male	Tinnitus	55	70			50%	100%			+ve	-ve

Sr. No.	Age	Sex	Symptoms	P.T.A.		Discrimination Scores		SISI scores		A.B.L.B.		T.D.T.	
				R.	L.	R.	L.	R.	L.	R.	L.	R.	L.
15	55	M	Gid. Vertigo +HA	80	70	85%	90%	100%	100%			-ve	-ve
16	17	M	Tin	10	100			60%	100%				-ve
17	18	M		10	HFL 70 dB				85%				
18	30	M	Tin	46	31	88%	84%		100%				
19	32	M		26	66				100%				
20	19	M		90	75				100%				
21	38	M		103	13		96%	100%					
22	82	M	Tin. Lt ear	100	42				100%				
23	43	M		20	40	100%	40%		100%		+ve		-ve
24		M	Tin	110	45 HF 70		100%						
25	40	M	Tin	30	60				100%				-ve
26	60	M		70	80			90%	100%				
27	50	M		60	90			100%	100%			-ve	-ve
28	40	M	Tin. Vertigo	70	20			100%					
29	40	M		52	35 HF 80			100%	80%				
30	27	M		30	5			35%					

CHAPTER V

SUMMARY AND CONCLUSION

SISI test was administered to 30 normal hearing subjects under different test conditions of varying intensity of the test tone 40 dB HL, 50 dB HL, 60 dB HL and with contralateral masking noise levels of 60, 70, 80 dB HL. Normative data was obtained for 100% SISI scores both in normal and the clinical group. (S. N. loss cases). The effect of contralateral, noise was studied in detail, both in normal and 10 unilateral sensorial neural loss cases. In the third part of the study Audiological results of 30 S.N. loss cases were studied.

Conclusions:

1) There is an increase in performance on SISI score with the raise in intensity of the test tone. About 75% of the normal hearing subjects obtained 100% scores at 65 dB HL and the rest obtained 100% within 80 dB HL.
2) Contralateral masking noise has facilitating influence on the SISI scores. The effect seen is similar, both in normal and sensori neural loss cases.
3) The effect of the noise is greater at lower sensation levels especially at 40 dB HL with the effect was greatest for all the intensity levels of noise tested i.e. 60, 70, 80 dB HL.
4) With the increase in intensity of noise there is an increase in the influence in SISI scores. Effect of 80 dB noise found to be the highest in the present study.
5) There is no significant difference between males and females, right and left ears regarding the influences of contralateral masking.

masking noise on SISI scores. No significant difference is seen between the frequencies 4K Hz and 2K Hz.

6) 98% of the sensori neural loss cases with cochlear pathology secured 100% SISI scores by about 80 dB HL or above. (Depending upon hearing loss). Thus at 80 dB HL the performance of the normal and the clinical group was similar on SISI scores.
7) There is a good agreement between the results of SISI tests and the other audiological test results.

Implication of the study:

The fact that at 80 dB HL all the normal hearing as well as the cases with sensori neural losses of cochlear origin secure 100% scores can be made use of to detect Retro Cochlear cases who in turn secure very low scores in the range of 20%, at this intensity level of the test tone. SISI test is a very useful diagnostic tool in the battery of tests used for differential diagnosis of cochlear versus Retrocochlear involvement of the Audiotory system.

Contralateral masking noise influences the SISI scores on the test ear. Thus the use of contralateral masking noise on the non test ear brings about changes in the auditory test results in the test ear may be means of a phenomenon called central remote masking, involving may be binaural interaction effects.

Limitations of the Study:

1) In the present investigation only 2 K Hz and 4K Hz wore made use of for testing the subjects on SISI scores.

2) Clinical group which was studied to investigate the effect of contralateral noise on SISI scores comprised of only 10 unilateral sensori loss cases.
3) Only a limited number of subjects, 30 of them, were studied in the detailed analysis of the audiological results in sensori neural loss cases.

Suggestions for Further Research:

* The effect of contralateral masking noise on SISI scores can be studied in still further detail for all the frequencies and in a larger clinical group.
* The effect of contralateral noise can be studied on other audiological test results.
* Contralateral remote masking effect can b studied in detail by electrophysiological procedures.
* Analysis of the audiological results in large number of sensori neural loss cases can be undertaken and follow up studies can be done.

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TABLE A

For Normal Subjects

Sr. No.	Age Years	Sex	P.T.A.		Ear	Frequency
			R	L		
1	17	Male	10	10	Left	2K
2	18	Male	0	0	Left	2K
3	25	Male	5	5	Left	2K
4	17	Male	5	5	Right	2K
5	17	Male	5	5	Right	2K
6	17	Male	0	5	Left	2K
7	17	Male	10	5	Left	4K
8	19	Male	5	5	Left	4K
9	18	Male	10	5	Left	4K
10	20	Male	0	5	Left	4K
11	18	Male	10	10	Left	4K
12	24	Male	5	0	Left	4K
13	25	Male	0	5	Right	4K
14	17	Male	5	5	Right	4K
15	23	Male	5	5	Right	4K
16	24	Male	5	5	Right	4K
17	18	Male	5	0	Left	4K
18	19	Male	0	5	Right	4K
19	19	Male	5	5	Right	4K
20	20	Male	10	5	Right	4K
21	21	Male	0	0	Left	4K
22	19	Male	5	0	Right	4K
23	20	Female	5	10	Left	4K
24	19	Female	10	5	Right	4K
25	21	Female	2	3	Right	4K
26	17	Female	10	5	Left	4K
27	19	Female	10	5	Right	4K
28	18	Female	10	10	Right	4K
29	22	Female	10	5	Left	4K
30	22	Female	5	5	Right	4K

APPENDIX

Technical Data: For the instruments used in the present study and the various calibration procedures used.

(1) Arphi Audiometer Model 700 Mark IV was used throughout in the present investigation. Arphi Audiometer are calibrated according to ISO/IHC specifications. The zero threshold for TdH- 39 ear phone, provided by the audiometer are:

125	250	500	1,000	1,500	2,000	3,000	4,000	6,000	8,000
47	26.8	131	7.1	7.0	9.27	10.7	10	15.5	10

Air conduction (A.C.) Calibration is dons at 60 dB and 1 K Hz.

Further checking up was done with Band K condenser microphone 4132 with cathode follower connected. A 500 gm weight is put on the ear phone, then at 60 dB dial settings the following readings were recorded.

Pure tone Ac calibration at 4K Hz.

125 Hz	- 160 dB
250Hz	- 83 dB
500 Hz	-72.5 dB
1,000 Hz	-65 dB
2,000 Hz	-69 dB
3,000 Hz	-70 dB
4,000Hz	-68 dB
6,000 Hz	-74.5 dB
8,000 Hz	-68 dB
10,000 Hz	-64.5 dB

Intensity step of the dial was checked and found in order.

Reading obtained again after 2 weeks:

125 Hz	- 107 dB
250Hz	- 86 dB
500 Hz	-72.5 dB
1,000 Hz	-66 dB
2,000 Hz	-70 dB
3,000 Hz	-70.5 dB

4,000Hz	-69 dB
6,000 Hz	-74.5 dB
8,000 Hz	-68 dB
10,000 Hz	-70 dB

The noise intensity dieal was calibrated at 4 K Hz when the frequency dial was set in the auto postion. The output levels of the noise dial at different settings for the Rt ear phone was as follows:

0 dB	- 41 dB SPL
10	- 41 dB SPl
20	- 42.5 dB SPL
30	- 48 dB SPL
40	- 48 dB SPL
50	- 56 dB SPL
60	- 66 dB SPL
70	- 76 dB SPL
80	- 86 dB SPL
90	- 96 dB SPL
100	- 106 dB SPL

Output levels obtained for the left ear tone were:

100 dB	- 106 dB SPL
90	- 96 dB SPL
80	- 86 dB SPL
70	- 76 dB SPL
60	- 56 dB SPL
40	- 48 dB SPL
30	- 45 dB SPL
20	- 44 dB SPL

The output levels were same for 2K settings.

Calibration Procedure for SISI test:

The pulse width was calibrated using Tetronix type 564A dual beam oscilloscope. The signal from the audiometer pulsating signal) was presented to the channel I of the oscilloscope. By presenting a time base signal to the second channel, Chanel I signal was compared measured with the same oscilloscope and was measured with the same oscilloscope and was found to be calibration. This was done at physics department at the University.