THE EFFECT OF TEST TONE LEVELS AND CONTRALATERAL MASKING NOISE LEVELS ON THE SISI SCORES FOR NORMAL AND SENSORI-NEURAL LOSS CASES *

PUSHPA GURUSWAMY

'As new tests are developed and old ones refined the audiologist finds himself with more and more 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 Luscher's normative data were considered to have cochlear lesion. Denes and Naunton (1950) required their patients to report a difference in loudness of two tones presented at two presentation levels of 4 and 44 dB SL. Normal subjects had large differences between the two levels, those with cochlear lesions showed very small differences between their DL's. Jerger (1952) modified Luscher-Zwislocki DL Test and used 15 dB SL presentation. Jerger (1953) used a DL test similar to Denes & Naunton but compared at 10 and 40 dB SL

In 1959, Jerger, Shedd and Harnford 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

* Abstract by the author

the scoring starts. The possibility of false positive and negative responses are reduced by the interspersion of either no increment or 5 dB at every five test presentation depending upon the character of 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 which are of significance for the results of SISI. However, discrepencies between SISI results and otological 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 later 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 KHz and 4 KHz 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 a normative data for 100% SISI results.

So far 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 loss)

(b) There is no significant difference between the different intensities of noise on 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 normal 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 selected for the study. Ten unilateral S. N. Loss cases as well as thirty S.N loss cases comprised the clinical group. SISI test was administered to all at different levels of the test tone at 40, 50, 60 dB HL and under three noise conditions viz, 60, 70, 80 dB masking noise in the non-test ear. The test was administered as described by Jerger (1959) in his original procedure with slight modification to suit the present study.

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 for the clinical group (S.N. loss cases).

(2) To study the effect of contralateral masking noise at different intensities on the SISI scores at varying intensity levels of the test tone in normal hearing subjects and 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 cases) and compare the results with ABLB test, tone decay test and speech and pure tone audiometric results.

Methodology :

Subjects :

(1) Thirty college students of mean age 19 years were chosen 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 sensori-neural 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, viz., at 40 dB HL, 50 dB HL and 60 dB HL. And with different intensities of contralateral masking noise viz., 60 dB HL, 80 dB HL at all the three tonal levels.

GENERAL PROCEDURE

(A) Clinical Group 1 (unilateral sensori-neural 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 case :

(1) Pure tone audiogram

(2) Speech reception threshold and discrimination scores.

(3) SISI test

(4) ABLB test (unilateral sensori-neural loss cases)

(5) TDT.

Pure tone audiometry by Hughson 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 frequencies 4KHz aud 2K Hz were randomly chosen The whole testing procedure 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 and fatigue on the part of the subjects, by the end of the testing. With the same subject when the testing conditions were split into 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 on 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 concentrations, 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 4KHz or 2KHz 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 in terms of percentages. Initially 5 dB increments were presented to familiarize the subject with the response task. Five such dB increments were given for a practice run. Then next five increments were 1 dB 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 the subjects' 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 introduction of either no increment or a 5 dB increment after every five one dB increments depending upon the type 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 observe the rhythmic event of the test increment presentation. So to overcome the rhythm effect and guessing, increments were with held as often as thought necessary. Similarly when the patient was not responding a 2 dB or 3 dB increment was presented so as to keep him alert. Also, only a 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. Some times 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 intensive masking noise was used. Yantis and Decker (1964) conclude from their studies that SISI test can be safely reduced to 10 presentations, for it not only conserves time but also reduce fatigue and loss of attention of the subject. Moreover they found that the split half reliability correlation coefficient is quite high especially at 4KHz i.e. there was correlation between scores obtained in the first ten presentation and the later ten.

Instructions given to the subject :

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

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

In the third part of this study sensori 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 test was administered on some of the cases wherever it was possible. But tone decay test was given for all the sensori-neural loss cases.

Audiological procedure used for A.B.L.B. test :

After finding the thresholds at 4 KHz in both the ears the tone (4 KHz) 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 inter-aural intensity difference at the point of balance was determined. When the inter-aural intensity difference at threshold was more than 10 dB it was considered that the recruitment was present.

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 procedure 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 minute, 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 satisfied the

ISO (1964) standards was used in this study. The audiometer was calibrated using Bruel and Kjaer equipment (artificial ear B & K type 4152, SPL meter B & K Type 2203, octave filter B K type 1613) 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 SPL and at 100 dB HL it was 106 dB SPL. The audiometer was provided with TDH 30 earphones with Max 41 ear cushion. The 1 dB increment required for the SISI test was calibrated both in terms of intensity and duration, by means of Tetronix Oscilloscope 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 a sound treated environment.

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 subject and were not homogenous it was decided to apply non-parametric statistics to the raw data.

Summary and Conclusions :

SISI test was administered to 30 normal hearing subjects under different test conditions of varying intensity of the test tone viz 40 dB HL, 50 dB, 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 sensori 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 scores with the raise in intensity of the test tone. About 75% of the normal hearing subjects 100% scores at 65 dB HL and 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 and 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 influence of contralateral masking noise on SISI scores. No significant difference is seen between the frequencies 4KHz and 2KHz.

(6) 98% of sensori-neural loss cases with cochlear pathology secured 100% SISI scores by 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 test and the audiological test results.

Implications of the study :

The finding 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 Retro-cochlear involvement of the Auditory system.

Contraleteral masking noise influence 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 ear may be by means of a phenomenon called central remote masking, involving Binaural interaction effects.

Limitations of the Study :

(1) In the present investigation only 2 KHz and 4 KHz were 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 ten 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 Research :

(1) 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.

(2) The effect of contralateral noise can be studied on other audiological test results.

(3) Contralateral remote masking effect can be studied in detail by electrophysoilogical procedures.

(4) Analysis of the audiological results in large number of sensori-neural loss cases can be undertaken.

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