EFFECT OF AMBIENT NOISE ON AUDITORY SENSITIVITY

Reg. No. 02SH0022

Independent Project as a part of fulfillment of
First YearM.Sc, (Speech and Hearing),
Submitted to the University of Mysore,
Mysore.

ALL INDIA INSTITUTE OF SPEECH AND HEARING,
MYSORE-570 006

May, 2003

Dedicated to

**My Mummy, Daddy, Akka,
Chitu & Banu**

CERTIFICATE

This is to certify that this Independent Project entitled **"EFFECT OF AMBIENT NOISE ON AUDITORY SENSITIVITY"** is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student **Register No. 02SH0022.**

Mysore
May, 2003

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CERTIFICATE

This is to certify that this Independent Project entitled **"EFFECT OF AMBIENT NOISE ON AUDITORY SENSITIVITY"** has been prepared under my supervision and guidance

Mysore
May, 2003

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INTRODUCTION

Sound is created when some force sets an object into vibration to the extent that the molecular movement of the medium in which the object is situated occurs, and a "sound wave" is propagated. Sound is "heard" when the characteristics of the wave propagated fall within the limitations of the human ear and nervous system. A medium is required to convey the wave motion originating at the vibrator and a hearing mechanism that can receive and perceive the energy of the propagated wave.

Sound has several measurable attributes that are of importance to the audiologist in the analysis of hearing impairment. They are,

1. Frequency
2. Intensity and
3. Duration.

The simplest form of sound is a pure tone, which has a single frequency. Such a sound can be adequately described in terms of only its frequency and intensity.

If there are two wave forms with same frequency and intensity the resulting spectrum of those waves will be different. If the two waves are in phase then there will be an increase in the amplitude of the resulting wave. If the two waves are out of phase, then the resulting amplitude will be zero. The principle used to combine any number of similar or dissimilar waves is basically the same as that just described for two similar waves. Their amplitude are algeberically summed on a point by point basis along the horizontal (time) axis, regardless of their phase relationship. However, combining unequal frequencies will not produce a sinusoidal result. Instead, the combined waveform depends on the particular sound being combined (Gelfand, 1998)

Thus, when there are two different stimuli the resultants of these two stimuli spectrum will be different from their individual spectrum. Thus the amplitude of the wanted stimulus can either be increased or decreased, resulting in difference in perception. The perception can also get affected by the effect of unwanted signal over wanted signal which is due to masking. This is a physiological phenomenon.

There are number of factors that can affect the absolute sensitivity. They are, physiological noise, adaptation effect, temporal integration, central masking, standing waves, and psychological factors like attention, motivation, fatigue, etc.

Differential sensitivity is also affected by many factors. They are, binaural or monaural mode of presentation, duration of the stimulus presented, type of stimulus eg. pulsed vs modulated tone, musically trained or untrained ear, critical bandwidth, mode of presentation (AC or BC), etc.

However the hearing sensitivity that is absolute and differential sensitivity of an individual can be affected by the presence of another sound, which could be either due to the spectral changes of the stimulus or may be due to the physiological changes, which take place at the auditory system.

Increase in threshold or threshold shift for one sound in the presence of another is called masking. It includes the reduction in loudness that can occur when a second sound is presented, this process is referred as partial masking (Meyer, 1959; Scharf, 1964, cited in Gelfand, 1998).

The masking produced by a particular sound is largely dependent upon its intensity and spectrum. These masking patterns reflect the activity along the basilar membrane. The traveling wave envelope of two waves overlaps due to which masking effect takes place.

Thus presentation of two stimuli simultaneously can alter the absolute and differential sensitivity, which could be due to physical changes of the sound spectrum or may be due to masking effect.

NEED FOR THE STUDY:

Its clear from the above discussion that either the physiological factors like body noise, central masking, or physical factors like ambient noise, standing wave, etc can affect the absolute or differential sensitivity. Several researches have been carried out both on absolute and differential sensitivity in a laboratory set up where noise level was low. Several researchers also have tried to find out how the differential is affected in different pathological conditions related to the ear. However, very less or no attempts have been made by the researchers to investigate the effect of noise on both absolute and differential sensitivity and the possible reasons for such variations. Moreover, research needs to be carried out on how the noise can affect both absolute and differential sensitivity increase in severity of hearing loss. An attempt also needs to be made to investigate the process, which is involved in changing both the absolute and differential sensitivities, i.e., whether the physical changes (spectral) of the stimulus in the presence another stimulus or physiological changes (masking effect), which takes place in the auditory system is responsible for such changes. If the elevation in the hearing sensitivity or differential sensitivity is due to the changes in the physical parameters of the sound, then their effect can be seen in individuals with any severity of hearing loss as long as the second stimulus is sufficient enough to bring the spectral change. If its only due to the physiological changes which takes place in the auditory system it can be seen only when the second stimulus is above the individuals hearing sensitivity. Thus this study has been taken up to evaluate the absolute hearing sensitivity and differential hearing sensitivity in noise for individuals with different degrees of hearing loss along with normal hearing subjects.

AIM OF THE STUDY:

- To investigate the way in which the noise affects the absolute hearing sensitivity in normals and in subjects with moderate, moderately severe and severe degrees of hearing loss.

- To investigate the effect of noise on differential sensitivity for normal hearing individuals and individuals with different degrees of hearing loss as mentioned above.

- To study the way in which the differential sensitivity is affected at different sensation levels.

- And lastly to find out whether the physical or physiological effects play a role in absolute or differential sensitivity in the presence of noise.

REVIEW OF LITERATURE

Human ear is sensitive to a wide range of intensities (0 dBSPL to roughly 40 dB SPL). In terms of frequency the human ear can hear as low as 2 Hz (although roughly 20 Hz is required for the perception of "tonality") and as high as about 20,000 Hz. Furthermore, the auditory system is capable of resolving remarkable small temporal differences (Gelfand, 1998).

According to the American National Standards Institute (ANSI, 1973, cited in Silman & Silverman, 1991), the threshold of hearing is the threshold of audibility. This threshold is defined as the "minimum effective sound pressure level of the signal that is capable of evoking an auditory sensation in a specific fraction of the trials."

The frequency and intensity sensitivity of the ear interacts affecting each other to a greater or lesser degree. In addition, when the duration of a sound is less than about of a second, it affects both frequency and intensity perception (Gelfand, 1998).

Finally, the ear is able to discriminate small differences in a wide range of stimuli, i.e., it has remarkable differential sensitivity - the ability to detect very small differences between similar sounds. This ability applies to all the three parameters: frequency, intensity and time (Gelfand, 1998).

The amount of change in stimulus that is required to produce just noticeable difference (jnd) in the sensation is called as differential limen. What the subject actually hears is sensory capability and the manner in which he responds is response proclivity. Response proclivity reflects the subjects sensitivity and also the biases and criteria that affects how he responds (Gescheider, 1976).

Factors affecting the absolute sensitivity:

Absolute threshold is the lowest level in intensity which an individual response 50% of the time. This can be affected by so many factors (Kavita, 2001).

1. Physiological factors

There are four major physiological factors that may affect the absolute sensitivity:

a. Physiological noise

b. Adaptation effect

c. Temporal integration

d. Central masking.

a. Physiological noise: Internal noise or physiological activity linked with vascular, digestive and respiratory functions can establish a "masking floor" below which signal detection is absent even though the organism may be capable of sensation. Random acoustic or neural energy within the system including tinnitus can contribute to this result.

b. Adaptation: This is another physiological phenomenon, which influence the test result. It is the gradual reduction of the activity in the sense organ when exposed to a constant stimulus of long duration. Using stimulus, which has a duration that is short, can eliminate this.

c. **Temporal integration** : This occurs when the duration of a tone pulse influences its audibility and loudness. Nearing threshold the tone pulse duration must be at least 0.5 sec for maximum audibility.

d. **Central masking** : This is a phenomenon where in when the masker is presented to one ear it causes a threshold shift of signal at the other ear even when the masker signal is too low for it to crossover to the signal ear. This contralateral effect of the masker is most likely due to an interaction of the masker and the test signal within the central nervous system probably at the level of the superior olivary complex. There is an effect of shift of around 10 dB due to central masking.

2. Physical factors

Standing waves : The average length of the ear canal is approximately 1.5 inches. The wavelength of an 8000 Hz tone is also approximately 1.5 inches. When an 8000 Hz tone is delivered via the ear phones into the ear canal and the distance between the tympanic membrane and the ear phone diaphragm is approximately 1.5 inches, the reflected wave from the tympanic membrane will be 180 degree out of phase with the incident wave and cancellation of the wave will take place. This may also occur at around 6000 Hz. Therefore, whenever there is a disparity between the 4000 Hz, 6000 Hz or 8000 Hz thresholds, the presence of standing waves should be suspected and the clinician should readjust the earphones.

Factors affecting DL measurements

Difference limen (DL) for loudness or frequency is the change in dB or frequency that results in a just-barely noticeable loudness or frequency is termed as the intensity difference limen for loudness (DLI) or difference limen for frequency (DLF) (Silman & Silverman, 1991). There are several factors, which can affect these measurements.

1. Monaural or binaural measurements

The binaural listening enables us to detect a change in intensity 15-30% smaller than monaural listening as reported by Riesz, 1928 (cited in Gelfand, 1998).

Studies have suggested that differential sensitivity for both frequency and intensity is better binaurally than monaurally (Knudsen, 1925; Young, 1926; Shower & Biddulph, 1931; Churcher, King & Davies, 1934; Upton & Holway, 1937 Rowland, 1947; Harris, 1963; Tobias, 1967; Pickles, 1995, cited in Jesteadt & Wier, 1977). These evidences support the notion that auditory discrimination of intensity and frequency is finer when both ears are involved.

2. Duration of the stimulus presented

The differential limen for frequency (DLF) for a signal with durations of more than 150 msec is fairly constant. However, for durations that are progressively shorter than 150 msec, there is a progressive increase in the size of the DLF (Trumbull, 1944; Oetinger, 1959; Chih-an & Chistovich, 1960; Cardozo, 1962, cited in Gengel, 1973).

3. Transition between tones

For optimal conditions the transition between the tones to be compared should be abrupt, instantaneous and silent. A gradual transition such as the sinusoidal variation is less easy to detect than an abrupt transition. Riesz, 1928 (cited in Gelfand, 1998) suggested that an abrupt transition may involve the production of unwanted transient noise, it influence the observer in deciding when he was able to detect a fluctuation in intensity.

If any interval of silence is introduced between tones, it decreases the sensitivity of the ear to detect the change in the intensity. If an interval of ½ second is introduced between the tones, it increases the required intensity change by three times. The effects can be demonstrated by presenting a tone, which is increased very slowly in intensity and decreased suddenly to the original value when this process is repeated. The observer reports hearing a tone, in which the discrete jumps grows less and less loud objective (intensity is same) at end of jump.

4. Control of Presentation

When two discrete tones are being presented for comparison the observer should be able to control the exact instance of transition from one tone to other. Thus the required intensity change was reduced by one half when the observer was allowed to operate the switch himself. This was because under these conditions the observers could be prepared for the change at the exact instant it occurs.

5. The frequency region of the tone and the intensity of the tone

At all frequencies Af reduces moderately as sensation level increases and the effect is more pronounced for the high than for the middle and low frequency.

However the influence of frequency on DLF is much more pronounced, where as for any given sensation level, DLF remains very nearly constant from 62 to 2 kHz it grows progressively larger with further increase in frequency (Gelfand, 1998).

Our ear is relatively insensitivity to frequency change at low loudness level, as the loudness level is increased our discrimination improves (Ponnumani, 2002).

The data obtained by Shower and Biddulph, 1931 (cited in Gelfand, 1998) for frequency modulated tone at 40 dBSL, demonstrated that Af is larger for FM tones at low frequencies and smaller for FM tones at high frequencies.

Jesteadt, Wier and Green (1977) noticed that Af/f improves (becomes smaller) as SL increases, so that Weber fraction approximates 0.002 for the mid-frequencies at 40 dBSL. The value of f/f is relatively constant for moderate sensation levels between about 600 Hz and 2k Hz, but becomes larger at higher and lower frequencies. Af/f is somewhat a complex function of both frequency and intensity, unlike I/I which appears to depend upon SL alone .

The absolute value of the frequency DL increases rather sharply at about 4 to 5 kHz (Moore, 1972).

Differential sensitivity for intensity (I/I) becomes more acute with increasing sensation level. It is difficult to state in a definitive manner whether the Weber fraction for intensity is constant across the audible frequency range. However, it appears safe that it is reasonably constant for the middle frequencies (Gelfand, 1998).

Ozimek and Zwislocki, 1996 reported that intensity just noticeable difference (jnd) decreases as SL is increased at all frequencies between 0.125 and 8kHz, at low and medium SL, jnd's were lowest at the lowest sound frequencies and increased monotonically with sound frequency.

6. Type of stimulus e.g. pulsed vs. modulated tones

Moore (1976) compared DLs for pulsed tones and modulated tones. It was seen that FDL's for modulated tones did not correlate significantly with those for steady tone. DL for steady tones differs widely and subjects showed large practice effects. DLs for modulated tones differed little among subjects and showed smaller practice effects.

Fasti (1978) compared the DLF of pulsed tone with frequency modulated tones at 300, 500, 1000, 2000, 4000 and 8000 Hz. At low frequencies DLF was larger for modulated than for pulsed tones but at 8 kHz controversy was found.

7. **Musically trained or untrained ear**

Madson, Edmonson, and Madsen, 1969 found that auditory discrimination was partially a function of age as well as function of musical training i.e. older subjects evidenced better discrimination. Also perception of the modulated frequency was best during the first 5 seconds of the frequency change.

In spite of mature neuropsychological and auditory system infant can discriminate only very gross differences in frequency such as 300 to 600 c/s differences. DL for children are greater than adults values at the same point on frequency spectrum. (Wolner & Pyle, 1933; Stubbs, 1934; Kasatkin & Levikova, 1935; Bast & Anson, 1949; Bridger, 1961; Leventhal & Lipsitt, 1964; Hutt, 1968, cited in Madsen, Edmonson, & Madsen, 1969).

It was also found that the DL values were inversely prepositional to age up to 8 years approximately. It could be further improved by training even in young children (Soderquist & Moore, 1970).

The degree of musical training reported by the subject appeared to be uncorrelating with the size of their frequency DLs. (Wier, Jesteadt & Green, 1977).

8 Method of presentation

DL is better in descending method then in ascending method (Jerger, 1960).

9. Critical bandwidth

The loudness of the two tones complex stays essentially the same for frequency separation, smaller than the critical bandwidth (roughly 200 Hz) whereas loudness increases when the frequency differences is greater than the width of the critical bandwidth. The loudness remains essentially the same for bandwidth's (or frequency separation) smaller than the critical band, but increases when the critical band is exceeded. (Zwicker & Feldkeller, 1955, 1956; Schart, 1959, cited in Gelfand, 1998). This loudness summation effect is minimal at near threshold level and the greatest loudness increase occurs for moderate signal levels (Gelfand, 1998).

10. The number of alternations of frequency per-second

Shower and Biddulph, 1931 (cited in Gelfand, 1998) reported that the rate of two per second between frequencies gives keener discrimination than other rates.

11. Culture bound effects (Lagenbeck 1965)

12. Mode of Presentation

Binaural air conduction differential sensitivity is better than bone conduction. Bone conduction differential sensitivity is better than monaural air conduction (Dean, 1930, cited in Harris, 1969).

DLI in individuals with hearing loss

Luscher and Zwislocki, 1949 (cited in Silman & Silverman, 1991) measured the critical percentage modulation at 40dBSL since this is the level at which the intensity DL is independent of frequencies. They found that recruiting ears had critical percentage modulation (intensity DLs) less than or equal to 8%. Non-recruiting ears on the other hand had critical percentage modulation exceeding 8%.

Liischer, 1951 (cited in Silman & Silverman, 1991) reported that intensity DLs were reduced in ears with cochlear impairment, DLs were normal in ears with retrocochlear pathology and increased in ears with functional hearing loss.

Liischer, 1951; Denes and Nauntun, 1950 (cited in Silman & Silverman, 1991) found larger inter subject variability and overlap in intensity DLs between normal hearing and hearing impaired persons.

Zollner and Hallbrock, 1952 (cited in Silman & Silverman, 1991) reported that persons with cochlear impairment had intensity DLs larger than those reported by Luscher and Zwislocki, 1949; Luscher, 1951; Jerger 1952, 1953, (cited in Silman & Silverman, 1991). They found that non-auditory factors such as personal occupation could affect the intensity DL, musicians for example had smaller DLs than other normal listeners.

AL values of the subject with menieres'disease lies distinctly above the values of normal hearing subjects (F a s t i & Schorn, 1981).

DLI at frequency of cochlea hearing loss may be normal or better when obtained at low SLs as well as high SLs. DLI in cochlea hearing loss also depends on the configuration of hearing loss. Sloping hearing loss causes worsening of DLI at all frequencies. Degree of hearing loss does not have much influence on the configuration of hearing loss (Harbert, Young & Weis, 1969).

DLF in hearing loss individuals

Meurman, 1954 (cited in Moore, 1972) conducted a study in cases with menieres' disease (monaural frequency discrimination). The results showed that group mean values of DLF of the subjects with menieres' disease were substantially greater than the values for normals especially at the higher frequencies.

Several studies have measured DLF in people with cochlear damage (Gengel, 1973; Tyler, Wood & Fernades, 1983; Hall & Wood 1984; Freyman & Nelson 1986,1987,1991; Moore, & Glasberg, 1986; Moore & Peters, 1992; Simon & Yund 1993, cited in Silman & Silverman, 1991). Results showed that frequency discrimination was adversely affected in subjects with cochlear hearing loss. There is considerable variability across individuals. This size of DLF has not been found to be strongly correlated with absolute threshold at the test frequency.

Moore and Peters (1992) measured DLF for four groups of subjects-young normal hearing, young hearing impaired, elderly with near normal hearing and elderly hearing impaired. The auditory filter shapes of the subjects have been estimated using notched noised methods. The DLF for both impaired groups were higher than for the young normal groups at all center frequencies (50-4KHZ). For the elderly with near normal hearing DLF were intermediate.

Zurek and Formby (1981) measured frequency modulated difference limen (FMDL). He used 3 Hz modulational rate and frequencies between 125Hz and 4KHz for subjects with sensorineural hearing loss at 25dBSL. The FMDLs tended to increase with hearing loss at a given frequency. This was greater at lower frequencies than at high frequencies.

In most of the conditions, the temporal effects on frequency discrimination were similar for hearing impaired and normal hearing subject (Gengel, 1973).

Meurman, 1954 (cited in Moore, 1976) found enlarged DLs for frequency modulation in cases of neural deafness, but not in conductive deafness.

It can be concluded from the above review that either physical or physiological factors can affect both absolute and differential sensitivity. Thus, the present study has been taken up to investigate whether these two sensitivities are affected in the presence of noise. If so, what could be the possible reason for such changes?

METHOD

The present study has been taken up with the aim to investigate the effect of noise on absolute sensitivity and differential sensitivity in normal hearing subjects and in subjects with different degrees of hearing loss.

Subjects

Two groups of subjects were taken.

1. The first group consisted of normal hearing adults (n=36 ears) with age ranging from 17 to 22 years.

Selection criteria

- The physical condition of the subjects was good.
- All were devoid of any neurological symptoms or history.
- All had pure-tone thresholds within 15 dB HL across frequencies from 250 Hz to 8 kHz.
- Immittance showed 'A' type tympanogram with reflexes present at normal levels.

2. The second group consisted of subjects with hearing loss (n = 35 ears) with age ranging from 15 to 18 years. This group was further divided into three sub-groups based on their degree and type of hearing loss. They were as follows:
   a) Moderate hearing loss: A total of twelve ears were taken out of which one ear had conductive hearing loss, eight ears had sensorineural hearing loss and three ears had mixed hearing loss.

b) Moderately severe hearing loss: A total of eleven ears were taken, out of which one ear had conductive hearing loss, five ears had sensorineural hearing loss and five ears had mixed hearing loss.

c) Severe hearing loss: A total of twelve ears were taken out of which four ears had sensorineural hearing loss and eight ears had mixed hearing loss.

Selection criteria

- Physical condition of the subjects was good.
- All were devoid of any neurological symptoms or history.
- Individuals with ear discharge and any visible abnormality seen in ear canal were not taken for the study.

Initially all the subjects underwent pure tone and immittance testing to decide about the degree and type of hearing loss.

Instrumentation

A calibrated clinical diagnostic audiometer OB 922 version-2 was used for assessing the auditory sensitivity for all the subjects. The same instrument was also used to obtain DLI and DLF.

A calibrated Immittance meter GSI 33 version-2 was used to assess the middle ear status.

Test Procedure

It was done in two steps

a. In quiet condition (in a sound treated room without white band noise).

b. In the presence of 70 dBSPL white band noise (WBN) which was presented through the speaker.

Both absolute and differential sensitivity was measure under these two conditions for all the groups.

a) In quiet condition

- Absolute sensitivity was measured using modified version of Hughson and Westlake procedure (Jerger & Carhart, 1959, cited in Silman & Silverman, 1991). Absolute air conduction pure tone threshold was obtained for the frequencies at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz using 5 dB steps.
- DLI and DLF were measured as part of differential sensitivity. The procedure which was used to obtain DLI and DLF values are as follows:
    - Differential Limen for Intensity: An amplitude modulated tone at 10 dBSL and 40 dBSL (in few subjects with severe hearing loss, attenuator was set to maximum audiometric limits) was presented at 500 Hz, 1kHz, 2k Hz and 4kHz. The amplitude-modulated tone was presented through the headphones separately for each ear. The subject was asked to listen to the amplitude-modulated tone and to indicate whether the modulation is perceived or not. Initially 5 dB modulated tone was given and later it was reduced gradually (4dB, 3dB, 2dB,

ldB, 0.8dB, 0.6 dB, 0.4 dB, 0.2 dB) till the subject no longer perceived it as a modulated tone. The smallest amount of amplitude modulation that was detected by the subject was taken as the differential limen for intensity.

- Differential Limen for Frequency: Frequency modulated tone at 10 dBSL and 40 dBSL (in few subjects with severe hearing loss, attenuator was set to maximum audiometric limits) was presented for the frequencies at 500 Hz, 1 kHz, 2 kHz and 4 kHz. Frequency modulated tone was presented through the headphones separately for each ears. The test tone was varied continuously in frequency at a rate of 5%, 2.5% 1%, 0.5%, and 0.2%. The subjects task was to detect the presence of a modulated tone as opposed to a steady tone. The DL was taken as the smallest difference in frequency that produces a perceptible modulation of the original tone.

b) In the presence of 70 dBSPL white band noise

A white band noise of 70 dBSPL was presented through the speaker (one at a time) for example. If the right ears were tested then the noise was presented through the right speaker (which was placed at one meter distance and kept at an angle of 45 degree azimuth with reference to the subject) and the tone was presented through the headphones to the right ear. Noise was given through the speaker continuously and both the absolute and differential sensitivity was measured in the presence of noise (70 dBSPL WBN) using the same procedure as mentioned above.

ANALYSIS

Absolute thresholds and differential thresholds obtained (at 10 dBSL and 40 dBSL) for all the groups in quiet condition and in the presence of white band noise were noted and tabulated. The data was then subjected to appropriate statistical analysis to study the significant difference in different conditions and across the groups and at different sensation levels if any.

RESULTS AND DISCUSSION

The data was statistically analyzed and the mean and standard deviation was calculated. Independent t-test was used to determine the significant difference between the means.

Effect of Noise on Absolute Sensitivity of normals, moderate, moderately severe and severe hearing loss (HL) subjects.

As seen in Table 1, there was statistically significant difference in the pure tone threshold in quiet and in the presence of 70 dBSPL WBN for the normal hearing subjects at all frequencies. This was because the noise level in the room was sufficient enough to mask the signal, which resulted in a significant change in threshold for normals. Whereas moderate hearing loss subjects showed no significant difference in the pure tone threshold in quite and in the presence of 70 dBSPL WBN at 250 Hz, 4 kHz and 8 kHz, the greater threshold variation was seen at 500 Hz, 1 kHz and 2 kHz that was statistically significant. This could be due to the fact that the ear is more sensitive to mid frequency, so less sound pressure level (SPL) is required to stimulate the ear, where as low and high frequency stimulus requires more SPL to stimulate. Thus 70 dBSPL WBN, which was presented through the speaker, could not bring any change in physiology at low and high frequency but were just sufficient to elevate threshold at mid frequencies. For moderately severe and severe hearing loss subjects, there was no significant difference in the pure tone threshold in quiet and in the presence of WBN at all frequencies, except at 500 Hz for moderately severe hearing loss group, which is statistically significant. Though it was statistically significant the mean threshold difference was approximately 2 dB, which is clinically insignificant. The insignificant variation in threshold seen in the later two groups is due to the insufficient noise level which does not bring any changes in the threshold, as the threshold in quiet is higher.

Table-1: Depicts the mean, standard deviation (SD) and t-scores of absolute sensitivity in quiet (Q) and in the presence ofWBN (N) for normals, moderate, moderately severe and severe hearing loss (HL) subjects.

		250 Hz			500 Hz			1 kHz			2 kHz			4 kHz			8k Hz		
		Mean	SD	t value	Mean	SD	t value	Mean	SD	t value	Mean	SD	t value	Mean	SD	t value	Mean	SD	t value
Normals	Q	9.44	4.59	-13.42**	11.66	4.14	-15.33**	9.72	4.77	-18.08**	7.63	5.13	-16.39**	6.94	5.24	-14.42**	5.97	5.95	-11.56**
	N	28.88	7.37		34.72	8.01		36.66	7.55		33.88	8.11		34.16	10.03		34.86	13.75	
Moderate HL	Q	42.08	12.14	-1.63 NS	50	5.64	-3.94**	56.25	6.78	-3.22**	54.58	7.52	-2.96**	58.33	13.70	-0.98 NS	63.33	20.03	-53 NS
	N	50	5.62		60	6.74		64.16	5.14		62.08	4.50		63.33	10.94		67.50	18.02	
Moderately Severe HL	Q	57.72	10.33	-1.73 NS	65.45	5.17	-2.82*	67.27	3.43	-1.74 NS	69.54	9.86	-1.02 NS	78.18	9.81	-0.70 NS	87.14	9.51	-0.42 NS
	N	64.54	7.89		67.27	3.43		70	3.97		74.09	10.91		81.36	11.20		89.28	9.32	
Severe HL	Q	69.58	15.44	-0.61 NS	78.75	3.77	-1.13 NS	82.91	6.20	-1.37 NS	82.50	9.53	-0.63 NS	81.25	9.56	-0.71 NS	87.27	16.34	-0.52 NS
	N	73.33	14.66		81.66	6.15		86.25	5.69		85	9.53		83.75	7.42		90.90	16.40	

*p < 0.05, ** p<0.01, NS = Not Significant

Table-2: Depicts the mean, standard deviation (SD) and t-scores of differential limenfor intensity (DLI) in quiet (Q) and in the presence ofWBN (N) at 10 dBSL and at 40 dBSLfor normals, moderate, moderately severe and severe HL subjects.

			500 Hz			1 kHz			2 kHz			4 kHz		
			Mean	SD	t value	Mean	SD	t value	Mean	SD	t value	Mean	SD	t value
Normals	10dBSL	Q	1.68	1.06		1.17	1.12		1.75	1.01		1.51	0.94	
		N	---	---		---	---		---	---		---	---	
	40dBSL	Q	1.36	0.89	-2.91**	1.23	0.84	-2.70**	1.33	0.81	-3.27**	1.25	0.89	-3.13**
		N	2.09	1.21		1.92	1.28		2.16	1.27		2	1.12	
Moderate HL	10dBSL	Q	1.80	1.29	-1.26NS	1.75	1.12	-1.29NS	1.63	0.98	-2.26*	1.38	0.91	-2.93**
		N	2.41	1.08		2.30	0.94		2.50	0.79		2.25	0.45	
	40dBSL	Q	1.31	0.87	-2.17*	1.36	0.72	-2.46*	1.46	0.82	-2.46*	1.21	0.75	-2.17*
		N	2.16	1.02		1.98	0.63		2.22	0.78		1.85	0.67	
Moderately Severe HL	10dBSL	Q	1.12	0.88	-0.70NS	1.21	1.11	-0.62NS	1.09	0.81	-0.59NS	1.18	0.94	-0.68NS
		N	1.41	1.03		1.54	1.20		1.34	1.03		1.49	1.15	
	40dBSL	Q	1.05	0.82	-1.07NS	1.03	0.83	-0.83NS	1.10	0.94	-0.75NS	1.14	0.87	-0.04NS
		N	1.52	1.20		1.34	0.99		1.41	1.15		1.16	0.96	
Severe HL	10dBSL	Q	1.30	0.76	-1.37NS	1.31	0.50	-1.83NS	1.46	0.7	-1.59NS	1.35	1.16	-2.05NS
		N	1.81	1.04		1.83	0.83		1.98	0.87		1.95	1.91	
	40dBSL	Q	1.03	0.67	-1.54NS	1.31	0.76	-1.27NS	1.11	0.58	-2.16NS	1.16	0.79	-1.96NS
		N	1.56	0.99		1.81	1.11		1.75	0.83		1.91	1.05	

*p < 0.05, ** p<0.01, NS= Not Significant

Effect of noise on DLI of normal, moderate, moderately severe and severe HL subjects at 10 dBSL and 40 dBSL

As seen from the Table 2, there was statistically significant difference for DLI in quiet and 70 dBSPL WBN for normals, moderate HL subjects at 40 dBSL for all frequencies. DLI values were more in the presence of noise than obtained in quiet. This variation in differential sensitivity is mainly because the noise level was sufficient to alter the physiology of the ear thus resulting in significant variation. DLI could not be measured in the presence of noise at 10 dBSL for normals, as the noise level was too high for them to perceive the signal. The DLI was almost the same across frequiencies. This is because DL for intensity at 40 dBSL is idependent of frequency (Luscher & Zwislocki, 1949, cited in Silman & Silverman, 1991). At 10 dBSL for moderate HL, DLI in quiet and in the presence of WBN, there was significant difference at 2 kHz and 4 kHz and no significant difference at 500 Hz and 1 kHz. This could be because the high frequency differential sensitivity is more vulnerable to changes to a minimum variation in any condition but mid frequencies are less vulnerable. It may be also that the Weber fraction is reasonably constant for the mid frequencies but varies at higher frequencies (Gelfand, 1998). Thus significant changes were seen in high frequencies. Moderately severe and severe hearing loss subjects did not show any significant difference in DLI between the two conditions at both lOdBSL and 40 dBSL for all the frequencies. DL did not change, as the noise presented was insufficient to bring any physiological changes. Thus, resulting in no significant change. However, mean DLI values obtained were more in noisy situation in all the groups, though significant difference was not obtained.

Table-3: Depicts the mean, standard deviation (SD) and t-scores of different limen for frequency (DLF) in quiet (Q) and in the presence ofWBN (N) at 10 dB SL and 40 dBSLfor normals, moderate, moderately severe and severe HL subjects.

			500 Hz			1 kHz			2 kHz			4 kHz		
			Mean	SD	t value	Mean	SD	t value	Mean	SD	t value	Mean	SD	t value
Normals	10dBSL	Q	1.64	0.94		1.50	0.98		1.04	0.83		0.86	0.66	
		N	---	---		---	---		---	---		---	---	
	40dBSL	Q	1.37	0.95	-2.15*	1.16	0.93	-2.96**	0.95	0.82	-3.67**	0.91	0.83	-3.19**
		N	1.92	1.21		1.81	0.92		1.74	0.98		1.58	0.96	
Moderate HL	10dBSL	Q	1.70	0.98	-1.63NS	2.12	1.24	-0.72NS	2.04	0.83	-0.53NS	1.45	0.78	-1.98Ns
		N	2.25	0.58		2.45	0.98		2.20	0.68		2.08	0.76	
	40dBSL	Q	2.01	0.37	-0.54NS	1.85	0.97	-0.65NS	1.85	0.97	-0.93NS	1.64	0.92	-0.89NS
		N	2.25	0.58		2.08	0.76		2.18	0.75		1.95	0.81	
Moderately Severe HL	10dBSL	Q	1.41	1.07	-0.62NS	1.41	1.07	-0.60NS	1.37	1.10	-0.39NS	1.23	1.03	-0.63NS
		N	1.70	1.10		1.75	1.52		1.39	1.08		1.52	1.12	
	40dBSL	Q	1.05	0.96	-0.58NS	1.14	1.08	-0.53NS	1.05	0.69	-0.47NS	1.05	0.16	-0.47NS
		N	1.30	0.99		1.39	1.08		1.25	1.02		1.25	1.02	
Severe HL	10dBSL	Q	1.51	1.04	-0.72NS	1.07	0.90	-1.25NS	1.00	0.93	-1.21NS	1.03	0.91	-0.75NS
		N	1.93	1.71		1.78	1.74		1.71	1.79		1.40	1.24	
	40dBSL	Q	1.05	0.92	-0.31NS	1.00	0.93	-0.11NS	0.92	0.95	-0.32NS	1	0.93	-0.50NS
		N	1.17	1.01		1.05	0.92		1.05	0.92		1.25	1.42	

*p < 0.05, ** p<0.01, NS= Not Significant

Effect of noise on DLF of normal, moderate, moderately severe and severe HL subjects at l0dB SL and 40 dBSL.

As seen from the Table-3, there is a significant change in DLF value at 40 dBSL in quiet and in the presence of WBN for normals. DLF value was more in noisy condition for almost all the groups though it has failed to reach significance level for maximum conditions. However subjects with moderate hearing loss did not show any significant change in DLF even at mid frequency as the DLF values were high both in quiet and noise at 10 and 40 dBSL. This is because this group had maximum number of sensorineural hearing loss subjects. It has been repoted that DLF is adversely affected in cochlear hearing loss cases (Gengel, 1972; Tyles, Wood & Fernades, 1983; Hall & Wood, 1984; Freyman & Nelson 1980, 1987, 1991; Moore & Glasberg, 1986; Moore & Peters, 1992; Simon and Yund 1993, cited in Silman & Silverman, 1991). Once again DLF could not be obtained at 10 dBSL in the presence of WBN in normals, as they could not perceive the signal. Subjects with moderately severe and severe HL did not show any statistically significant difference in DLF, which maybe also due to the insufficient level of noise that failed to bring sufficient change.

Table-4: Depicts the t-scores with the levels of significance between two groups for DLI and DLF at 10 dBSL and 40 dBSL in quiet.

			500 Hz		1kHz		2 kHz		4 kHz	
			t value	S/NS	t value	S/NS	t value	S/NS	t value	S/NS
Normal vs moderate HL	DLI	lOdBSL	-0.29	NS	0.03	NS	-0.36	NS	0.425	NS
		40dBSL	0.15	NS	-0.49	NS	-0.46	NS	0.116	NS
	DLF	lOdBSL	-0.20	NS	-1.76	NS	-3.56**	S	-3.04**	S
		40dBSL	-0.82	NS	-2.15*	S	-3.11**	S	-2.65*	S
Normal vs Moderately severe HL	DLI	lOdBSL	1.58	NS	1.40	NS	1.94	NS	1.02	NS
		40dBSL	1.01	NS	0.67	NS	0.79	NS	0.87	NS
	DLF	lOdBSL	0.66	NS	0.25	NS	-1.62	NS	-2.06	S
		40dBSL	0.96	NS	-0.06	NS	-0.49	NS	0.85	NS
Normal vs severe HL	DLI	lOdBSL	1.16	NS	1.32	NS	0.90	NS	0.57	NS
		40dBSL	1.16	NS	-0.30	NS	0.86	NS	0.28	NS
	DLF	lOdBSL	0.38	NS	1.33	NS	0.13	NS	-0.69	NS
		40dBSL	1.01	NS	0.51	NS	0.09	NS	0.25	NS
Moderate vs moderately Severe HL	DLI	lOdBSL	1.44	NS	1.13	NS	1.43	NS	0.51	NS
		40dBSL	0.73	NS	1.01	NS	1.00	NS	0.69	NS
	DLF	lOdBSL	0.67	NS	1.45	NS	1.19	NS	0.41	NS
		40dBSL	1.37	NS	1.55	NS	1.86	NS	2.04*	S
Moderately severe vs Severe HL	DLI	lOdBSL	-0.50	NS	-0.27	NS	-1.12	NS	-0.51	NS
		40dBSL	0.06	NS	-0.83	NS	-0.02	NS	-0.53	NS
	DLF	lOdBSL	-0.22	NS	0.83	NS	1.28	NS	0.92	NS
		40dBSL	0.01	NS	0.43	NS	0.43	NS	0.22	NS
Moderate vs Severe HL	DLI	lOdBSL	1.15	NS	1.21	NS	0.49	NS	0.10	NS
		40dBSL	0.88	NS	0.16	NS	1.20	NS	0.15	NS
	DLF	lOdBSL	0.46	NS	2.36*	S	2.84**	S	1.54	NS
		40dBSL	1.45	NS	2.15*	**S**	2.34*	S	2.32*	S

$*p < 0.05$, $**p < 0.01$, NS = Not Significant, S = Significant

Comparison between the groups for DLI and DLF at 10 dBSL and 40 dBSL in quiet obtained from normals and hearing loss subjects.

As seen in Table 4, there was no significant difference between any groups for DLI at 10 dBSL and 40 dBSL in quiet. This is in agreement with the observation made by Harbert, Young and Weiss, 1969. They have reported that DLI for chochlear hearing loss may be normal or better when obtained at low or high SLs. Another reason could be the intersubject variability and overlap in intensity DLs seen in normals and hearing impaired persons (Denes, Naunton, 1950; Liischer, 1951, cited in Silman & Siverman, 1991). However, Zollner and Hallbrock, 1952 (cited in Silman & Silverman, 1991) reported larger intensity DL in person with cochlear hearing loss.

It also can be observed from the Table that, there was a significant difference between normal and moderate HL subjects at 1 kHz at 40 dBSL, 2 kHz and 4 kHz at both 10 dBSL and 40 dBSL, between normals and moderately severe HL subjects, at 4 kHz at 10 dBSL, between moderate and moderately severe HL subjects at 4 kHz at 40 dBSL, between moderate and severe HL subjects at 1 kHz and 2 kHz at 10 dBSL and 40 dBSL. However significant difference was not found between the rest of the groups and for other frequencies. Significant difference is seen only when DLF value obtained in moderate hearing loss was compared with other groups. This is because DLF value obtained in this group was higher than DLF obtained in any other group. Higher DLF was obtained because this group had maximum number of subjects with sensorineural hearing loss (SN HL) compared to any other hearing loss. The literature also suggests that subjects with SN HL show higher DLF than normals (Meurman, 1954, cited in Moore, 1976). Another thing can be noticed is that significant difference is seen mainly at higher frequencies. It has been observed that the absolute value of the frequency DL increases rather sharply at about 4 to 5k Hz (Moore, 1972). Meurman, 1954, cited in Moore, 1976, also observed greater DLF at high frequencies for subjects with meniere's disease compared to normals, which is seen in this study also. In contrast, Zurek and Formby (1981) reported greater FMDL at low frequencies than at high frequencies. However, DLF values failed to reach significant level between other two groups. This may be due to the lack of correlation between the size of DLF and absolute threshold as observed by Gengel, 1972; Tyles, Wood and Fernades, 1983; Hall and Wood, 1984; Freyman and Nelson 1980, 1987, 1991; Moore and Glasberg, 1986; Moore and Peters, 1992; Simon and Yund 1993 (cited in Silman & Silverman, 1991).

Table 5: Depicts the mean, SD and t-scores for DLI and DLF between 10 dBSL and 40 dBSL for normals, moderate, moderately severe and severe HL subjects in quiet.

	Quiet		500 Hz			1 kHz			2 kHz			4 kHz		
			Mean	SD	t value	Mean	SD	t value	Mean	SD	t value	Mean	SD	t value
Normals	DLI	10dBSL	1.68	1.06	1.41NS	1.76	1.12	2.38*	1.75	1.01	1.93NS	1.51	0.94	1.22 NS
		40dBSL	1.36	0.89		1.20	0.83		1.33	0.92		1.25	0.89	
	DLF	10dBSL	1.64	0.94	1.42NS	1.50	0.98	1.42NS	1.04	0.83	0.55NS	0.86	0.66	-0.26 NS
		40dBSL	1.32	0.94		1.18	0.93		0.93	0.83		0.91	0.83	
Moderate HL	DLI	10dBSL	1.80	1.29	1.07NS	1.75	1.12	0.99NS	1.63	0.92	0.46NS	1.38	0.91	0.48 NS
		40dBSL	1.31	0.87		1.36	0.72		1.46	0.82		1.21	0.75	
	DLF	10dBSL	1.70	0.98	-0.63NS	2.12	1.24	0.84NS	2.04	0.83	0.51NS	1.45	0.78	-0.52 NS
		40dBSL	2.01	1.37		1.85	0.97		1.85	0.92		1.64	0.92	
Moderately Severe HL	DLI	10dBSL	1.21	0.88	0.19NS	1.21	1.11	0.43NS	1.09	0.89	-0.04NS	1.18	0.94	0.09 NS
		40dBSL	1.05	0.82		1.03	0.83		0.91	0.89		1.14	0.87	
	DLF	10dBSL	1.41	1.07	0.83NS	1.41	1.07	0.99NS	1.37	1.10	0.17NS	1.23	1.03	0.50 NS
		40dBSL	1.05	0.96		1.14	0.81		1.05	0.96		1.05	0.93	
Severe HL	DLI	10dBSL	1.30	0.76	0.90NS	1.31	0.50	0.21NS	1.46	0.70	0.21NS	1.35	0.51	0.78 NS
		40dBSL	1.03	0.67		1.31	0.76		1.11	0.58		1.16	0.79	
	DLF	10dBSL	1.51	1.04	1.16NS	1.07	0.90	0.17NS	1.00	0.93	0.21NS	1.03	0.91	0.06 NS
		40dBSL	1.05	0.92		1.00	0.96		0.92	0.95		1.00	0.93	

*p < 0.05, NS= Not Significant

DLI and DLF at 10 dBSL and 40 dBSL for normals, moderate, moderately severe and severe HL subjects in quiet

As seen from the Table-5, a significant difference was seen only for normals at 1 kHz for DLI between 10 dB and 40 dBSL in quiet. However careful observation of the table does suggest that either DLI or DLF values obtained at 40 dBSL were lesser than that obtained at 10 dBSL though it has failed to reach significance level. Several researchers have also reported that DL (both DLI and DLF) tends to reduce with increase in sensation level. Similar results were also reported by Rowland and Tobias (1967). They observed largest scores at the lowest level (20 dBHL) and the smaller scores at the higher levels (50 dBHL).

It can be seen from the table 1 that a significant difference in absolute threshold was seen for normals and at some frequencies for moderate degree of HL subjects, but not seen for the subjects with higher degrees of hearing loss. When the noise presented is above the threshold we have seen significant difference in pure tone threshold. This variations in pure tone threshold could be mainly due to the masking effect because this effect was not seen in moderately severe and severe degree of hearing loss groups. If the threshold variation were due to the spectral change of the wanted stimulus in the presence of second stimulus, then this threshold variation would have been seen in all the groups, which was not observed. At the same time, the threshold variation was more when the hearing sensitivity is better and the variation is lesser when the hearing sensitivity is poor. This also justifies by saying that better the hearing sensitivity more is the masking effect i.e., the noise level will bring more elevation in the threshold and vise-versa.

The result also clearly shows that the differential sensitivity (both DLI and DLF) in normals is affected by the presence of noise at 40 dBSL. At 10 dBSL in the presence of 70 dBSPL WBN, normal hearing subjects were unable to perceive the modulation. And this effect was not seen in subjects with moderate, moderately severe and severe degree of hearing loss.

This again justifies that this effect is mainly due to masking effect and not due to physical changes of the test stimulus. When two stimuli are presented, we can expect spectral changes. If this change was the reason for the variation in the differential limen for intensity and frequency in the presence of noise, this would have been seen in all the groups, which is not seen. Thus the variation in normals (for both DLI and DLF) and subjects with moderate hearing loss (for DLI) is mainly due to the physiological changes that took place at the cochlea.

SUMMARY AND CONCLUSION

Sound is heard when its characteristics falls with in the human limitation. The perception of a sound can be affected by several factors, which is unavoidable. One such factor that can affect the individuals hearing sensitivity (absolute and differential sensitivity) is the presence of another signal. The presence of unwanted signal can either alter the spectrum of the wanted signal or can change the physiology of the auditory system. The perception of any sound also depends on the nature of the individual (i.e., motivation, interest, attention, etc.) or the general physical conditions (especially the individual's hearing status).

Thus the present study was taken up with the aim to find the effects of noise on absolute sensitivity and differential sensitivity (DLF and DLI) and also to study the way in which the absolute sensitivity and differential sensitivity is affected by noise in normals, moderate, moderately severe and severe degree of hearing loss subjects. Yet another aim was to study the way in which DL varies with the sensation level.

A total of thirty-six ears with normal hearing and thirty-five ears with moderate, moderately severe and severe hearing loss subjects were taken for the study. Absolute and differential sensitivity was obtained for all the subjects in two conditions. The testing was done in two steps. First in quiet condition (in a sound treated room without white band noise) and then in the presence of 70 dBSPL white band noise, which was presented through the speaker.

Clinical diagnostic audiometer OB 922 version- 2 was used to obtain absolute threshold and DLI and DLF. An immittance meter was used to assess the middle ear status.

An amplitude modulated tone at 10 and 40 dBSL with the modulation ranging from 5 dB to 0.2 dB was presented for 500 Hz, 1 kHz, 2 kHz, and 4 kHz through the headphone. The smallest amount of amplitude modulation that was detected was taken as the subject's differential limen for intensity.

Frequency modulated tone at 10 dBSL and 40 dBSL with modulation ranging from 5% to 0.2% was also presented for 500 Hz, 1 kHz, 2 kHz and 4 kHz frequencies through the headphones separately for each ear. The DL was taken as the smallest difference in frequency that produces a perceptible modulation of the original tone.

The results indicated that there was a significant difference in absolute threshold between quite and noisy condition at all frequencies for normals. A significant difference was obtained for absolute threshold for subjects with moderate hearing loss at some frequencies. No significant difference was obtained for absolute threshold for subjects with moderately severe and severe hearing loss.

A significant difference was obtained for DLI and DLF in quiet and in the presence of WBN at 10 and 40 dBSL for normals at all frequencies. For moderate hearing loss subjects, significant difference was obtained for some frequencies for DLI and no significant difference for DLF (at both 10 and 40 dBSL) in quiet and in the presence of noise. Significant difference was not seen for the subjects with moderately severe and severe hearing loss at 10 and 40 dBSL for both DLI and DLF in quiet and in the presence of noise

A significant difference was obtained between normals and subjects with moderate hearing loss for DLF at 10 and 40 dBSL in quiet. No significant difference was obtained for DLF in other groups at 10 and 40 dBSL in quiet. And also no significant difference was obtained for DLI at 10 and 40 dBSL in quiet for any group. However, the DL values obtained at 40 dBSL were smaller than that the values obtained at 10 dBSL.

Hence the results clearly indicates noise affects both absolute and differential sensitivity and this effect is seen in normals but the effect is less in subjects with hearing loss. No effect is seen with increase in degree of hearing loss.

It can be concluded that the variation in absolute and differential threshold is mainly due to the masking effect. The physiological changes that take place at the cochlea brought the changes, but were not really because of the spectral changes of the wanted stimuli, as all the cases have failed to show similar changes.

IMPLICATION

This study gave an idea regarding the way in which the ambient noise can affect one's hearing sensitivity. It also gave a clear idea that the biological correction factors, which are usually applied in camps, are not applicable for all degrees of subjects with hearing loss. It should be applied only for the subjects with normal hearing or for subjects with lesser degrees of hearing loss.

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