# RELATIONSHIP BETWEEN DISCRETE STIMULI AND SPEECH LOUDNESS DISCOMFORT LEVELS USING DIFFERENT TRANSDUCERS AMONG HEARING IMPAIRED SUBJECTS

**Register No.MOl 11**

An Independent Project submitted in part fulfillment for the
first year **M.Sc, (Speech and Hearing)**
University of Mysore, Mysore.

All India Institute of Speech and Hearing
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Mysore

**MAY 2002**

***Dedicated to***

*Lord Jesus*

*parents and*

*my sisters and*

*brothers*

*with love beyond words*

# CERTIFICATE

This is to certify that the Independent Project entitled : "RELATIONSHIP BETWEEN DISCRETE STIMULI AND SPEECH LOUDNESS DISCOMFORT LEVELS USING DIFFERENT TRANSDUCERS AMONG HEARING IMPAIRED SUBJECTS" is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with Register No.MOl 11.

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Mysore
May 2002

# CERTIFICATE

This is to certify that this Independent Project entitled : "RELATIONSHIP BETWEEN DISCRETE STIMULI AND SPEECH LOUDNESS DISCOMFORT LEVELS USING DIFFERENT TRANSDUCERS AMONG HEARING IMPAIRED SUBJECTS" has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.


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# DECLARATION

I hereby declare that this Independent Project entitled "RELATIONSHIP BETWEEN DISCRETE STIMULI AND SPEECH LOUDNESS DISCOMFORT LEVELS USING DIFFERENT TRANSDUCERS AMONG HEARING IMPAIRED SUBJECTS" is the result of my own study under the guidance of *Dr. K. Rajalakshmi.,* Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any other University for the award of any Diploma or Degree.

Mysore<br>May 2002.

Reg. No.MOl 11

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# INTRODUCTION

Deafness is worse than blindness, so they say it is the loneliness, the sense of isolation that makes it so, and the lack of understanding in the minds of ordinary people. The problem of the deaf from birth is quite different from that of man or woman who has become deafened after school-age or in adult life. . . . But for all of them, the handicap is the same, the handicap of the silent world, the difficulty of communicating with the hearing and speaking world.

*Scott Stevenson*

Before any amplification system is evaluated, prescribed or recommended, the audiologist must determine that the limits of its output across frequency are not greater than the levels at which clients experience discomfort, that is, their loudness discomfort levels (Hawkins, 1980).

Loudness discomfort level (LDL) is the sound pressure level (SPL) at which the stimuli becomes uncomfortably loud (Stach, 1994).

Loudness discomfort level is the intensity level (in dB) at which audio signals (pure tones, noise or speech) become uncomfortably loud (Maryanne, 1994).

Various terms have been employed to describe the intensity at which an auditory signal elicits an uncomfortable subject response. These include loudness discomfort level (LDL), threshold of discomfort (TD), uncomfortable loudness level (ULL), maximum tolerable pressure (MTP), uncomfortable level curve, discomfort level and tolerance. Presently, three of these are used most often : LDL, UCL and TD (Hawkins, 1980).

The major reason for measuring LDLs for hearing-impaired persons is to assist in determining the appropriate saturation sound pressure level (SSPL) of a hearing aid or other amplification device.

Watson, Davis & Silverman (1940) recognized that such information was of value in hearing aid evaluations. The logic is that a hearing aid should not amplify any signal above the level at which the person experiences discomfort (cited in Hawkins, 1980).

A second reason to obtain LDLs from hearing-impaired persons is for diagnostic purposes (Hood & Poole, 1966; Dix, 1968; Hood, 1968, cited in Hawkins, 1980). The suggestion has been that persons with normal hearing and those having lesions confined to the cochlea will yield similar LDLs, while those with conductive, mixed or retrocochlear losses will have LDLs at more intense levels.

A variety of clinical procedures to obtain LDLs and select SSPL90 have been recommended in the literature (Hawkins, Walden, Montgomery & Prosek, 1987). They differ in instructions, stimuli, psychophysical procedures and the manner in which the stimuli are delivered.

Recommended stimuli included are pure tones, 1/3-octave bands of noise, narrow bands of noise and speech. Delivery of stimuli have been through standard earphones, insert ear phones, sound field, low-impedance hearing aid receivers and high-impedance hearing aid receivers. Psychophysical procedures have included Bekesy tracking, method of limits, method of adjustment and method of constant stimuli. However, it still remains unclear as to what stimulus type should be used to elicit the discomfort measures (Olson & Hipskind, 1973; Morgan, Wilson & Dirks, 1974; Dirk & Kamm, 1976; Hawkins, 1980; Cox, 1981).

And also the exact data of relationship between earphone versus free-field suprathreshold loudness judgements is not available.

## NEED FOR THE STUDY

1. The stimulus type which can be very effectively used to elicit discomfort measures is still not clear and hence there is a need to study the relationship between various acoustic stimuli for LDL measurement and also to find which is the best stimuli for LDL measurement.
2. Exact relationship between earphone versus loud speaker LDL measurement is not available.

Hence, there is a need to study the relationship between earphone versus loudspeaker LDL measurement for various acoustic stimuli.

The present study was undertaken with the following aims. To compare:

1. Mean LDLs for speech and pure tones centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and pure tone LDL average of 500 Hz, 1000 Hz and 2000 Hz.
.2. Mean LDLs for speech and narrow band noise centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
3. Mean LDLs for speech and warble tones centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
4. Mean LDLs for speech and white noise
5. Mean LDLs for the discrete stimuli, white noise and speech under headphone versus loud speaker listening conditions.

# REVIEW OF LITERATURE

Effective amplification is vital for the rehabilitation of the hearing-impaired. Hearing aid fitting is a mixture of art and science a challenge to the skills of the audiologist. The overall aim of the fitting is to provide an amplified signal that will allow maximum benefit to be gained from the residual hearing area. Hearing aids are selected according to the medical, audiological and other needs of the individual (Hull, 1982).

An important pre-selecrion of amplification is determined by the monoaural unaided functions of (Bess & Humes, 1990).

1) The severity of hearing loss.
2) The frequency configuration of the hearing loss.
3) Speech discrimination
4) Most comfortable loudness level (MCL)
5) Loudness discomfort level (LDL)

Before any amplification system is evaluated, prescribed or recommended an audiologist must determine the limits of the output across frequency of the amplification system are not greater than the levels at which patients experience discomfort. Of the various factors enumerated above, Watson, 1944, (cited in Stephens and Anderson, 1971) first advocated the measurement of the subjective ULL in patients as a means of testing for the recruitment phenomena. Since that time, it has been assessed and advocated by Bangs & Mullins, 1953, (cited in Stephens & Anderson, 1971) in the USA, and has grown in popularity. Particularly since the publication of Hood & Poole, 1966, (cited in Stephens & Anderson, 1971), who call it the loudness discomfort level test.

Subsequently, the LDL has gained some popularity in differential diagnosis of auditory disorders (Hood, 1968;Dix, 1968; cited in Dirks & Kamm, 1976).

The advantage of this test is that, it provides a simple method requiring no special equipment for detecting recruitment in patients with bilateral symmetrical hearing loss. Another important advantage of this test is to select the saturation. Sound pressure level of a hearing aid.

In hearing aid evaluation procedures, the LDL has been considered as an estimate of the optimal saturation sound pressure level for amplification by defining an upper limit beyond which amplified sounds become uncomfortable to a listener.

**Loudness discomfort levels in normal and auditory disordered Individuals**

For normal listeners, discomfort levels have been reported at SPLs as high as 120 dB (re: 0.0002 dyne/$cm^2$) for speech (Davis, 1946; cited in Dirks & Kamm, 1976). But more typically have been found at SPLs of approximately 100 dB (Hood & Poole, 1966; cited in Dirks & Kamm, 1976; Stephens & Anderson, 1971, Morgan, Wilson & Dirks, 1974).

One of the main disadvantages of LDL is the variability of results which may occur among normal subjects. None of the authors have specified values for the ULL in normal subjects but using an incremental continuous presentation technique (Silverman, 1947; cited in Stephens & Anderson, 1971) found initial levels of discomfort at 11O dBSPL.

The LDLs of patients with conductive loss and VIII nerve disorders are generally elevated to levels beyond 120 dB SPL (Silman & Silverman, 1991).

Hood & Poole, 1966, (cited in Dirks & Kamm, 1976) found that LDLs of patients with unilateral cochlear pathology with recruitment were similar to those of normal hearing persons. That is, the LDLs are obtained within the intensity range of 90-105 dB HL regardless of the degree of hearing loss in cochlear impaired persons. Therefore, the LDL test may be used to determine the presence/absence of loudness recruitment. However, Kamm, Dirks & Mickey (1978) found that a non-linear relation exists between the magnitude of the hearing loss and the LDL.

The LDLs in sensory neural hearing-impaired persons were increased with increase in hearing loss beyond 50 dB. They also found large intersubject variability. So the LDL could not accurately be predicted from the magnitude of the hearing loss. Because of the dependence of the LDL upon the magnitude of the hearing loss beyond 50 dB HL and its large intersubject variability, they concluded that the LDL test is not a clinically feasible measure of recruitment.

Hood & Poole, 1966, (cited in Stephens & Anderson, 1971) using a manual technique with 5 dB steps found a mean value of 99 dB SPL in the normal ears of subjects suffering from unilateral meniere's disease.

It has been shown that there is a high intersubject variability in LDL results. This could be attributed to differential habituation of loudness.

The measurement of LDLs recently has received renewed attention. As a result the audiologist faces an accumulation of new and often contradictory information pertaining to procedures, applications and expected values (Hawkins, 1980).

A variety of clinical procedures to obtain LDLs have been recommended in the literature (Hawkins, 1980; Walden, Montgomery, Prosek, 1987). However, there are a host of variables affecting the measurement of LDL.

These can be classified as,

1) Instructions
2) Psychophysical procedures
3) Stimuli
4) Manner in which stimuli are delivered.

## 1) Instructions

The instructions that are given to the patients probably constitute the largest source of potential variability in measurements of the LDL. Over the years instructions to the subject have ranged from "Tell me when the sound hurts your ears" to "tell me when sound first becomes annoying". The same user might well give values of 130 dB SPL and 95 dB SPL for these two sets of instructions (Mueller & Hawkins, 1995).

The above two instructions has been characterized as representing "extreme discomfort" and "initial discomfort" (Hawkins, 1980).

The majority of other recommended instructions fall in between these two, a category described as "definite discomfort". For eg. "Tell me when the sound becomes uncomfortably loud". (Mueller & Hawkins, 1990).

Hawkins, Walden. Morgomery & Prosek (1987), have given a different approach for LDL measurement wherein subject was instructed to label each presented sound as "comfortable", "comfortable but slightly loud", "comfortable but slightly soft", "soft", "very soft", "loud but OK", "uncomfortably loud", "extremely uncomfortable", "painfully loud". Their results indicated stable LDLs which could be mainly attributed to clarity of instructions and availability of names for each loudness category.

Thus, it is evident that the LDL instructions play an important role in the measurement of LDLs.

2) Psychophysicai procedures

The two most important psychophysicai methods for clinical determination of LDLs are an ascending method of limits with 3 crossings (Stephens & Anderson, 1971; Shapiro, 1975; Denneberg & Altshuler, 1976) and a simple ascending approach with no specific definition or criterion for level determination (Hood & Poole, 1966; Silverman, 1947; Berger, 1976a; cited in Hawkins, 1980; & Schmitz, 1969).

Other methods that have been used include constant stimuli and adjustment (Morgan, Wilson & Dirks, 1974), an adaptive procedure (Dirks & Kamm, 1976) and a tracking Bekesy Procedure (Stephens & Anderson, 1976; Morgan, Wilson & Dirks, 1974; Woodford, 1976, (cited in Irving Shapiro, 1975).

Stephens & Anderson (1971) compared LDLs obtained with tracking procedure and manual ascending method of limits in normal subjects. The results indicated that LDLs were approximately 10 dB higher with tracing procedure than with manual ascending method of limits. For experimental subjects, the two methods resulted in essentially the same LDLs. The same results were obtained by Stephens (1970) & Pried & Coles (1971).

Morgan, Wilson & Dirks (1974) measured LDLs for a 1000 Hz tone using 3 methods (constant stimuli, tracking and adjustment) and found that constant stimuli and tracking methods gave equivalent results and did not change with repeated exposures. The method of adjustment yielded significantly lower LDLs and with increasing practice showed a training effect and higher LDLs.

Dirks & Kamm (1976) used adaptive procedures to determine psychometric functions of LDL for pure tones in the range of 500 - 2000 Hz and speech using normal and hearing impaired subjects. The results indicated that both groups demonstrated steeply rising functions with the 50% point at approximately 100 dB SPL. This study correlated with the earlier studies (Hood & Poole, 1966, cited in Morgan, Dirks & Wilson, 1974) which suggest that these adaptive procedures provide a reliable estimate of the SPL at which signals become uncomfortable for an individual.

Cox (1981) compared Bekesy and Hughson - Westlake procedures. On the average repeatability of LDL procedure, Bekesy procedure was poorer in the low frequencies than that of thresholds but on the repeatability of LDL procedure, Hughson-Westlake procedure was about the same as that of thresholds. A significant practice effect was observed with both LDL procedures.

Beattie & Sheffler (1981) compared mean LDLs for speech using method of adjustment and limits. The mean LDLs for the respective methods of adjustment and limits were 86.8 and 92.9 dB and they found significant interaction between the two methods based on the order in which the methods were carried out.

With such differences in results dependent on the methodology, more than a simple ascending or abbreviated ascending method of limits procedure is necessary. The use of more systematic approaches such as the method of constant stimuli, a tracking procedure, or an adaptive technique, appears justified. Morgan, Wilson & Dirks (1974) concluded that for research purposes the method of constant stimuli was a "reliable and practical" procedure.

3) LDL Stimuli :

The third major variable in LDL measurement is the type of stimulus that is employed.

Virtually all type of stimuli typically available in a clinical setting have been used to obtain loudness discomfort levels (Hawkins, 1980).

These have included pure tones, narrow bands of noise, speech in the form of continuous discourse, sentences, spondees, non-sense syllables, filtered speech and warble tones.

The most commonly used are "cold running speech" (Carhart, 1946; Silverman, 1947; cited in Hawkins (1980); Schmitz, 1969; Denneberg & Altshuler, 1976) and pure tones (Watson, 1944; Silverman, 1947; Hood & Poole, 1966; cited in Hawkins, 1980; Priede & Coles, 1971; Stephens & Anderson, 1971; Morgan & Dirks, 1974; Dirks & Kamm, 1976). Other stimuli have been narrow bands of noise (Wallenfels, 1967; cited in Hawkins, 1980; Morgan, Wilson, Dirks, 1974; Shapiro, 1975) and spondaic words (Dirks & Kamm, 1976; Alpiner, 1975 cited in Hawkins, 1975).

Measurement of subjective LDLs of tolerance limits for various acoustic stimuli have been utilized for many years as a means of identifying the upper tolerable limits of sound for normal hearing and hearing-impaired individuals.

In an early study of tolerable limits, Davis, et al 1946, (cited in Morgan, Wilson & Dirks, 1974) were among the first investigators to report a systematic study of the threshold of discomfort for pure tones and speech.

Although specific experimental methods were not described, these investigators reported that an initial median threshold of discomfort for listeners with normal hearing was 110 dB SPL for pure tones and 117 dB SPL for speech and hard-of-hearing subjects showed consistently higher tolerance levels than normal hearing subjects.

Silverman, 1947, (cited in Hawkins, 1980) compared LDLs for various stimuli and found that in the normal hearing persons the LDL for speech was approximately 10 dB higher than the average LDL of eight pure tone frequencies.

Hood & Poole, 1966, (cited in Morgan, Wilson & Dirks, 1974) used tonal bursts to find LDL in subjects with unilateral sensori-neural hearing loss. The results indicated mean LDLs for the normal ears of 98.0, 98.2, 98.9 and 95.0 dB SPL at the frequencies of 500, 1000, 2000 & 4000 Hz respectively. 90% of their subjects selected discomfort levels between 90 and 105 dB for all stimuli and the LDLs for pure tones in the hearing-impaired ears of the same subjects was "remarkably similar" despite the differences in pure tone thresholds.

Epstein & Schill (1968) determined tolerance thresholds for the selected pure tones (125, 1000 & 4000 Hz) by measuring the amplitude of the electrodermal response following exposure to a pure tone at increasing intensities (70-130 dB SPL). The results indicated an increase in the amplitude of the electrodermal response as intensity is increased, especially for stimuli above 110 dB SPL at 1000 and 4000 Hz and above 120 dB SPL at 125 Hz.

Woodford & Holmes, 1976., (cited in Irving Shapiro , 1979) compared LDLs for pure tones and wide band noise for normal listeners and subjects with sensori-neural hearing loss (mild to moderate). They found significant differences in LDL for pure tones between the two groups.

Dirks and Kamm (1976) determined the psychometric functions of LDL for pure tones (500 and 2000 Hz) and speech (spondaic words) using adaptive procedures in normal and hearing-impaired listeners. Both groups demonstrated steeply rising functions with the 50% point at approximately 100 dB SPL. The standard deviations for the stimuli ranged from 5.2 to 9.9 dB. Smaller standard deviations were observed for the 2000 Hz tone than for the speech and 500 Hz signals. Significant differences were not demonstrated for LDL across stimuli.

The SPLs of the LDLs at 50% ranged from 97.0 to 100.8 dB for the experimental stimuli. These results are in good agreement with the findings of several previous LDL investigations. (Stephens & Anderson, 1971; Morgan, Wilson & Dirks, 1974; Hood & Poole, 1966; (cited in Dirks & Kamm, 1976).

Morgan, Wilson & Dirks (1974) measured the LDL for pure tones at octave frequencies from 125, 250, 500, 1000, 2000, 3000, 4000 Hz and for a wide and narrow band of noise for normal subjects. Results indicated identical LDLs (range : 107.4 - 108.5 dB SPL) for the 1000, 2000 and 4000 Hz pure tones and for wide band noise. LDLs increased as frequency decreased below 1000 Hz i.e. 113.1 and 124.1 db SPL at 500 and 250 Hz respectively. At 125 Hz the LDL was 132.8 dB SPL. The noise bands produced LDLs at intensities of 107.4 (wide band) and 111.2 dB SPL (Narrow band). Analysis of variance revealed significant differences among the various stimuli employed except for the differences between 1000 and 2000 Hz and between 2000 and 4000 Hz.

Hawkins (1980) obtained LDLs on 19 normal hearing subjects with 18 different stimuli - five pure tones (250, 500, 1000, 2000 & 4000 Hz), five one-third octave bands of noise (with center frequency of 250, 500, 1000, 2000 & 4000 Hz), five one-third octave bands of filtered multitalker babbles (250, 500, 1000, 2000 Hz), wide band noise (100-6000 Hz), spondaic words and sentences. Results indicated the following:

(1) There was no significant differences among the three frequency specific stimuli. However, a significant frequency effect was found.

(2) LDLs for the two speech stimuli and wide band noise were not significantly different and were similar to values for signals in the 500 to 4000 Hz region.

(3) Small differences among the mean LDLs for pure tones, one-third octave bands of noise and filtered speech was found. Standard deviations for these stimuli were large (approximately 7-10 dB) with no apparent difference among stimulus types. Ritter, Johnson & Northern (1979) reported standard deviations of similar magnitudes for pure tones.

Cox (1981) measured LDLs at 500, 1000 and 2000 Hz for pulsed 1/3 octave bands of thermal noise and for 1/3 octave bands of continuous multitalker speech babble. The results revealed that the mean speech-band LDLs were 2-3 dB higher than the mean noise band LDLs. They made an additional analysis and concluded that the speech band LDL can be predicted from the noise-band LDL and the predicted LDL will be within 3-4 dB of the true LDL 68% of the rime. They concluded that an individuals LDL measured with a pulsed 1/3 octave band of noise calibrated in Root Mean Square (RMS) level would provide a fairly accurate or slightly conservative estimate of the same individuals LDL or a similarly calibrated 1/3 octave band of continuous speech babble.

Beattie & Boyd (1986) found the relationship between mean LDLs for speech and pure tones of 250, 500, 1000, 2000, 3000, 4000 & 6000 Hz and the pure tone LDL average of 500, 1000 & 2000 Hz in subjects with mild-moderate sensori-neural hearing loss. The results indicated statistically significant correlations between the speech LDL and pure tone LDLs for 500, 1000, 2000, 3000 Hz or the PTA. These findings were consistent with the spectral composition of speech (Dunn & White, 1940; Fletcher, 1953; Rudmose, Clark, Carlson, Eisenstein & Walker, 1948;cited in Beattic & Boyd, 1986), with loudness summation formula (SteVens, 1956,1 972; cited in Beattic & Boyd, 1986) and with previous research (Davis, et al. 1946, cited in Beattie & Boyd, 1986; Kamm, Dirks & Mickey, 1978; McLeod & Greenberg, 1979; Ritter, Johnson & Northern, 1979).

Statistically higher LDL was observed at 250 Hz than at 500 & 1000 Hz. Mean pure tone LDLs were higher than the speech LDL at

4000 Hz (5.7 dB) and 6000 Hz (12.1 dB). Statistically significant relationship between the speech LDL and pure tone LDL at 500 Hz, 1000 Hz and the PTA was found.

Bentler & Pavlovic (1989) found the relationship between threshold of discomfort (TD) estimates and the number of components in a complex signal. They obtained TD for 16 pure tones located at the center frequency of critical bands from 250 to 4000 Hz. Subsequently, TD were obtained for 2, 4, 8 and 16 tone complexes and summation of discomfort(s) was obtained for 15 normal and 15 hearing-impaired adults. Summation of discomfort(s) was defined as the difference between the TD for pure tone presented in isolation and within the complex. The results indicated that doubling the number of components from l to 2 decreases the threshold of discomfort by 5.5 dB for the normal hearing listeners and by 7.8 dB for the hearing-impaired listeners. Further doubling of the components (from 2 to 4, from 4 to 8 and from 8 to 16) decreases the threshold of discomfort by 3.5 dB for the normal hearing listeners and 3.9 db for the hearing-impaired listeners.

**4) Manner in which stimuli are delivered :**

The last Major variable that affects the LDL Measurement is how the stimulus is delivered to the car and how the delivery system is calibrated.

The most commonly used delivery methods are the: Standard audiometric earphones, Loud speaker. Both of these transducers can be calibrated according to various standards. Using earphone, the LDL can be obtained for pure tones, narrow bands of noise, white noise and speech. Through loudspeaker, the LDL can be obtained for narrow band noise, white noise, warble tones and speech.

Various investigators have recommended that for the purpose of determining the acceptable SSPL of a hearing aid, LDLs should be determined with pure tones under earphones (Berger, 1976; cited in Hawkins, 1980), with speech under earphones and in a sound field (Alpiner, 1975) or with only speech under earphones (Berger, 1971; cited in Hawkins, 1980). According to few studies a markedly different results will be obtained when LDLs are measured under earphones and loudspeaker conditions.

Stephens & Anderson (1971) measured uncomfortable loudness level (ULL) at 1000 Hz on groups of normal hearing subjects using various methods of stimulus presentation under both earphone and free-field presentations. In first experiment, the LDL was found monoaurally for 12 experimental subjects using a continuous Bekesy stimulus. In the free field condition, subject was facing the loudspeaker and the non-test ear was occluded with a disconnected sharp HA-10 circumaural earphone. Mean values of 98.8 dB SPL (SD 9.0 dB) and 99.1 db (SD 9.7 dB) were found for the ULL for earphone and free-field measurement respectively. The difference was not significant.

In second experiment, LDLs were obtained for both monoaural (right ear) and binaural under similar conditions in free field stimulus presentation. The mean value found in the binaural presentation was 97.5 dB SPL (SD 7.1 dB) and 100.0 dB (SD 7.2 dB) for the monoaural measurement.

In third experiment, the LDLs were obtained under binaural free- field versus binaural and monoaural earphone conditions.

The mean and median SPL values obtained in different conditions are, free-field binaural 89.1 and 89.7 dB SPL.

In earphone (binaural) 89.2 and 90.7 dB SPL and ear phone (monoaural), 93.0 and 94.7 dB SPL respectively.

In each case the standard deviation of the measures was 9 dB. The free field and earphone measures were same in this experiment.

Morgan, Wilson & Dirks (1974) studied LDLs for pure tones and wide band noise on normals under standard audiometric headphones. The LDLs measured were essentially identical (range : 107.4 - 108.5 dB SPL) for pure tones of 1000, 2000 & 4000 Hz and also for wide-band white noise. However, the LDL increased systematically as frequency decreased below 1 kHz. They proposed that such a difference across frequencies (frequency effect) resulted from the differences between the SPL measured in a standard coupler and that actually generated in the ear under a supra-aural headphone. Hence, they conducted experiments to determine if the frequency effect could be explained adequately on the basis of differences between conventional and real ear calibration methods and to extend LDL measurements to free-field conditions.

Determination of the SPL generated by a earphone and by a loudspeaker in the free field was accomplished with a probe tube at the entrance to the ear canal under earphone and free-field conditions and by conventional calibration methods. Psychophysical measurements of LDL were conducted under earphone and in free-field conditions. The corrections derived from differences between standard calibration procedures and probe tube measurements were applied to the LDL measurements.

The corrected data showed that the LDL is obtained at approximately equal SPLs across the frequency range tested. Furthermore, there was remarkable agreement between earphone and free field results. Thus they concluded that the differences in LDLs under earphone and in free field is the effect of calibration methods.

Ritter, Johnson & Northern (1979) compared the LDLs for various acoustic stimuli (pure tones, warble tones, spondaic words and speech spectrum noise) obtained under earphones and in the sound field for 3 groups of subjects.

The LDLs were obtained to higher sound pressure levels for all stimuli under earphone condition than in the LDLs decreased as the frequency of the warble tone increased from 250 Hz - 1000 Hz and then increased at 2000 Hz.

The LDLs for spondaic words closely approximated the average of the 500, 1000 & 2000 Hz warble tone LDLs under earphone and in sound field for all group of subjects. The LDLs of speech noise for all 3 groups were obtained at the lowest SPLs of any acoustic stimuli used • in the experimental condition. Also found that LDLs for all the stimuli obtained at higher level through headphones than the loudspeakers.

A review of literature reveals that whereas some researchers have found differences between LDLs measured in sound field and under headphones (Morgan, Wilson & Dirks, 1974; Ritter, Johnson & Northern, 1979), others have not (Stephens & Anderson, 1971). Though the researches have found differences between LDLs measured in sound field and under headphones there is no consensus among the reports. Hence, the present study has taken mode of stimulus delivery as an important procedural issue which must be taken into consideration when measuring LDLs.

# METHODOLOGY

The main aim of this study was to determine the relationship between loudness discomfort levels (LDLs) estimated with discrete stimuli [such as pure tone (PT), narrow band noise (NBN)] and white noise (WN) LDLs with speech LDL among a group of sensory neural hearing-impaired subjects. More specifically the following were undertaken:

1) Comparison of mean LDLs for speech and pure tones of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and pure tone LDL average of 500 Hz, 1000 Hz, 2000 Hz.
2) Comparision of mean LDLs for speech and narrow band noise centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz
3) Comparision of mean LDLs for speech and warble tones centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz
4) Comparision of mean LDLs for speech and white noise.

5) Comparision of mean LDLs for the discrete stimuli, white noise and for speech under headphone versus loudspeaker listening conditions.

SUBJECTS :

A total of 20 hearing-impaired subjects in the age range of 18-76 years, with a median age of 47 years took part in this study. Right ear of each subject was tested.

The criteria for subject selection were as follows:

The subjects should have had bilateral symmetrical moderate - moderately severely sensory neural hearing loss with flat configuration based on the following criteria.

Pure tone thresholds within 51-70 dB at octave intervals from 250 Hz through 8 kHz.

Not more than 5 dB difference between pure tone thresholds at adjacent octaves.

The subjects should not have had any evidence of external or middle ear problems.

This was confirmed with otoscopic examination and tympanometry based on the following criteria.

Clear external auditory meatus and tympanic membrane.

'A' type tympanogram

## INSTRUMENTATION

(1) A two channel clinical audiometer, MADSEN OB 822 with TDH-39 earphones housed in a circumaural cushions, MX-41 AR and loud speakers (MADSEN PA 5010 preamplifier were used for testing).

The Calibration of frequency and intensity for pure tones, narrow band noise and warble tones and calibration of intensity for white noise and speech was done to conform to ANSI 1989 specifications.

(2) An immittance audiometer was used to obtain tympanogram.

## TEST ENVIRONMENT

The data was collected in an acoustically treated, air conditioned, two room situation. The ambient noise levels measured were within permissible limits as recommended by .ANSI 1999, cited in Wilber, 1994.

**PROCEDURE**

Initially, the subjects were tested on a routine pure tone audiometry and impedance audiometry. Only those subjects who met the criteria of moderate-moderately severe sensori-neural hearing loss and 'A' type tympanogram underwent further evaluation for LDLs.

**ESTIMATION OF LDLs**

***STIMULI***: The stimuli used to determine the LDLs were,

1) Pure tones at octave intervals from 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
2) Warble tones centred at octave intervals from 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
3) Narrow band noise centered at octave intervals from 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
4) White noise, and
5) Speech

The speech stimuli consisted of question related to the patients level of comfort/discomfort.

These included questions such as,

1. Can you tolerate this loudness?
2. Is it too loud?
3. Does the sound hurt you?

## INSTRUCTIONS

"I am going to present stimuli, it may be tones, noise or speech. The intensity of the stimuli will become louder gradually, the moment you find it uncomfortably loud, you have to give a verbal indication.

## METHOD

LDLs were obtained for each subject, for each of the stimuli listed above. Narrow band noise, white noise and speech were routed through headphones and as well as loudspeakers to obtain LDLs under the two output transducer conditions. Whereas, warble tones were directed to loudspeakers and pure tones were directed to earphones for determining the LDLs. The speech stimuli was presented in a monitored live voice condition.

The subjects were seated in a calibrated spot in the test environment at a distance of 1 meter from the loudspeaker at 135° azimuth.

The method used to obtain LDLs was a simple up-down method.

The stimuli, initially were presented at the subjects most comfortable listening level and then increased in 5 dB steps until the subjects indicated that the stimuli was uncomfortably loud.

This was taken as the LDL. The subjects were instructed to respond during the 5-sec silent interval following each stimulus presentation.

A second measurement trial was obtained by starring at 5-10 dB above the LDL obtained on the first trial. Different starting levels were used to minimize starting level bias and to encourage subjects to search thoroughly around their mean LDL before making a final decision.

## STATISTICAL ANALYSIS

The data obtained was subjected to statistical analysis. The mean and Standard Deviation (SD) of the LDLs obtained for the various stimuli and the different transducer conditions were determined. Further the paired t-test of significance was calculated to determine whether any significant differences emerge between LDLs obtained for discrete stimuli versus speech and LDLs obtained under earphone versus loudspeakers for the various stimuli considered.

# RESULTS AND DISCUSSION

The aim of the study was to determine the relationship between LDLs estimated with discrete stimuli (such as PTs, NBN, WTs, WN)LDLs with speech LDL with stimulus presentation through headphones and loudspeakers among a group of sensori-neural hearing -impaired subjects.

In order to fulfill the aim, data was obtained from 20 sensori-neural impaired ears which met the other selection criteria as well.

The obtained data was then subjected to statistical analysis using the statistical package SPSS, version 10.0.

The means and standard deviations of LDL for various stimuli under two transducer conditions were obtained and tabulated.

In order to determine the relationship between discrete stimuli LDL, white noise and speech LDL under headphone and free-field condition the following comparisons were made.

1. Mean LDLs for speech versus those of PT LDLs centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and PT LDL average at 500 Hz, 1000 Hz and 2000 Hz.
2. Mean LDLs for speech versus those of NBN LDLs centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
3. Mean LDLs for speech versus those of WT LDLs centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
4. Mean LDLs for speech versus those of WN LDL.
5. Mean LDLs for the discrete stimuli, white noise and for speech under earphone versus loudspeaker conditions.

An independent, 2 tailed t-test was used in order to determine if any significant difference emerges for the above mentioned comparisions.

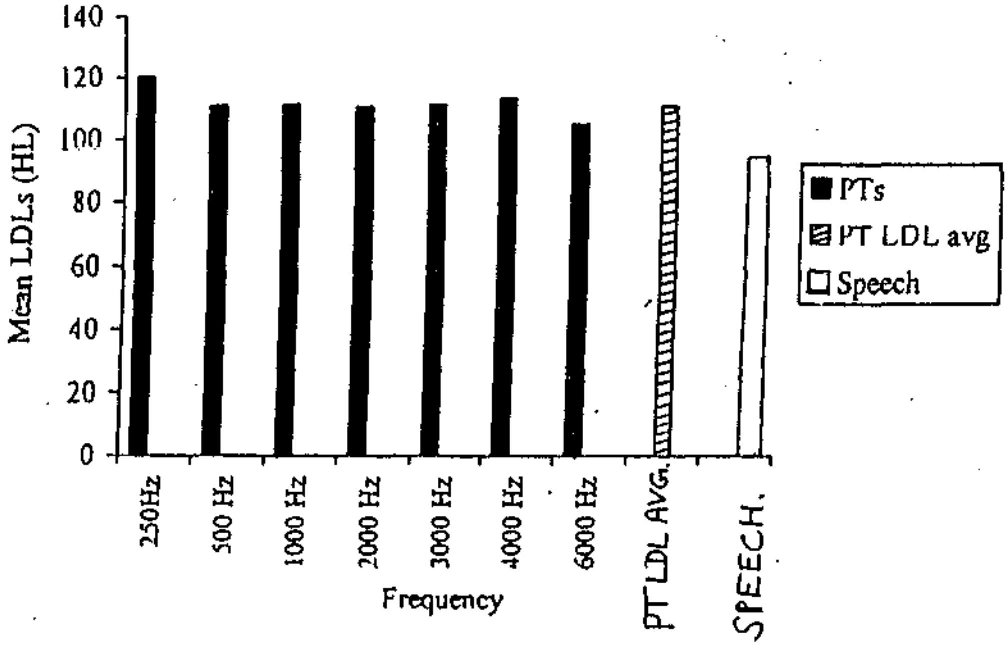
1. The means, SDs and t-values of LDLs for speech versus those of PT LDLs centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and pure tone LDL average at 500 Hz, 1000 Hz, 2000 Hz obtained under headphones are tabulated in Table - 1. The same is displayed in Graph 1.

Table-1 : Means, SDs and t-values of LDLs for speech and pure tones of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and PT LDL averages of 500 Hz, 1000 Hz and 2000 Hz.

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| 250 Hz | 102.25 | 4/72 | 8.008** |
| Speech | 93.25 | 4.67 | |
| 500 Hz | 110.75 | 5.91 | 10.92** |
| Speech | 93.25 | 4.67 | |
| 1000 Hz | 111.25 | 5,82 | 12.65** |
| Speech | 93.25 | 4.67 | |
| 2000 Hz | 110.50 | 6.05 | 9.62** |
| Speech | 93.25 | 4.67 | |
| 3000 Hz | 111.25 | 5.59 | 10.26** |
| Speech | 93.25 | 4.67 | |
| 4000 Hz | 113.00 | 4.10 | 13.84** |
| Speech | 93.25 | 4.67 | |
| 6000 Hz | 104.75 | 1.12 | 11.14** |
| Speech | 93.25 | 4.67 | |
| PT LDL average (500, 1000 and 2000 Hz) | 110.80 | 5.0 | 12.10** |
| Speech | 93.25 | 4.66 | |

**p<0.01

Grnph-1: Mean LDL for speech and pure tone centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and pure tone LDL average nt 500 Hz, 1000 Hz, 2000 Hz




The mean, speech LDLs were found to be significantly different from the mean PT LDLs nt frequencies from 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and also from mean pure tone LDL averages of 500Hz, 1000 Hz and 2000 Hz.

The mean speech LDLs were found to be obtained at lower levels than mean PT LDLs at various frequencies and also mean PT LDL averages at 500 Hz, 1000 Hz and 2000 Hz and the difference was found to be statistically significant at 0.01 level.

According to Beattie and Boyd (1986) there was no statistically significant difference between LDLs for speech, 500 Hz, 1000 Hz, 2000 Hz, and 3000 Hz. Whereas significant difference was obtained at 4000 Hz and 6000 Hz. The reason given for higher LDLs at 4000 Hz and 6000 Hz probably reflects the greater loss of puretone sensitivity at these frequencies. Same authors have also found statistically significant relationship between speech LDL and PT LDLs at 500 Hz, 1000 Hz and the PTA which is in accordance with the present study.

Dirks and Kamm (1976) found small differences between PT and speech LDLs because of the flattening of equal loudness contours and the diminished effect of stimulus bandwidth at high intensities.

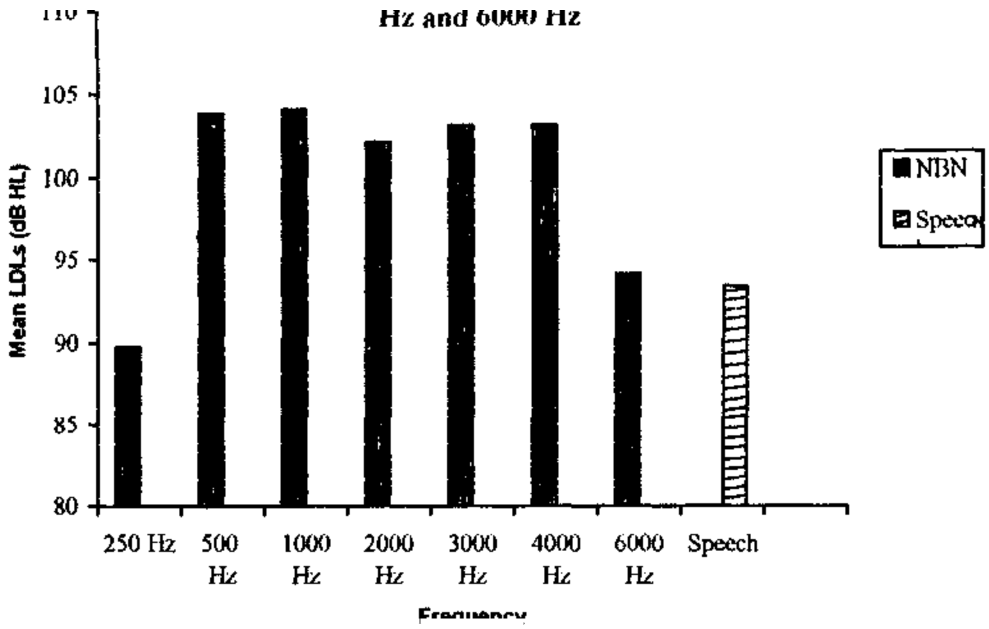
2. The means, SDS and t-values of LDLs for speech and NBN centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz obtained under headphones are tabulated in Table-2. The same is displayed in Graph 2.

Table-2 : Means, SDs and t-values of LDLs for speech and narrow band noise centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz through headphones

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| 250 Hz | 89.75 | 1.12 | 4.27** |
| Speech | 93.25 | 4.67 | |
| 500 Hz | 103.75 | 2.22 | 10.29** |
| Speech | 93.25 | 4.67 | |
| 1000 Hz | 104.0 | 5.28 | 8.83** |
| Speech | 93.25 | 4.67 | |
| 2000 Hz | 102.0 | 4.10 | 5.87** |
| Speech | 93.25 | 4.67 | |
| 3000 Hz | 103.25 | 4.67 | 5.41** |
| Speech | 93.25 | 4.67 | |
| 4000 Hz | 103.75 | 4.55 | 5.80** |
| Speech | 93.25 | 4.67 | |
| 6000 Hz | 94.0 | 2.05 | 0.77 NS |
| Speech | 93.25 | 4.67 | |

NS = Not significant; ** $p<0.01$

Graph-2 The mean LDLs for speech & narrow band noise centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz




There was a significant difference between the mean LDLs for speech and NBN centered at all the frequencies other than 6kHz.

The mean LDLs for speech were found to be obtained at lower level than the mean LDLs for NBN at various frequencies and the difference was statistically significant at 0.01 level. However, it was not significant at 6000 Hz.

Hawkins (1980) found small differences among normal hearing subjects for the speech stimuli and NBN and SDs were found to be larger with no apparent difference among stimulus types.

Cox (1981) found that the mean speech-band LDLs were 2-3 dB higher than the mean noise band LDLs (500 Hz, 1000 Hz, 2000 Hz).

The possible reason for getting different results could be attributed to calibration with reference to their root mean square levels or the instructions which also plays a role in LDL value.

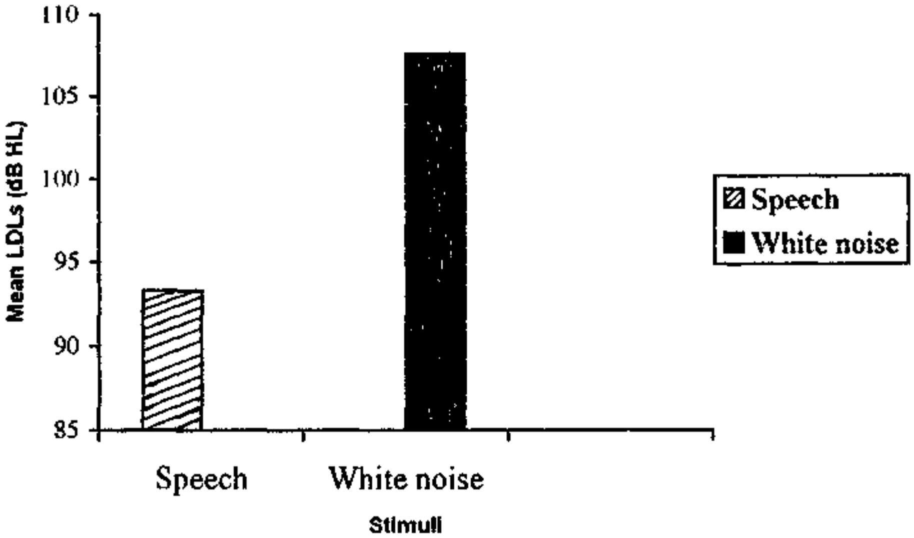
3. The means, SDS and t-values of LDLs for speech and WN obtained under headphones are tabulated in Table-3. The same is displayed in Graph 3.

Table-3 : Mean, SDs and t-values of LDLs for speech and white noise through headphones

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| White noise | 107.50 | 180 | 11.21** |
| Speech | 93.25 | 4.67 | |

** $p<0.001$

Graph-3;Mean LDLs for speech
and white noise through headphones




There was significant difference between mean LDLs for speech and WN.

The mean LDLs for speech was obtained at lower levels than for white noise LDLs and it was found to be statistically significant at 0.01 level.

Woodford and Holmes, 1976, (cited in Irving Shapiro, 1979) have reported the similar results for normal and sensori-neural hearing-impaired persons.

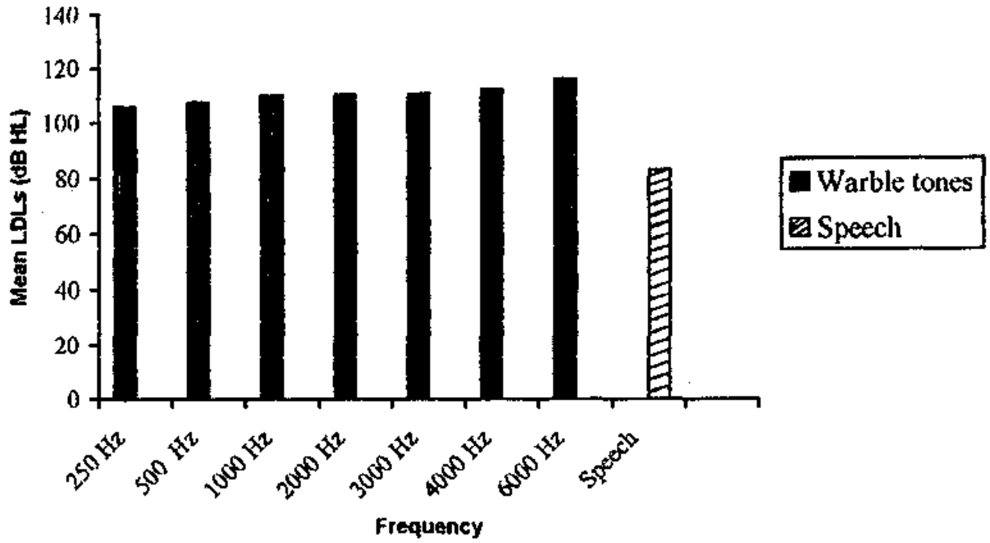
4. The means, SDs and t-values of LDLs for speech and WTs centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz under loudspeaker are tabulated in Table-4. The same is displayed in Graph 4.

Table-4 : Means, SDs and t-values of LDLs for speech and warble tones(250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hzjthrough loudspeaker

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| 250 Hz | 105.75 | 9.07 | 9.75** |
| Speech | 82.25 | 9.10 | |
| 500 Hz | 107.75 | 7.69 | 11.42** |
| Speech | 82.25 | 9.10 | |
| 1000 Hz | 109.5 | 7.76 | 11.39** |
| Speech | 82.25 | 9.10 | |
| 2000 Hz | 109.75 | 7.86 | 12.72** |
| Speech | 82.25 | 9.10 | |
| 3000 Hz | 110.0 | 8.27 | 11.88** |
| Speech | 82.95 | 9.10 | |
| 4000 Hz | 111.5 | 9.04 | 14.19** |
| Speech | 82.25 | 9.10 | |
| 6000 Hz | 115.0 | 7.59 | 13.48** |
| Speech | 82.25 | 9.10 | |

** $p<0.01$

Graph-4 Mean LDLs for speech & warble tones (WTs)
centrered 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz,
**4000 Hz and 6000 Hz**




There was a significant difference between mean LDLs for speech and WTs at various frequencies.

The mean speech LDLs were obtained at lower levels than mean WT LDLs at various frequencies and it was found to be statistically significant at 0.01 level.

Ritter, Johnson and Northern (1979) found that for normal hearing subjects, the mean SPL of the WT LDLs decrease with increase in frequency from 250 Hz to 2000 Hz. For hearing-impaired subjects, the SPLs of the LDLs decreased as the frequency of the WT increased from 250 Hz to 1000 Hz and also significant difference was found between WT LDLs (250 Hz, 500 Hz, 1000 Hz, 2000 Hz) and speech LDLs and the LDLs for speech was obtained at lower level which supports the present study.

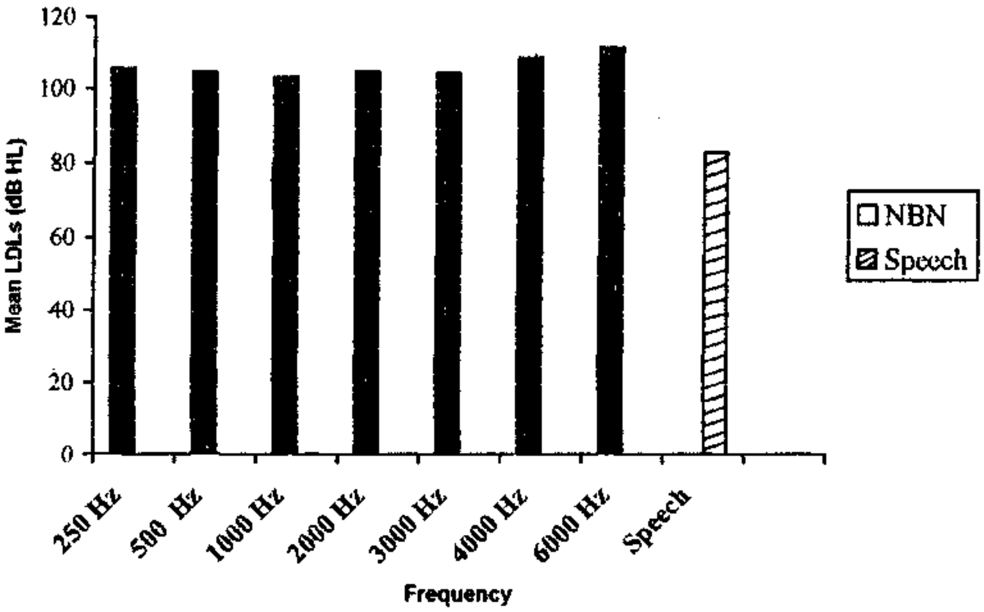
5. The means, SDs and t-values of LDLs for speech and NBN under loudspeaker are tabulated in Table-5. The same is displayed in Graph 5.

Table-5 : Means, SDs and t-values of LDLs for speech and narrow band noise of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz through loudspeaker

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| 250 Hz | 82.25 | 9.10 | 8.54** |
| Speech | 105.50 | 9.44 | |
| 500 Hz | 82.25 | 9.10 | 9.30** |
| Speech | 104.50 | 9.16 | |
| 1000 Hz | 82.25 | 9.10 | 8.62** |
| Speech | 102.75 | 8.65 | |
| 2000 Hz | 82.25 | 9.10 | 10.15** |
| Speech | 104.50 | 7.41 | |
| 3000 Hz | 82.25 | 9.10 | 8.72** |
| Speech | 104.00 | 7.88 | |
| 4000 Hz | 82.25 | 9.10 | 9.88** |
| Speech | 108.25 | 8.77 | |
| 6000 Hz | 82.25 | 9.10 | 11.32** |
| Speech | 110.75 | 7.30 | |

** $p<0.01$

Graph-5 Mean,LDLs for speech & narrow band noise (NBN) centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz




There is a significant difference between the mean LDLs for speech and NBN through loudspeaker.

The mean LDLs for speech was found to be obtained at lower levels than mean LDLs for NBN and it was found to be statistically significant at 0.01 level.

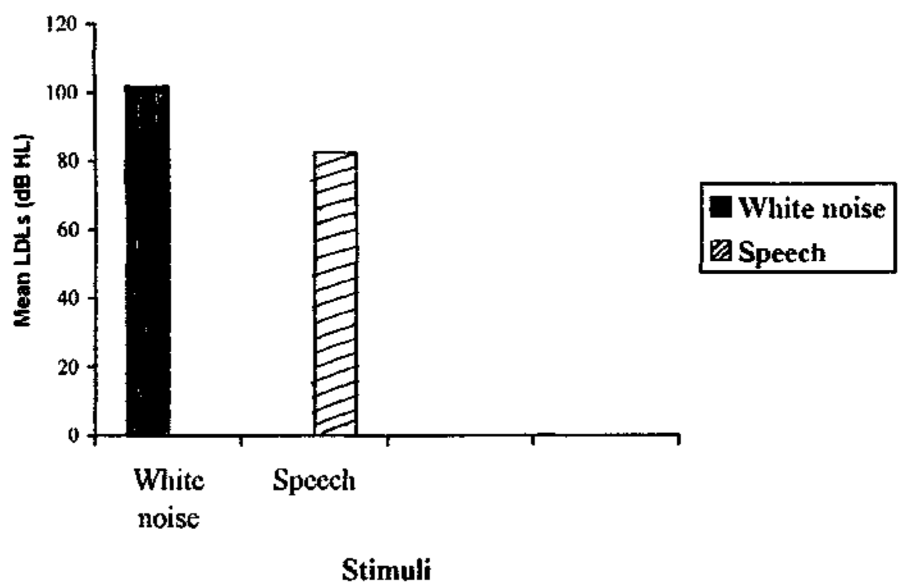
6. The means, SDS and t-values of LDLs for speech and WN obtained under loudspeaker are tabulated in Table-6. The same is displayed in Graph 6.

Tablc-6 : Means, SDs and t-valucs of LDLs for speech and white noise through loudspeaker.

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| Speech | 82.25 | 9.10 | 12.67** |
| White noise | 102.0 | 6.57 | |

** p<0.01

Graph-6 Mean, LDLs for speech & white noise through loudspeaker



The mean speech LDLs were found to be significantly different from mean WN LDLs.

The mean speech LDLs were obtained at lower levels than mean WN LDLs and it was found to be statistically significant at 0.01 level.

There is scarcity of literature regarding the above two mentioned variables.

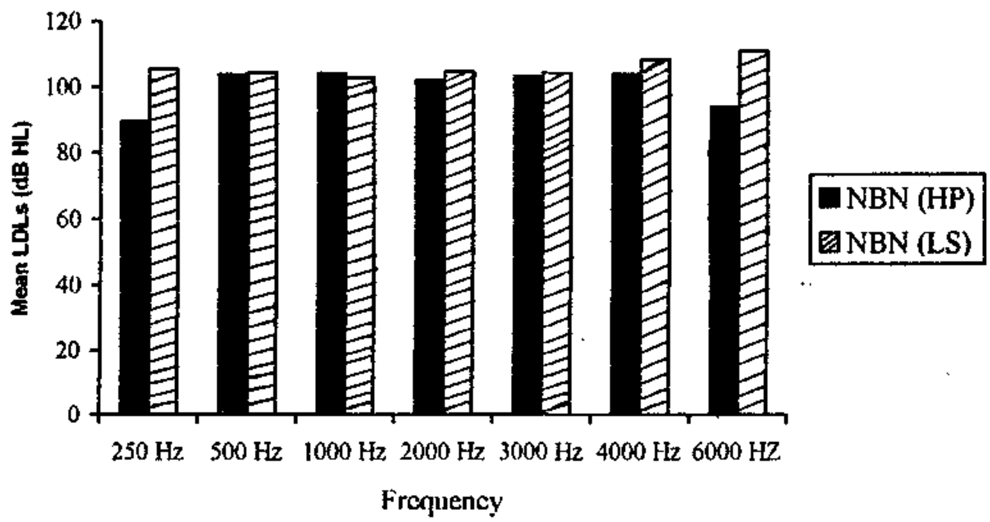
7. The mean, SDs and t-values of LDLs for the NBN obtained under headphone and loudspeaker conditions are tabulated in Table-7. The same is displayed in Graph 7.

Table - 7 : Means, SDs and t-values of LDLs for narrow band noise centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz through headphones (HP) and loudspeakers (LS)

| **Stimuli** | Mean | SD | **t-value** |
|---|---|---|---|
| 250 Hz (HP) | 89.75 | 1.12 | 7.64** |
| 250 Hz (LS) | 105.50 | 9.45 | |
| 500 Hz (HP) | 103.75 | 2.22 | 0.42 NS |
| 500 HZ (LS) | 104.50 | 9.16 | |
| 1000 Hz (HP) | 104.00 | 5.28 | 0.74 NS |
| 1000 Hz(LS) | 102.75 | 8.67 | |
| 2000 Hz (HP) | 102.00 | 4.10 | 1.88 NS |
| 2000 Hz (LS) | 104.50 | 7.41 | |
| 3000 Hz (HP) | 103.25 | 4.67 | 5.29** |
| 3000 Hz (LS) | 104.00 | 7.88 | |
| 4000 Hz (HP) | 103.75 | 4.55 | 2.71 NS |
| 4000 Hz (LS) | 108.25 | 8.78 | |
| 6000 Hz (HP) | 94.0 | 2.05 | 9.57** |
| 6000 HZ (LS) | 110.75 | 7.30 | |

NS = Not significant ; ** $p<0.01$

Graph-7 Mean LDLs for narrow band noise (250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz) obtained under headphone and loudspeaker conditions




There was a significant difference for NBN LDL at 250 Hz and 6000 Hz under the two conditions, whereas there was no significant difference at other frequencies.

The mean LDLs of NBN obtained under free-field condition was found to be obtained at higher level at 250 Hz and 6000 Hz than under headphone conditions and it was statistically significant at 0.01 level.

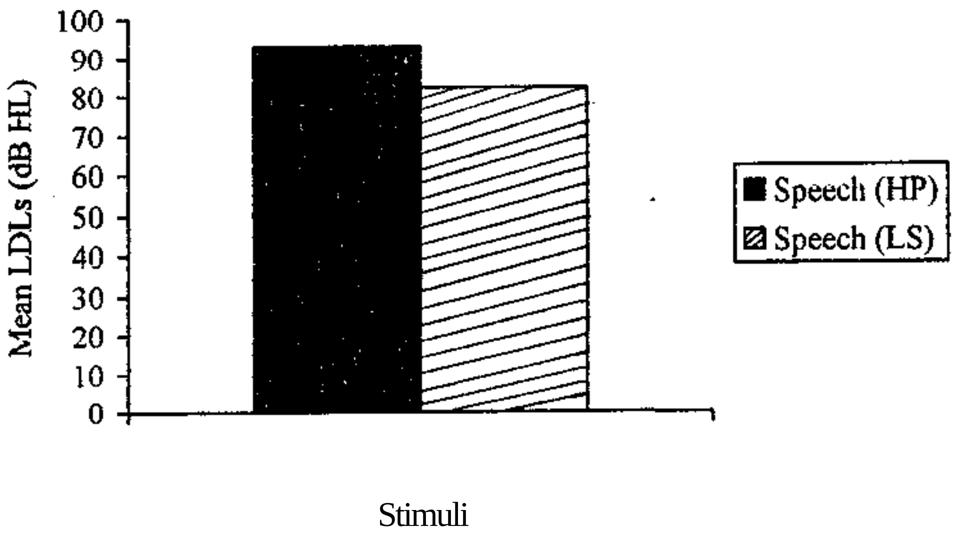
8. The means, SDs and t-values of LDLs for speech obtained under headphone and loudspeaker conditions are tabulated in Table-8. The same is displayed in Graph 8.

Table-8 : Means, SDs and t-values of LDLs for speech through headphones and loudspeakers

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| Speech (LS)) | 82.25 | 9.10 | 6.68** |
| Speech (HP) | 93.25 | 4.67 | |

** $p<0.01$

Graph 8: Mean LDLs for speech through headphone versus loudspeaker condition



There was a significant difference for speech LDLs obtained under both the two conditions.

The mean LDLs of speech under headphone was obtained at higher level than under loudspeaker condition and it was statistically significant at 0.01 level.

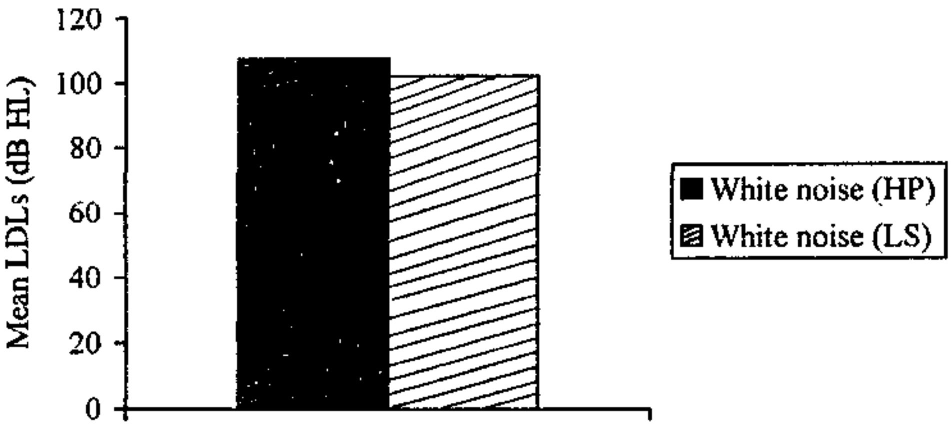
9. The means, SDs and t-values of LDLs for white noise under headphone and loudspeaker conditions are tabulated in Table-9. The same is displayed in Graph 9.

Table-9 : Means, SDs and t-values of LDLs for white noise through headphones and loudspeakers

| Stimuli | Mean | SD | t-value |
|---|---|---|---|
| White noise (LS) | 102.00 | 6.56 | 4.819** |
| White noise (HP) | 107.5 | 3.80 | |

**.p<0.01

Graph 9: Mean LDLs for white noise (WN) through headphone versus loudspeaker condition




Stimuli

There was a significant difference between the mean LDLs for white noise under both the conditions at 0.01 level.

The mean LDLs for white noise through headphone was obtained at higher level than through loudspeaker.

Stephenson and Anderson (1971) found the similar results in both the conditions, whereas Morgan, Wilson and Dirks (1974) found the difference in LDLs under both the conditions and this difference was attributed to the effect of calibration methods.

Ritter, Johnson and Northern (1979) found that mean LDLs for all the stimuli obtained at higher level through headphones than with loudspeakers which supports the present study.

Hence from the results of the present study, it can be concluded that, LDLs for speech can be obtained at lower level *in* comparision to other acoustic stimuli (PT, WT, NBN, WN) in both the conditions. Lower LDLs can be established through loudspeaker for speech and white noise, whereas inconsistent results was seen for NBN LDLs.

# SUMMARY AND CONCLUSION

A number of investigations have been undertaken in the past to study the relationship between various acoustic stimuli available in the measurement of LDL. However, the relationship between LDLs for these stimuli has not been studied systematically.

A number of other studies have also been conducted to study whether there is any significant difference between mode of presentation (Headphone versus loudspeaker) for LDL measurement. But the results are very inconsistent.

Some authors (Berger, 1980, cited in Beattie and Boyd, 1986 and Hawkins, 1980) comment that PTs and NBN are frequency specific and thus enable greater precision than speech in SSPL selection.

PT LDLs can be compared to the manufacturer's SSPL90 curve (ANSI, 1982, cited in Beattie and Boyd, 1986).

**Present study aimed to investigate the relationship between** :

1. Mean LDLs for speech versus those of PT LDLs centered at, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz and PT LDL average at 500 Hz, 1000 Hz and 2000 Hz.
2. Mean LDLs for speech versus those of NBN LDLs centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
3. Mean LDLs for speech versus those of WT LDLs centered at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz and 6000 Hz.
4. Mean LDLs for speech versus those of WN LDL.
5. Mean LDLs for the discrete stimuli, WN and for speech under earphone versus loudspeaker conditions.

Twenty hearing-impaired subjects in the age range; 18-75 years participated in the study. The subjects had bilateral symmetrical moderate-moderately severe sensori-neural hearing loss with flat configuration. Ears with external or middle ear problems, giddiness, ototoxicity, noise exposure etc. were excluded from the study. Testing was done using two channel clinical audiometer MADSEN OB 822 with TDH-39, MX-41AR earphones and loudspeakers (Madsen).

**Results revealed the following :**

1. The mean speech LDLs were found to be significantly different from the mean PT LDL at frequencies from 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 6000 Hz and mean pure tone LDL average at 500 Hz, 1000 Hz and 2000 Hz.
2. There was a significant difference between mean LDLs for speech and NBN centered at all frequencies other than 6 kHz through headphones.
3. There was a significant difference between mean LDLs for speech and white noise in both the conditions.
4. The mean speech LDLs were found to be obtained at lower levels than mean WT LDLs at various frequencies and it was statistically significant.
5. The mean LDLs for speech was found to be obtained at lower levels than mean LDLs for NBN through loudspeaker and it was statistically significant.

6. The mean speech LDLs were obtained at lower levels than mean WN LDLs through loudspeakers and it was statistically significant.
7. The mean LDLs of NBN under free-field condition was obtained at higher level at 250 Hz and 6000 Hz than under headphone condition and it was statistically significant whereas there was no significant difference at other frequencies.
8. The mean LDLs for speech and white noise under headphone was obtained at higher level than under loudspeaker condition and it was statistically significant.

In comparision with other acoustic stimuli, the LDLs for speech were obtained at lower level in both the conditions.

Some authors (Briskye, 1980; Carhart, 1946; Davis, et al. 1946; cited in Beattie and Boyd, 1986) maintain that speech is more realistic than pure tones, which rarely occur in everyday listening and usually are not meaningful. Moreover the LDL for speech has high face validity and it can be obtained in less time than is required to measure LDLs at several PT, NBN and WT frequencies.

Testing under earphone is advantageous because it enables all subjects to be tested with a constant frequency response and allows stimulus calibration with a standard 6cc coupler.

Testing under loudspeaker is advantageous because it is useful for establishing LDLs and even for comparison of aided and unaided conditions.

From the results of the present study, it can be concluded that, speech is the appropriate stimuli to obtain LDL at lower level.

When speech is presented through loudspeaker, lower LDLs can be obtained compared to other stimuli and through other transducer (Headphone).

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