A FEASIBLE WAY TO PRESCRIBE HEARING AIDS FOR THE MILD TO MODERATE HEARING IMPAIRED

Reg. NO.M9711

Independent Project submitted as part fulfilment for the first year M.Sc, (Speech and Hearing), Mysore.

All India Institute of Speech and Hearing

Mysore 570006

1998

Dedicated

to

my Mummy, Papa

Bhaiya

&

Sis

CERTIFICATE

This is to certify that this Independent Project entitled *A FEASIBLE* ***WAY TO PRESCRIBE HEARING AIDS FOR THE MILD TO MODERATE HEARING IMPAIRED*** *is the* bonafide work in part fulfilment for the degree of Master of Science (Speech and Hearing) of the student with Register No.M9711

Dr.(Miss)S.Nikam

Mysore
May, 1998

Director
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CERTIFICATE

This is to certify that this Independent Project entitled A FEASIBLE WAY TO PRESCRIBE HEARING AIDS FOR THE MILD TO MODERATE HEARING IMPAIRED has been prpared under my supervision and guidance.

Mysore

May, 1998

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DECLARATION

This Independent Project entitled A FEASIBLE WAY TO PRESCRIBE HEARING AIDS FOR THE MILD TO MODERATE HEARING IMPAIRED is the result of my own study under the guidance of Dr. Asha Yathiraj, Reader inAudiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earner at any University for any other diploma or degree.

Mysore

May, 1998 ***Reg. NO.M9711***

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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 child deaf from birth is quite different from that of the 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'" (Stevenson, 1977).

Hearing handicap refers to the interference in hearing that results from the hearing loss. Thus, the influence of the hearing-impairment is the hearing handicap.

Demographics

There are several studies that have been conducted both in Western countries as well as in India which indicate that the incidence of hearing increases as a function of age (Metropolitan Life Insurance Company, 1976; ASHA, 1984; Indrani, 1981; Manimegalai, 1983). In all these studies, the degree of hearing loss in the adult population invariably ranges from mild to moderate.

Impact of Hearing Loss

Despite the high number of people who have acquired hearing losses during adulthood, relatively little research has examined the impact of communication difficulties on the functioning and quality of life and the coping skills used by these individuals to cope with their loss (Rutman, 1989). The impact of a hearing loss that has its onset during adulthood, depends on several factors. These include the age of onset (i.e. prevocational or post vocational) nature, degree, and configuration of hearing loss, lifestyle and occupation of the person, and perceived handicap (Health and Welfare Canada, 1988).

For an elderly individual, a hearing problem may not only signify a loss of one of their senses, but may also symbolise many concerns about aging and thus represent a very complex emotional issue.

Schlesinger and Meadow (1972), derived a psychological profile of adults with hearing loss. They noted that the adult hearing-impaired individuals tend to-

1. Be immature
2. Withdraw, especially from communication situations.
3. Be less flexible than a normal hearing adult.
4. Adhere rigidly to a set routine.
5. Demonstrate a negative self-image; this is due in part to a general lack of information concerning the nature of hearing-impairment.
6. Have a narrow range of interests.
7. Show a lack of social judgement.
8. Exhibit a lack of regard for the feeling of others.
9. Be more naive than the normal hearing adult.
10. Be more dependent than the hearing adult.
11. Be irresponsible
12. Be impulsive
13. Be possessive and over accepting, especially if the loss has occurred early.
14. Be depressed, but in cases where the hearing-impairment occurred later in life.

Rehabilitative intervention should, therefore, provide emotional support and information as well as audiological assistance.

According to Goodman and Chasin (1973) individuals with mild hearing loss have difficulty with faint speech especially from a distance and those with moderate hearing loss have more frequent difficulty with hearing normal speech.

Individuals with mild degree of loss are recommended amplification based on reported degree of difficulty and frequent to full time hearing aid use is recommended for the individuals with moderate degree of hearing loss.

Aural Rehabilitation

The aim of aural rehabilitative efforts is to overcome the 'handicap'. Aural rehabilitation is anattempt to reduce the barriers to communication that result from hearing-impairment and facilitate adjustment to the possible psychosocial, educational and occupational impact of the auditory deficit.

Assessment of the individual's threshold levels for hearing, per se, and determination of his/her ability to hear and understand speech, are the first important steps in the aural rehabilitation process.

Following this, the initiation of a hearing aid evaluation, if deemed necessary, and the other steps involved in the total aural rehabilitation program can begin.

Assessment of hearing for pure tones provides valuable information regarding sensitivity, but only limited information concerning receptive auditory communication ability. Moreover, investigations of pure tone sensitivity and speech understanding have shown no clear cut relationship between these two measures. There appears to be no satisfactory means of accurately predicting speech understanding ability from pure tone results (Solomon et al. 1960; Young and Gibbons, 1962; Elliot, 1963; Harris, 1965; Marshall and Bacon, 1981).

Speech tests are essential to the evaluation of the adults as they offer the clinician a means of assessing receptive communication function in a quasisystematic manner, using material and procedure that vary in complexity (Olsen and Matkin, 1984).

Specifically, speech tests yield objective, easily quantifiable information about (a) acoustic confusions deriving from the hearing loss (b) recognition ability in selected listening situations, and (c) the ability to recognise selected materials including monosyllabic words and sentences. Theoretically, the latter information provides the client's function in everyday listening situations. In addition to information about communication efficiency, speech tests provide differential diagnostic information relating to site of lesion and assist in decisions regarding hearing aid candidacy and selection of personal hearing aids. Finally, data on speech understanding are used to determine the extent to which the aging process, changes in the central nervous system, changes in the auditory periphery or cognitive factors account for deficits in speech understanding which many older people exhibit.

Speech discrimination testing in some form is an integral part of most hearing aid selection procedures (Burney, 1972). This has been the case following Carhart's (1946) description of an evaluation procedure comparing speech understanding with different hearing aids in quiet and noise. Still, there is far from complete agreement on what method is most efficient or which procedure discriminates best among hearing aids. However, it is clear that a patient's speech performance is one of the critical factors in determining which ear to fit and the prognosis for successful use of amplification.

Meagre information is available regarding the communicative problems and the rehabilitative measures (especially in adverse listening conditions) for an individual with mild to moderate hearing loss. Hence, most of the times the clinician is not able to provide services as to the consumers* satisfaction.

The present study was taken up with an intention of developing a test protocol for evaluation and habilitation of individuals with mild to moderate sensori-neural hearing loss. The aim of the study is to develop a test which would tap the conditions in which they have communication difficulties. This test could also be used to select an appropriate amplification device for them.

Around 12% of the general population and 43% of the population with hearing loss suffer from a mild to moderate degree of hearing loss (ASHA, 1984; Metropolitan Life Insurance Company, 1976). Indrani (1981) and Manimegalai (1983) found the incidence to be similar in the Indian population also. The population mainly constitutes of individuals above 50 years of age. Hence, it is evident that there is a large population with mild to moderate loss requiring adequate rehabilitation.

Hearing aids are prescribed for the mild to moderate hearing-impaired usually using more of objective tests like insertion gain measurements (Barlow, et al. 1988; Seewald, et al. 1985; Hawkins, 1990b; Punch et al. 1990) and articulation indices. Rarely are functional tests used.

Hence, the functional tests used do not always tap their difficulties. The test results indicate that these individuals don't require any form of rehabilitation. However, they do face a lot of communication problem.

There is hardly any research done to develop a functional test that can be utilised to prescribe hearing aids for these individuals with mild to moderate degree of hearing loss. Thus, this study is warranted in order to evaluate the deficits faced by these individuals in social environments; and if deemed necessary the test can also provide an appropriate amplification device.

REVIEW OF LITERATURE

Hearing loss is used to indicate the type of problem (e.g. conductive vs. sensori-neural) or that the hearing ability has been lost (Davis and Silverman, 1970).

Hearing-impairment is closely related with hearing level and terms are sometimes used interchangeably (Hearing level is a measurement made on an audiometer and reported in decibels, ANSI, 1991). Hearing-impairment implies that performance is poorer than normal. It is generally categorised as mild, moderate, or severe. Hearing handicap refers to the interference in hearing that results from the hearing loss. Thus, the influence of the hearing-impairment is the hearing handicap.

Hearing loss has acquired two distinct meanings (Davis and Silverman, 1960)-

1. The symptom or condition of impaired hearing, particularly impairment of the sensitivity of hearing.

2. The ratio, expressed in decibels, of the threshold of hearing of an ear at a specified frequency to a standard audiometric threshold for this the term *"Hearing Level* is employed.

Sensori-neural hearing loss is the loss of sensitivity characterised by equal loses of threshold by air and bone conduction testing. Such losses usually involve the peripheral sensory and neural mechanism.

Sensorineural hearing loss is characterised by elevated pure tone thresholds and reduced speech recognition, particularly in noisy environments (Davis and Silverman, 1960).

The signs and symptoms of sensori-neural hearing loss include - elevated thresholds, abnormally rapid loudness growth, subjective tinnitus, poor speech discrimination, and a reduction in temporal summation of acoustic energy. One important affect associated with sensorineural hearing loss is the broadening of the cochlear filter mechanism which may influence loudness growth and perception of complex sounds. Low frequency components pose the most serious problems when there is a significant loss of tuning; excitation will now readily spread toward the high frequency. A conventional hearing aid cannot restore normal frequency selectivity; however, one way in which the spread of excitation might be minimised in a hearing aid is to limit the maximum output of low frequency sounds (by band pass filters) (Jalvi et al. 1983).

DEMOGRAPHICS

The metropolitan Life Insurance Company (1976) reported the incidence of hearing loss to be 71% across all ages in the United States of America. Fig.I shows the median threshold levels for men and women as a function of age. Persons under the age of 17 experienced an incidence rate of 1.3% while persons from the age range of 45-64 years experienced an incidence of 11.4%. In the decade from 65-74 years, the incidence rate for hearing loss rose to 23.1%, and for those individuals beyond the age of 75 years, it was 39.9%. The no.of hearing-impaired individuals increases markedly with age.

The findings of the ASHA (1984) report is in concurrence with the above study. ASHA reported in 1984 that there was a significant increase in hearing loss from about 4% among the 35-54 year olds to 15% in the 55-64 years old to 39% among those 75 years and older (Jacobs-Condit, 1984). The same report indicated that older Americans (65 years and over) made roughly 12% of the general population but 43% of the population with hearing loss.

A rise in the frequency of hearing-impairment among adults is predicted, largely because of the increase in the median age of North Americans and increased life expectancies.

Indrani (1981) studied the variation in hearing acuity by air conduction as a function of age and sex, among a group of subjects of Indian nationality. A sample of 180 subjects of age ranging from 10 years 6 months to 87 years were selected randomly from the general population. The sample was categorised in to six age groups 10 years 6 months to 20 years 6 months; 20 years 6 months to 30 years 6 months; 30 years 6 months to 40 years 6 months; 40 years 6 months to 50 years 6 months; 50 years 6 months to 60 years 6 months and 60 years 6 months and above. Each age group consisted of 30 subjects, with equal sex representation.

The results from the study were that there was a significant changes in hearing acuity occurred with age. Individuals under the age of 20 experienced an incidence rate of 1.7% while persons from the age range of 40-50 years experiences an incidence of 12.2%. Tn the decade of 50-60 years, the incidence rate of hearing loss increased to 20.3% and for those individuals beyond the age of 60 years it further rose to a rate of 43%. Thus, the study revealed that the prevalence of high frequency loss -was greater in the geriatric population. The age related changes in hearing seemed to be common for males and females, and the hearing acuity changes related to age did not seem to be different for the right and left ears.

Manimegalai (1983) reported similar findings while studying the speech discrimination performance across age and sex, in an Tndian population.

Impact of Hearing-Impairment

Effect of hearing loss on general communication :

Rutman (1989) states that persons who sustain hearing-impairments after 18 years of age experience social and psychological losses. She proposed that loss of hearing in adulthood is less a problem of development, as in the case with congenitally deaf or hard-of-hearing individuals. Rather it is one of reorganization of an already developed personality and adjustment to altered life circumstances.

Flexor (1995) reported that there are about 39.5 million school children in the U.S. and approximately 8 million of them have the some type and degree of hearing loss. But only 1% of them were being served. The children not served, identified, or underserved were those with minimal, mild or unilateral (stable/fluctuating) hearing-impairments.

Flexor (1995) investigated the kinds of problems they face. It was found that these children had several problems, which included the following :

1. Hearing faint/distant speech (more than 25% of the classroom instruction could be missed).

2. Hearing subtle conversational cues that could cause a child to react inappropriately

3. Following fast-paced verbal exchange.

4. Hearing the final word sound distinctions that denote plurality, tense, possessives etc.

5. Because of the extra effort needed to hear, the child may appear immature and become fatigued.

6. Thus, the premise of the educational system is undermined.

Hearing loss gives an *"acoustic filter effect"* i.e. it distorts, smears, or eliminates incoming sounds, especially sounds from a distance - even at a short distance.

To investigate the effect of minimal hearing loss on academic/ intellectual performance Burner and Mouw (1982) carried out two studies. The first study involved co-relating group data and audiometric test results obtained on eliminatary school students from three sites in southern Illinois. The second study compared the performance of two groups of learning disabled students on individual intelligence measures. One group had a minimal hearing loss, while the other had no detectable loss, nor had evidence of a loss during their developmental history.

The results indicated that minimal hearing loss was related to poor academic achievement and to lower scores on group IQ measures. The learning disabled children with a minimal hearing loss had significantly lower verbal performance and full scale IQ scores than did their hearing counter parts. The IQ was determined using the WISC-R.

Effect of Hearing Loss on Speech Perception

a) With reference to segments : Zakier (1992) studied transition duration effects on place perceptions in hearing- impaired (mild-moderate sensori-neural losses). F1 F2 F3 were varied between the values of /d/ and /g/. These were combined with transition duration ranging from 20-50 cms in 5 milli seconds steps. A trend was noticed for hearing-impaired listeners to identify stimuli with shorter transition duration as /dE/ in the absence of other unequivocal cues of place of articulation.

b) With reference to features : Bilberg and Wang (1976) found difference in perception by hard of hearing with difference in degree of hearing loss features well perceived by individuals having mild hearing loss were sibilant, nasality, high back/anterior frication and voicing. Individuals with moderate hearing loss perceived the following features : sibilant, duration, voicing, place. Sibilants were best perceived, followed by duration, voicing and place features. Nasality was not well perceived.

Godfrey and Millay (1978) assessed the effect of sensori-neural hearing loss on the perception of particular cues. Stimuli consisted of synthetic consonant-vowel syllables, varying along a continuum in the duration of initial formant transitions, such as the shorter stimuli sounded like /bE/ and the longer ones like /wE/. Subject with mild to moderate hearing loss -were asked to identify the stimuli, and their performance was compared to that of normal hearing listeners. Observed differences suggest that categorising these sounds as stops vs. glides is especially difficult for some impaired listeners. The difficulty is shown to be specific to the *"rapid spectral change"* cue, independent of frequency content or intensity level.

Social Effects of Hearing Loss

Blair, Peterson, and Vichweg (1985) studied the effects of mild sensori-neural hearing loss on academic performance of young school-age children. Their study measured the academic performance of children with mild sensori-neural hearing loss of 20-45 dB by comparing them with a normal hearing control group. 24 pairs of children in the first to fourth grades were compared. A 2-way analysis of variance was used to compare the achievement scores from the Iowa test of Basic Skills administered to the two groups. The results indicated statistical significance on some subjects of the 1st and 4th Grade student scores. The standard mean score was almost always poorer than that of the normal hearing control group in every grade.

Kell, Pearson, Acton and Tayler (1971) studied the social effects of hearing loss due to weaving noise. The mean measured hearing levels of a group of 96 female weavers of mean age 64.7 years were greater than those of a group of 96 non-noise-exposed female controls of mean age 64.5 years. The average loss at 0.5, 1 and 2 KHz was 36.6 dB for the weavers compared to 12 dB for controls.

Speech audiometry showed that all the weavers, at all ages, had a poorer understanding of speech than the controls.

The social consequences of this impaired ability were :

(a) difficulty at public meetings (weavers 72%, controls 6%)
(b) difficulty talking with strangers (weavers 80%, controls 16%)
(c) difficulty talking with friends (weavers 77%, controls 16%)
(d) difficulty understanding telephone conversation (weavers 64%, controls 5%)

(e) 81 % of all weavers considered their hearing was impaired while only 5% of the controls did so
(g) 53% of weavers and no controls used lip-reading.

The study has established the areas of social impairment due to noise induced hearing loss.

Dirks and Carhart (1962) conducted a survey to study the reactions from users of binaural and monaural hearing aids who had moderate sensori-neural hearing loss. Situations, listed in order of superiority for binaural users were :

- listening to a person at the dinner table
- listening to music on the ratio or on a record player
- listening to a person at a quiet party
- listening to a group conversation in a quiet room
- listening to a person while driving a car.
- listening to a person on a city street
- listening to a person in your backyard
- listening to a person when attending a movie.

From nine of these listening conditions, binaural users rated their efficiency somewhat higher than did monaural users. By contrast, both groups reported relatively poor performance in conditions with strong background sounds.

As a rule, people can tolerate, and may even prefer, a certain amount of background noise, the noise is considered to be acceptable if it neither disturbs room occupants nor interferes with speech communication.

Despite the high number of people acquiring hearing losses during adulthood, relatively little research has examined the impact of communication difficulties on the functioning and quality of life and the coping skills used by these individuals to cope with their loss (Rutman, 1989).

The impact of a hearing loss that has it's onset during adulthood depends on several factors. These include the age of onset (prevocational or postvocational), nature, degree and configuration of hearing loss, life style and occupation of the person, and perceived handicap (Health and Welfare Canada, 1988).

The prevalence of noise induced hearing loss is rising, largely because of noise pollution in factories, as well as increased exposure of many people to amplified music. Although occupational hearing loss may negatively affect self-esteem, family relationships, and job performance, noise-induced workers tend to be reluctant to acknowledge the hearing loss and seek professional help (Hetu, LaLande and Getty, 1987).

Most of the literature on acquired hearing-impairments have emphasised the social isolation reported by late-deafened adults. Successful coping is difficult but appears to be facilitated by acknowledgement and acceptance of hearing loss (Rutman, 1989).

For an elderly, a hearing problem may not only signify a loss of one of their senses, but may also symbolise many concerns about aging and thus represent a very complex emotional issue.

Oyer and Oyer (1978) discussed the following social consequences of auditory deprivation in individuals with presbyacusis -

(1) Embarrassment (2) Fatigue (3) increased irritability (4) Increased tension (5) Avoidance and withdrawal (6) Increased vulnerability to promises of restored hearing (7) Increased endangerment to bodily safety (8) Boredom (9) Rejection (10) Depression (11) Acting upon mis-information (12) Negativism (13) Diminished opportunity to assume leadership roles, and (14) Reduction in amount of information.

Thus, it can be seen that a hearing-impairment results in problems in communication in a variety of situations. On account of this communication problem, their social life gets adversely affected.

Speech Perception in Noisy Conditions

Acceptable noise levels for enclosures used for various types of activities were developed by Baranek et al. (1971) and recently revised by Baranek (1989) in the form *of "preferred noise criteria"* (PNC) curves represent the tolerance of average listeners with normal hearing to noise at frequencies between 31.5 Hz and 8 KHz.

Excellent listening conditions, such as in concert halls, require that noise levels, expressed in terms of A-weighted averages, be no greater than 20 dB. For good listening conditions in auditoriums and drama theatres the background noise levels should not exceed 45 dB. Noise levels in shops, offices and computer rooms, with normally operating equipment should not exceed 60 dB. High noise levels, as they are found in many factories, are unacceptable from a communication standpoint even in safety standards are not violated. Such noise conditions are often tolerated because significant noise reduction might be too costly or even impossible.

When an individual speaks in the presence of noise then some parts of the speech might be obscured by the noise, and become in audible or "masked". The masking effect of noise depends on various parameters of the noise (a) the long average spectrum, (b) the intensity fluctuation over time, and (c) the average intensity relative to the intensity of speech. Masking is most effective by a noise which has the same long term spectrum.

Speech perception for normal hearing listeners was affected more by steady-state noise than by fluctuating interfering signals such as competing speech (Carhart et al. 1969; Festen and Plomp, 1990). Impulsive noises tend to be less disruptive than steady-state noises (Nabelek and Pickett, 1974 a).

The overall effects of noise on speech perception can be inferred from signal-to-noise (S/N) ratio expressed in dB. Speech recognition scores are generally high when the S/N is high and low when the S/ N is low.

The intelligibility of speech materials fells along a continuum of difficulty based on the meaningful information in the utterance. Then more information there is, the steeper its performance - intensity (PI) function. Four syllable words were more intelligible than three - syllable words were more intelligible than nonsense syllables, and sentences were more intelligible than polysyllabic words. The number of sounds in a word, as well as the number of syllables, have been shown to affect intelligibility (Egan, 1948; Miller et al. 1951; Hirsh, et al. 1954). The same researchers demonstrated that the PI function varied depending on the signal-to-noise ratio. As the signal-to-noise ratio becomes less favourable, the effects on speech performance are more pronounced for sensori-neural hearing-impaired subjects than for normally hearing subjects (Olsen and Tillman, 1968).

Pearsons et al. (1977), reported average A-weighted background noise levels at schools and at homes to be between, 45 dB and 55 dB. With the average speech level of approximately 65 dB measured at 1 - m distance from the mouth of the talker, the S.N in schools and homes is about -10 to +20 dB.

Hearing-impaired listeners need higher sound pressure levels of speech than normal hearing people in order to hear what is being said. Many hearing-impaired listeners perform very well if speech is sufficiently amplified. These individuals however, can usually achieve high performance levels only in quiet. Conventional hearing aids and hearing aids with amplitude compression do not improve scores either in noise or reverberation (Nabelek, 1983), and currently available hearing aids with speech processing capabilities are useful for only selected clients in selected listening conditions (Jerger, et al. 1989).

Speech perception in noise and in reverberation, by normal hearing as well as hearing-impaired college students with moderate to profound hearing losses, was compared by Nabelek and Pickett (1974 b). A similar study was carried out by Finitzo-Hieber and Tillman (1978) with school children who had normal hearing or moderate hearing losses. The results of these studies clearly showed that hearing-impaired listeners face great perceptual difficulties in such adverse listening conditions.

Speech recognition scores decreased in noise for both the normal hearing and hearing-impaired listeners but there were two differences of practical importance between them. First, the impaired listeners' performance was adversely affected at signal-to-noise ratios and reverberation values which did not alter the speech perception of normal hearing listeners. Second, since the hearing-impaired listeners performed more poorly than that of the normal hearing listeners, their scores became unacceptably low under more adverse conditions.

Festen and Plomp (1990) investigated the effect of noise fluctuations on speech perception and found important differences between normal hearing and hearings-impaired adults. The normal hearing listeners perception was not affected by steady state noise, less by fluctuating noise such as speech babble, and least by a single interfering voice. These differences disappeared for the hearing-impaired listeners. Festen and Plomp suggested that this result is due to reduced temporal and frequency resolution in the impaired ears.

Various surveys (Surr, et al. 1978; Kapteyn, 1977; Franks and Beckman, 1985) indicated the background noise is one of the major reasons for dissatisfaction with hearing aids. Nabelek et al. (1991), found that full time hearing aid users tolerated higher levels of background noise when listening to speech than listeners who used their hearing aids sparingly. Some of these latter listeners selected very low noise (25 dB below the speech level, for fully satisfactory listening situations. It is alarming that even a relatively low background noise may cause rejection or very limited use of hearing aids.

Carhart and Tillman (1970) administered NU tests to four groups of subjects monaurally. These tests measured discrimination for monosyllables against competing sentences. Four primary - to - secondary ratios were used. Discrimination in quiet was also determined. The results indicated that the conductive losses functioned as did the normal hearing subjects. By contrast, the two groups of persons with sensori-neural hearing loss were excessively disturbed by competing sentences. The disruption was equivalent to having the masking efficiency of the sentences enhanced from 12-15 dB.

The implication of these findings, which have confirmation in other research, is that a third dimension of handicap may be imposed by sensori-neural pathology, namely, such a pathology not only changes threshold and often impairs intelligibility in quiet but can also disturb the ability to resist masking when in complex environments containing background sounds, particularly speech.

Effects of Noise on the Speech Performance of the Elderly

In general, it appears that when the listening tasks is made more difficult, speech recognition tends to decline Dubno, et al. (1984) used an adaptive procedure to assess speech recognition performance of young and elderly listeners with normal hearing and mild sensorineural hearing loss. Dubno et al. (1984) contrasted the signal-to-babble ratios (S-B Rs) at which young, elderly and hearing-impaired listeners achieve a 50% criterion score for high/ low predictability items from the Speech Perception in Noise test (SPIN). In general, irrespective of intensity level, normal and hearing-impaired subjects over 65 years required more advantageous S-BRs to achieve a 50% criterion score on the low predictability sentences than did their younger counterparts (Dubno, et al. 1984).

Jerger and Hayes (1977) found the age effects to be task dependent. They examine the effect of age on monosyllabic word recognition ability and on speech recognition ability, using the ipsilateral competing SSI. The latter materials "were presented in ipsilateral speech competition. In general, performance for the sentence materials decreased significantly with increasing age, with the decrements becoming more pronounced after the age of 65.

Orchik and Burgen (1977) confirmed the task dependence of scores on speech recognition tests *in* elderly listeners with essentially normal hearing. They found the age effect to be most pronounced when synthetic sentences (SSI) were presented in unfavourable message to competition ratio (i.e.MCR > -10 dB).

Plomp and Mimpen (1979) found the speech reception threshold for sentences as a function of age and noise level for 140 males (20 per decade between 60-89 and 12 for the age 90-96). They investigated the monaural speech reception threshold in quiet and at four noise levels (22.5, 37.5, 67.5 dB A noise with LTAS). The median SRT as well as the quartiles were given as a function of age. Every hearing loss was interpreted as the sum of a loss A (attenuation), characterised by a reduction of the speech signal and noise, and a loss D (distortion), comparable with a decrease in signal-to-noise ratio. Bom SHL (A+D) and SHL (D) increase progressively above the age of 50 (reaching typical values of 30 and 6 dB respectively at the age 85). The spread of SHL (D) as a function of SHL (A+D) for individuals was so large ($\sigma = 2.7$ dB) that subjects with the same hearing loss for speech in quiet may have differed considerably in their ability to understand speech in noise. The data confirmed that the hearing handicap of many elderly subjects manifests itself primarily in a noisy environment. Acceptable noise levels in rooms used by the aged must be 5-10 dB lower than those for normal hearing subjects.

Macrae and Brigdin (1973) investigated the effect of auditory threshold impairment on the reception in quiet and in noise, for lists of sentences designed to represent every day speech in war veterans. Majority of them had mild to moderate sensorineural hearing loss.

It was found that reception of the sentences by the subjects could be predicted with reasonable accuracy by means of articulation index, which proved to be a better predictor than the three-frequency average hearing level. The results indicate that everyday speech reception by listeners with impaired hearing is very largely determined by the degree of threshold impairment and not by impairment of maximum speech discrimination, and that threshold impairment at frequencies above 2 KHz has an adverse effect on speech reception in some noisy situations.

Many studies have been reported illustrating the hearing thresholds for pure tones decline with advancing age. It is long been clear, however, that older persons apparently experience greater difficulties in understanding speech than the pure tone audiogram would suggest (Bergman, 1971).

Studies were reportedly Bergman in which the hearing of speech under difficult listening conditions were tested in adults of each age decade from 20-89. The results of these and similar studies by others strongly document the observation of decreased ability, with aging, in hearing for speech heard under conditions of distortion and competing signals, even in persons who have relatively normal hearing audiometrically.

It is suggested that these difficulties are related to problems in time-related processing abilities.

Jerger and Hayes (1977) studied the speech discrimination performance of the elderly. They point out that individuals with pure high frequency cochlear losses display a strong tendency toward monosyllabic word scores that are significantly poorer than synthetic sentence scores. On the other hand, they postulate that individuals with same type of neural involvement central to the cochlea will display sentence intelligibility scores that are poorer than monosyllabic word scores.

Distance and Its Effect on Speech Perception

Peutz (1971) obtained speech recognition scores at various distances from speech source in rooms differing in volume and reverberation. The SPL of speech was kept constant. At 1 m in front of the score, the scores were very good in all rooms. They declined gradually until a certain distance was reached beyond which the sources remained constant and independent of the distance to the equal to the critical distance of each room. This very important finding indicated that beyond the critical distance, the full effect of masking by reverberation takes place and remains constant. Peutz (1971) also showed that only within the critical distance, speech intelligibility may be improved by reducing the distance.

These data was replicated by Johnson et al. (1990), in a medium-sized classroom with normal hearing and hearing-impaired listeners. The critical distance of the classroom was 3 m, whereas the speech recognition score was the highest at 1 m from the loudspeaker, the scores remained the same at 4 m and 8 m from the loudspeaker.

**Assessment of Hearing Handicap
Using Speech Tests:**

Groen (1969) developed a method for assessing the social handicap caused by hearing loss. It was developed because neither the pure tone audiogram and Fletcher rule of thumb loss, nor speech audiogram (whether monaural or binaural) depicted the actual social difficulties the hard of hearing patient encountered when he listened to conversation amidst ambient noise.

It appeared that it would be sufficient to have phoneme - scores for S/N ratios of 00 +10, 0 and -5 *dB* in order to determine the discriminability of testee in noise. 40 subjects -with presbyacusis were used who aged between 62 to 73. Their pure tone loss (Fletcher average) was between 20 and 60 dB with an average of 40 dB.

Table-1 depicts the effect S/N ratios has on the perception of phonemes by the hearing-impaired and normal hearing individuals.

S/N ratio	Phoneme score % Patient	Phoneme score % normal
	67	100
+10	62	95
0	50	82
-5	20	60

Table-1: Effect of S/N ratios on the phoneme score for the hearing-impaired and normal hearing individuals.

From Table-1 it can be learned that for the average patient with presbycusis, his social handicap in free-field condition was clearly expressed in his rapidly declining phoneme score when the ambient noise reached the speech level and surpasses it. His scores compared unfavourably with that of the normal listeners.

Self-Assessment of Hearing Handicap

One purpose of speech recognition testing is to predict the impact of hearing loss on performance in everyday life situations, since they offer the clinician means of accessing communication function in a quasi-systematic manner (Olsen and Matkin, 1984).

In an effort towards external validation of scores on speech recognition tasks, a number of researchers have attempted to correlate scores on self-assessment scales and quantify the extent of perceived hearing handicap experienced by hearing-impaired listeners (Anderson, 1990). The premise underlying these investigation was the incomplete relationship between hearing-impairment data measured using self-assessment techniques. Clinically, it was apparent that individuals with minimal hearing loss often experience significant handicap whereas persons with moderate hearing loss may not perceive themselves as being handicapped. Data on the relation between word-recognition ability and perceived handicaps confirm that scores on speech measures account for little of the variability in the perception of communication difficulties and in the perception of psychological ramifications of hearing loss. Interestingly, correlations between pure tone measures and self-assessed hearing handicap are stronger (Weinstein and Ventry, 1983; Berkowitz and Hochberg, 1971) than those between impairment data and handicap scores. The weak or relations was a consistent finding across populations, settings and self-assessment scores, suggesting that speech understanding tests are not representative of experience in everyday listening conditions (CHABA, 1988; Weinstein and Ventry, 1983; Berkowitz and Hochberg, 1971; McCartney, Maurer and Sorenson, 1976.

Rowland et al. (1985) made a comparison of Speech Recognition-in-Noise and subjective communication assessment, he used quiet and babble (Speech Perception-in-Noise Test) conditions, and items from a self-assessment scale concerned with communication ability in quiet and noise (understanding speech section of the Hearing Performance Inventory (HPI). For the hearing-impaired group, correlations between speech recognition scores and ratings on the self-assessment items were poor, suggesting that performance measured with these tests have only a weak relationship.

Thus;

1. Listeners of differing age groups perform similarly on speech recognition tasks in quiet when matched for equivalent hearing loss (Townsend and Bess, 1980).

2. If the role of the audiologist includes helping the patient gain insight into his communicative problem testing should be designed to describe the communicative handicap as completely as possible. In terms of hearing and understanding everyday speech, speech discrimination testing in quiet does not provide the necessary data to do so, regardless of the test used (Orchik and Burgess, 1977).

3. Handicap questionnaires can provide complementary information and useful clinical in sights not obtained with word or sentence identification test (Tyler and Smith, 1983).

4. The purpose of the speech discrimination task (eg. reveal age effects quantify problems in everyday listening situations) should dictate the materials, presentation level, response format, test paradigm, and conditions under which the speech recognition performance is assessed (Carhart, 1965).

Speech Perception in Hearing Aid Users

McConnell, Silber, McDonald (1960) conducted a study to determine the test-retest reliability of speech audiometry measures with hearing aid wearers randomly selected in a routine clinical situation. Subjects for the first portion of the study included 40 subjects on whom aided discrimination scores and speech reception thresholds were obtained twice on the same day. A second group of 37 subjects was used to yield similar repeat data from tests performed from two weeks to three month after the first test.

Speech discrimination scores were found to have a markedly high degree of test-retest consistency in both test conditions as well as when the results obtained by one audiologist were compared with those obtained by other clinicians.

Zerlin (1962) proposed a different approach to hearing aid selection. He presented six different hearing aids equated for gain, two at a time, with an input of running speech in the presence of cafeteria noise. The pair output were simultaneously recorded on to a dual-channel tape, and the procedure repeated for all possible combination of pairs of aids. Half lists of the CDD W-22 recordings were transduced through the aids and recorded.

Hearing-impaired subjects then made a paired-comparisons choice on each set of two aids and ultimately ranked all the six aids. Intelligibility scores were derived on the basis of half-list responses.

It was noted that while the intelligibility scores did not differentiate among the aids, preference scores based on the paired comparisons yielded clear-cut discriminations among five of the six. Reliability of the paired-comparisons judgements also appeared encouraging.

Tillman, Carhart and Olsen (1970) investigated the hearing aid efficiency in a competing speech situation. They used four types of subjects (normal, conductive losses, non-presbyacusic sensorineural losses and presbyacusis). The main findings were :

1. The sound pressure levels at which the spondee thresholds for the hearing-impaired occurred were poorer when measured at the ear via the hearing aid system than when measured unaided in a sound field.

2. Intelligibility of aided monosyllabic words presented in quiet was somewhat poorer than unaided intelligibility at equivalent sensation levels.

3. Subjects with sensorineural losses and those with presbyacusis -were less resistant to masking by competing sentences during unaided listening than were the normal or conductive loss group.

4. At reduced sensation levels, all groups exhibited reduced intelligibility for words heard against competing sentences. The effect on normals and conductive loss cases were equivalent to increasing the masking efficiency of the noise about 10 dB and 18 dB respectively. The effect for the other two groups varied with primary-to-secondary ratio but was severe.

The practical implications of these findings is that there are situations in which a person wearing a hearing aid cannot understand his companions even though amplification is ample and the background competition is sufficiently mild that a person with normal hearing can easily disregard the competition.

Muller and Stephen (1986) investigated the influence of hearing loss and age. The gain with and without hearing aid was assessed by SRT in a noiseless environment. It was found that a significant correlation existed between hearing loss and SRT gain by the hearing aid for a pure tone hearing loss of less than 40 dB at 500 Hz, irrespective of the age whereas for a hearing-impairment of 40-60 dB, the gain by using the hearing aid was dependent on the age of the patient.

Upfold (1989) conducted a survey on the children with hearing aids in the proportional fitting rate of children with average impairments of less than 61 dB and also a strong trend towards the fitting of children with very mild impairments. Comparing children with aids fitted in 1970 with those fitted in the 1980s, it was seen that children with better ear average impairments of less than 31 dB constitute approximately one in three aided children in the latter period, whereas no children at this levelof impairment was seen in 1970 survey.

The trend is undoubtedly related to changes in audiologic and otologic methods a well as developments in hearing aids and increased community awareness of the problems, experienced by the mildly hearing-impaired.

Flexor, Wray, Black and Milin (1986) evaluated classroom effectiveness for moderately hearing-impaired college students using amplification devices. Ten moderately hearing-impaired college students were used for the study. Study results indicated that the FM unit performed significantly better than both hardwire unit and personal hearing aids.

Plomp (1979) assessed the auditory handicap of hearing-impairment and benefit of hearing aids. He suggested that hearing loss for speech can be interpreted as the sum of a loss A (attenuation), characterised by a reduction of the speech signal and noise, and a loss D (distortion), comparable with a decrease in signal to noise ratio. On the average, the hearing loss of class D (hearing loss in noise) appears to be about l/3rd of the total hearing loss (A+D, hearing loss in quiet). A hearing aid can compensate for class A hearing losses, giving difficulties primarily in quiet, but not for class D hearing losses, giving difficulties primarily in noise. The latter class represented the first stage of auditory handicap, beginning at an average hearing loss of about 24 dB.

Cooper and Cutts (1971) indicated that it is important to determine a patient's discrimination potential in noise.

Flexer (1995) indicated that the S/N ratio should be enhanced for children with minimal hearing loss and a child's hearing problem interferes with his/her access to spoken intervention. Thus, the child is denied an appropriate education.

By providing information about hearing and by advocating for and accessing the critically important auditory modality of children with minimal hearing impairments succeed in a mainstreamed classroom.

Factors Determining the Potential For Success **of Amplification Devices** :

Kasten and Miller (1981) discussed factors that must be considered -when evaluating potential for success for an elderly potential hearing aid user. They are :

(1) Motivation,
(2) Adaptability
(3) Personal Appraisement
(4) Money
(5) Social awareness
(6) Millieu
(?) Mobility and
(8) Variety.

Rupp et al. (1977) present 11 factors in their *"feasibiility Scale for Predicting Hearing Aid Use".* Their predictive factors are (1) Motivation and referral, (2) self-assessment of listening difficulties, (3) verbalisation as to *"fault* of communication difficulties, (4) Magnitude of loss, (5) Informal verbalisations during hearing aid evaluation regarding quality of sound, mold and size, (6) flexibility and adaptability versus sensitivity, (7) age, (8) manual hand and finger dexterity and general mobility, (9) visual ability (10) financial sources, and (11) significant other persons to assist the individual, (12) magnitude of loss.

Improved face validity is also one of the purposes of recent attempts to generate sentence tests of speech discrimination (Berger, 1967; Jerger et al. 1966) air which speech stimuli more nearly resemble ordinary conversation.

Millin and Glaser (1971), Shore et al. (1963), Pollack (1975) recommended Carhart's procedure as it uses constant stimulus level, and therefore permits the aid to function more as it would in everyday use, increases the sensitivity of word discrimination tests to differences in hearing aid frequency response effects.

Thus, from the review of literature it is evident that there is a high percentage of mild to moderate degree of hearing loss individuals above the age of 50. They experience great difficulty in speech discrimination in noise although their performance is adequate in quiet conditions.

Meagre information is available on the rehabilitation of such individuals using functional tests; which can appropriately tap the handicap these individuals face.

Self-assessment and speech perception in noise is being currently used to detect the hearing handicap; also it adds to the face validity of the test.

METHODOLOGY

This study was undertaken to evaluate the protocol for hearing aid prescription for mild to moderate hearing loss cases.

SUBJECTS

30 subjects were taken for the purpose of this study. All the subject were selected based on the following criteria:-

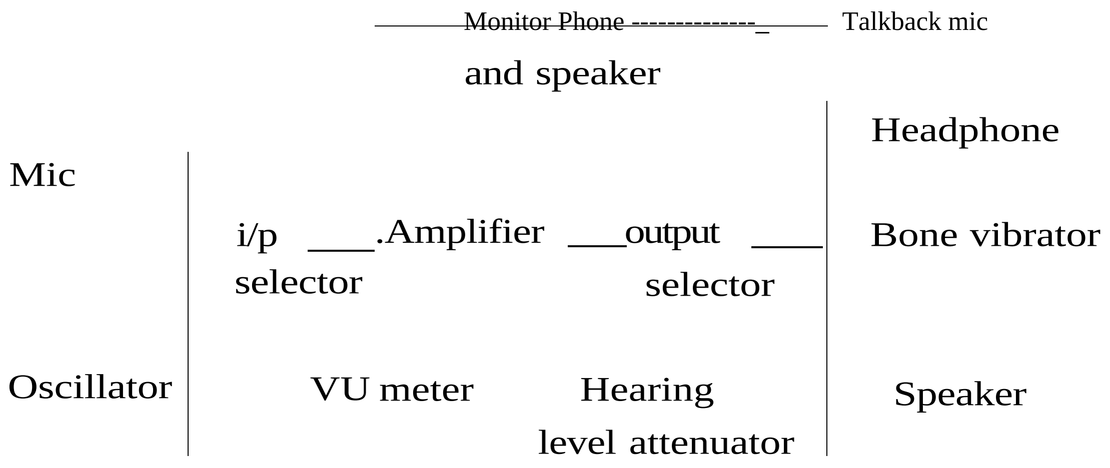
1. Age range of 18-75 years.
2. Mild to moderate degree of hearing loss.
3. Sensori-neural type of hearing loss.
4. All subjects were fluent in Kannada language.
5. Had no middle ear pathology as per an immittance test and ENT evaluation.

INSTRUMENTATION

The data was collected using monitored live voice (MLV) on a dual channel audiometer (Madsen OB 822). The output of the audiometer for pure tone testing was fed to earphones (TDH-39) housed in circumaural ear cushions (MX 41-AR). For speech testing, the output of the audiometer was fed to loud speakers placed at 45 degree azimuth at a distance of one meter from the subject. Calibration of the audiometer was done for pure tones (AC, BC) and speech output as prescribed by ISO 1989.

A block diagram of the instrumentation used is depicted in the figure 2.

Figure 2: BLOCK DIAGRAM OF THE INSTRUMENTATION



TEST ENVIRONMENT

The data was collected in a sound treated two-room setup. The ambient noise level in the room was measured and it confirmed to the recommendations specified by the ANSI,1991.

PROCEDURE

Calibration:

Instrumental calibration was carried out to achieve reliable results. Biological calibration was carried out everyday to confirm the day to day test reliability (Appendix 2).

Test material:

Paired words and everyday questions in Kannada whichn were developed at the All India Institute Of Speech and Hearing were used.

The paired -words consisted of six sets each consisting of five paired words.

Six sets of everyday questions were used in which each set consisted of five questions (Appendix 3)

Instructions

FOR THRESHOLD ESTIMATION

"You are going to hear some signals, raise your finger at the slightest sound you hear. The signal will get softer and softer. Bach ear will be tested separately ".

FOR SPEECH TESTING IN PRESENCE OF NOISE

For questions

"I *am going to ask you some questions, please answer them ".*

For paired words

"I will say some words, please repeat them after me ".

Procedure:

Initially, the pure tone thresholds were found for the frequencies 250 Hz, 500 Hz, 1 KHz, 2 KHz, 4 KHz and 8 KHz under TDH-39 earphones using the ANSI S3.21 1978 method for manual pure tone audiometry.

Bone conduction thresholds were also found out for the frequencies 250 Hz, 500 Hz, 1 KHz, 2 KHz and 4 KHz.

Using free field speakers, the paired words and questions were presented in the presence of speech noise. The test was carried out at -5,0 and +10 S/N ratios. The order of presentation was randomly arranged.

Answers to questions and repetition of paired words were elicited for both unaided and aided conditions. In the aided condition the subjects wore on a hearing aid that was prescribed to them. The responses were recorded for each level of presentation.

Response mode:

Responses were elicited in verbal mode.

DATA RECORDING

The data collected was represented under the following format

Name :
Age/Sex :
Date :
Hearing Threshold

	250 Hz	500 Hz	1 KHz	2 KHz	4 KHz	8 KHz
(R) AC						
(L)AC						

B.C.

Free field testing

	Sl.No.	Signal (inHL)	Noise (inHL)	S/N ratio	Q	PW
	1.	40	45	-5	/10	/10
UA	2.	40	40	0	/10	/10
	3.	40	30	+10	/10	/10
	4.	40	45	-5	/10	/10
A	5.	40	30	+10	/10	/10
	6.	40	40	0	/10	/10

Scoring :

Each response of a subject was scored as follows :

2 - Correct response on the first presentation
1 - Correct response on repetition (one)
0 - No response/wrong response even on repetition

Thus, on each subtest a maximum score often could be obtained.

RESULTS AND DISCUSSION

The main purpose of the study was to develop a test protocol for hearing aid selection for individuals with mild to moderate hearing loss.

The data was collected according to the methodology given in the previous chapter. The mean and standard deviation values for sentences and paired words were tabulated. Table-2 shows the mean and standard deviations for the data at +10 dB, 0 dB and -5 dB signal-to-noise ratios.

Stimuli	S/N ratio (indB)	Unaided		Aided	
		Mean	S.D.	Mean	S.D.
Questions	+10	2.8	3.37	8.8	1.98
	0	2,.7	2.73	8.46	1.69
	-5	1.86	2.48	9.1	1.42
Paired words	+ 10	2.9	3.12	9.2	1.28
	0	2.7	3.41	8.96	1.88
	-5	1.96	2.86	9.23	1.17

Table-3 : Mean and Standard deviation for questions and paired words at +10 dB, 0 dB and -5 dB signal-to-noise ratios.

MEAN RESPONSES FOR QUESTIONS AN© PAIRED WORDS

A) Unaided Responses

Froml Table-2 we can conclude that as the noise level in the test situation was increased, the performance deteriorated i.e. poorer the signal-to-noise ratios poorer is the performance. Their performance was the poorest at the - 5 dB signal-to-noise ratio level. This shows than an individual with mild to moderate degree of hearing loss finds it more difficult to communicate at lower signal-to-noise values. The data corresponds with literature. Similar findings have been reported in various studies (Goodman, 1968; Davis and Silverman, 1970; Jalvi, et al. 1983; Rutman, 1989; Flexer, 1995; Kell, et al. 1971; Dirks and Carhart, 1962; Carhart et al. 1969; Festen and Plomp, 1990; Pearsons, et al. 1977; Nabelek, 1983; Jerger, et al. 1989; Nabelek and Pickett, 1974b, Finitzo-Hieber and Tillman, 1978).

b) Aided Responses

The mean values from the Table-1 shows that there was a definite improvement in the listening performance as compared to the unaided conditions. The difference between the aided and the unaided conditions were statistically significant in all the conditions with the aided scores being higher than the unaided. This difference was maximum in the -5 dB signal-to-noise ratio condition. The signal was presented at 40 dB HL. It is speculated that this improvement in performance could be due to the automatic gain control (AGC) built in monitoring circuit in the hearing aids prescribed. Various studies have been conducted to compare the speech intelligibility in noise using an AGC aid against linear aids. All the studies have reported that AGC aids help to improve aided performance of many individuals who are marginal candidates (mild to moderate) for amplification. In addition the AGC aids reduce tolerance problems by increasing the dynamic range (Tolerance problems are faced by most individuals with sensori-neural hearing loss) (Schweitzer, 1979; Dillon and Walker, 1983; Lippmann, 1981; Wernick. 1985: Nabelek. 1983).

CRITICAL RATIOS FOR QUESTIONS AND PAIRED WORDS

From the data presented in the Table-1, the critical ratios i.e. the ratio between the unaided and aided responses were calculated (Garrett, 1966). This was done for both questions and paired words. The critical ratios are given in Table-3 (for different signal-to-noise ratios).

	Stimuli	Signal-to-noise ratio (in dB)		
		+ 10	0	-5
Critial Ratios	Questions	8.95	10.62	13.92
	Paird words	10.22	8.81	12.91

Table-3 : Critical ratios between unaided and aided conditions (for questions and paired words) under different signal-to-noise ratios.

Critical Ratios Between Unaided and Aided Conditions

The analysis of the critical ratios (CR) indicated that there was a significant difference in the speech performance of the subjects between the unaided and aided conditions. This was true for both questions and paired words. The CR were found to be significant at the 0.01 levels of significance for all conditions. This indicated that individuals with a mild to moderate degree of hearing loss show a definite improvement in speech performance when fitted with a hearing aid.

Critical Ratios Between The Different Signal-To-Noise Ratios

Computation of the critical ratios for the different signal-to-noise ratios i.e.+10 dB, 0 dB and -5 dB clearly indicated that the -5 dB condition ratio was most suitable for successfully determining whether the patients needs a hearing aid or not. This was so because the contrast between the aided and unaided was more evident in this condition.

The results from the study clearly indicated that it is essential to evaluate an individual with mild to moderate degree of hearing-impairment in a situation that would simulate the social environment which encounters in his day-to-day life. Among the three signal-to-noise ratios which were used to assess the speech performance, statistics revealed that the condition with the poorest signal-to-noise ratio (i.e. the -5 dB signal-to-noise ratio) was the most decisive in detecting the handicap which individuals with mild to moderate degree of hearing loss individuals face.

Several research in literature have also suggested that hearing aid selection should be carried out in the presence of noise (Carhart, 1946b; Tillman, et al, 1970; Millin and Glases, 1971; Shore, et al. 1963; Pollack, 1975). However, most of the studies do not specify the signal-to-noise ratios that should be used during hearing aid selection.

Two of the subjects in the present study exhibited good scores in the unaided conditions in all the three signal-to-noise ratios. Their pure tone average was comparatively better than that of the other individuals (26.6 dB and 3O dB), As these cases performed well without a hearing aid, no device was prescribed for them.

In an informal interview, the cases reported that they faced maximum difficulty in comprehending faint speech or when the environment was noisy. Most of them reported that they tried to compensate for this deficit by lip reading or asking the speaker to repeat the message loudly.

The results also indicated that though the individuals with mild to moderate hearing-impairment do not face much of a difficulty while communicating in situations having better signal-to-noise ratios, the speech performance severely deteriorates when an individual is in a noisy situation. He may also perform well in a quiet situation with or without a hearing aid. But such individuals often report of limited benefit, in the presence of noise, with their device. Kasten (1981) estimated that around 20-30% of the mild to moderate hearing aid users tend to reject their hearing aids after a short period of trial. Therefore, a hearing aid trial in the presence of a background noise is strongly recommended. This will allow more consumer satisfaction and greater reliability in the prescription of hearing aids.

Hence, it is recommended that a hearing aid selection for individuals with mild to moderate sensori-neural hearing loss should be carried out keeping the following points in mind :

a) Using a speech test either paired words or everyday sentences as they both yield similar results.
b) At an intensity that would be difficult for the individual to hear with ease, but can be heard by a normal hearing person.
c) Using an signal-to-noise ratio that would result in a significant contrast between the aided and unaided performance i.e. -5 dB signal-to-noise ratio.

SUMMARY AND CONCLUSION

Hearing aids are prescribed for the mild to moderate hearing-impaired usually using objective tests (Barlow, et al. 1988; Seewald, et al. 1985; Hawkins, 1990b; Punch, et al. 1990). Rarely are functional tests used. Hence, the functional tests used do not always tap their difficulties.

An experimental study was conducted in order to develop a protocol for the evaluation of mild to moderate degree of hearing loss cases for hearing aid prescription. The speech-tests used were everyday sentences and paired words developed at the All India Institute of Speech and Hearing in Kannada. These were done on thirty adults who had mild to moderate degree of sensorineural hearing loss.

The speech test was carried out in the presence of speech noise. This was done at +10 dB, 0 dB and -5 dB signal-to-noise ratios. The responses were scored and recorded.

The data was subjected to statistical analysis and the critical ratios for all the three conditions were tabulated (Garrett, 1966).

From the results it can be concluded that the following points should be borne in mind while carryingout hearing aid prescription for the mild to moderate hearing loss cases :

a) A speech test in the presence of noise should be used. The material could be either paired words or very day sentences as they both yield similar results.

b) The intensity used should be such that it would be difficult for the individual to hear with ease, but can be heard by a normal hearing person (i.e. 40 dB SL).

c) The signal to noise ratio employed should reveal the greatest contrast between the aided and unaided performance. It was found that the -5 dB signal to noise ratio most aptly served this purpose.

Thus, the present study suggests that there is a need to test the mild to moderate degree of hearing loss cases using a speech test at -5dB signal to noise ratio as a routine procedure for hearing aid prescription.

SUGGESTIONS FOR FURTHER RESEARCH

1) A follow up study on individuals who have been prescribed hearing aids using this procedure has to be carried out to check how effectively they have been rehabilitated.

2) Same procedure can be replicated by using other maskers like speech babble.

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APPENDIX I
CALIBRATION PROCEDURE

Earphone Calibration

Both intensity and frequency calibration was done for the pure tones generated by the clinical audiometer (Madsen OB 822).

Intensity Calibration

Intensity calibration for air-conducted tones were carried out with the output of the audiometer set at 70 dB HL (ANSI, 1969). Through the earphones (TDH 39 with MX-41/AR ear cushions) the acoustic output of the audiometer was given to a condenser microphone (B&K 4144) which was fitted into an artificial ear (B&K 4152). The signal was then fed to a sound level meter (B&K 2209) attached to an octave filter set (B&K 1613) through a pre-amplifier (B&K 2616). The sound level meter was fitted with a half inch to one inch adapter (B&K DB 0962). At each of the test frequencies, i.e. 250 Hz to 8 KHz, the output sound pressure level (SPL) value was noted. A discrepancy of more than 2.5 dB between the observed SPL value and the expected value (ANSI Standards, 1989), was corrected by means of internal calibration.

Bone Vibrator Calibration

The intensity calibration for the bone vibrator (Radioear B-71) was done, for the frequencies 250 Hz to 4 KHz. The output of the audiometer was set at 40 dB HL (ANSI, 1969). From the bone conduction vibrator (Radioear B-71) the acoustic signal was fed to the artificial mastoid (B&K 4930). This output was then ted via a preamplifier (B&K 2616) to the sound level meter (B&K 2209). A difference of more than 2.5 dB between the observed SPL value and the expected value (ANSI standards, 1989), was internally calibrated. Thus, the output of the audiometer was maintained within 2.5 dB of the standard (ANSI, 1989).

Frequency Calibration

A time/frequency counter (Radart 203) was utilized to calibrate the frequency of the pure tones. The electrical output of the audiometer was fed to the counter which gave a digital display of the generated frequency. The difference between the dial reading on the audiometer and the digital display of a given frequency, did not exceed +or - 3% of each other.

Sound Field Calibration

Intensity Calibration

Intensity calibration for speech in the sound field was carried out with setting the audiometer output to 70 dB. A one inch condenser microphone (B & K 4145) with a 90 degree grid azimuth was placed at the point in the room where the head of the subject would be positioned during testing. The distance from the microphone to the loud speaker was one meter. The microphone was connected to a sound level meter (B&K 2209) and the octave filter st (B&K 1613). The output SPL was compared for the frequencies 250 Hz to 6 KHz, with the values given by Morgan et al. (1979). A discrepancy of more than 2.5 dB between the observed SPL values and the expected values (Morgan, et al. 1979), was corrected by means of internal calibration.

Linearity check

The linearity of the audiometer attenuator was checked. The procedure used was similar to that utilised to check the intensity calibration except that the intensity dial of the audiometer was set at the maximum level and the frequency dial was set to 1000 Hz. The attenuator on the sound level meter was set at a level corresponding to the maximum level on the audiometer. The attenuator setting on the audiometer was decreased in 5 dB steps till 30 dB and the corresponding reading on the sound level meter was noted. For every decrease in the attenuator setting the sound level meter indicated a corresponding reduction.

Frequency response characteristics of earphones and loudspeaker

The frequency response characteristics of the TDH-39 earphone and the free field loudspeaker were obtained using B&K signal generator (1023) microphone (B&K 4145/4144), B&K frequency analyser (2107) and a graphic level recorder (B&K 2616). The electrical output of the signal generator (1023) was fed to the loudspeaker. The output picked-up by the microphone (B&K 4145) was fed to the frequency analyser (B&K 2107). This output was recorded on the graphic level recorder (B&K 2616). The frequency response of the earphone was obtained using a similar procedure except that a pressure microphone (B&K 4144) was used instead of a free field microphone (B&K 4145).

APPENDIX- 2,

LIST OF QUESTIONS AND PAIRED WORDS USED FOR THE SPEECH - TEST

SET - A

1) ನಿಮ್ಮ ತಂದೆಯ ಹೆಸರು ಏನು?

Nimma tandeya hesaru ēnu?

2) ನೀವು/ನೀನು ಇಲ್ಲಿಗೆ ಬಸ್ಸಲ್ಲಿ ರೈಲಲ್ಲಿ ಬಂದಿರಿ?

Nivu / Ninu illige bussulli / Raillalli bandira?

3) ನೀವು ರಾತ್ರಿ ಎಷ್ಟು ಗಂಟೆಗೆ ಮಲಗುತ್ತೀರಿ?

Nivu ratri esṭu ganṭege malgutira

4) ನಿಮ್ಮ ಊರು ಯಾವುದು?

Nimma ūru Yavudu ?

5) ನೀವು ಬೆಳಗ್ಗೆ ಏನು ತಿಂಡಿ ತಿಂದಿರಿ?

Nivu belligge ēnu tindi tindiri

1) ಬೇಳೆ – ಕಾಳು

beḷe - kaḷu

2) ಹೊಲ – ಗದ್ದೆ

hola - gadde

3) ಗಂಟು – ಮೂಟೆ

gantu - muṭe

4) ಅತ್ತ – ಇತ್ತ

atta - itta

5) ಸುತ್ತ – ಮುತ್ತ

sutta - mutta

SET - B

1) ನಿಮಗೆ ಎಷ್ಟು ವಯಸ್ಸು?

nimage esṭu vayasu ?

2) ನಿಮ್ಮ ಹೆಸರು ಏನು?

Nimma hesaru ēnu ?

3) ನಿಮಗೆ ಯಾವ ಕಿವಿಯು ಚೆನ್ನಾಗಿ ಕೇಳಿಸುತ್ತೆ?

Nimage yaava kiviyu channagi kelisutte ?

4) ನೀವು ಏನು ಕೆಲಸ ಮಾಡುತ್ತೀರಾ?

Nivu enu kelasa maḍuthira ?

5) ನಿಮಗೆ ಯಾವ ಯಾವ ಭಾಷೆ ಬರುತ್ತದೆ?

Nimage yaava yaava bhaashe baruttade ?

1) ಕಷ್ಟ — ಸುಖ

Kasṭa - Sukha

2) ತಾಯಿ — ತಂದೆ

Tayi - Tande

3) ಅಂದ — ಚಂದ

Anda - Chanda

4) ಹೊಟ್ಟೆ — ಬಟ್ಟೆ

Hoṭṭe - Baṭṭe

5) ನಡೆ — ನುಡಿ

Naḍe - Nuḍi

SET- C

1) ನಿಮಗೆ ಎಷ್ಟು ಜನ ಅಕ್ಕ — ತಂಗಿಯರು ಇದ್ದಾರೆ?

Nimmage estu jana akka - tangiyaru iddare ?

2) ಈಗ ಗಂಟೆ ಎಷ್ಟು?

Iga gante estu ?

3) ಮನೆಯಲ್ಲಿ ಯಾವ ಭಾಷೆ ಮಾತನಾಡುತ್ತೀರ?

Maneyalli yaava bhashe matanaduttira ?

4) ನೀವು ಏನು ಓದಿದ್ದೀರ ಓದುತ್ತಾ ಇದ್ದೀರ?

Nivu ēnu odidhira / odthaidira ?

5) ನಿಮ್ಮ ಮನೆಯಲ್ಲಿ ಎಷ್ಟು ಜನ ಇದ್ದಾರೆ?

Nimma maneyalli estu jana iddare ?

1) ಅತ್ತಿ — ಆಸೆ

Atti - Āse

2) ಕಪ್ಪೆ — ಚಿಪ್ಪು

Kappe - Chippu

3) ಮನೆ — ಮಠ

Mane - Matha

4) ನಮ್ಮ — ನಿಮ್ಮ

Namma - Nimma

5) ಗುರು — ಶಿಷ್ಯ

Guru - Sisya

SET - D

1) ನೀವು ಬೆಳಿಗ್ಗೆ ಎಷ್ಟು ಗಂಟೆಗೆ ಏಳುತ್ತೀರಾ?

Nivu bellige esṭu gantege eḷuthira ?

2) ನಿಮಗೆ ಎಷ್ಟು ಜನ ಅಣ್ಣ ತಮ್ಮಂದಿರು ಇದ್ದಾರೆ?

Nimage esṭu jana anna - tammandiru iddare ?

3) ನೀವು ಮನೆಗೆ ಬಸ್ಸಿನಲ್ಲಿ ಆಟೋದಲ್ಲಿ ಹೋಗುತ್ತೀರಾ?

Nivu manege bassinalli / Autodalli Hoguthira ?

4) ನಿಮ್ಮ ಮನೆ ಎಲ್ಲಿದೆ?

Nimma mane ellide ?

5) ನಿಮ್ಮ ಜೊತೆ ಯಾರು ಬಂದಿದ್ದಾರೆ?

Nimma jotte yaaru bandidare?

1) ತಿಂಡಿ - ತೀರ್ಥ

Thindi - Tirtha

2) ಅಲ್ಲಿ - ಇಲ್ಲಿ

Alii - Illi

3) ಸಣ್ಣ - ಪುಟ್ಟ

Saṇṇa - Puṭṭa

4) ಕನಸು - ನನಸು

Kanasu - Nanasu

5) ಗಂಟು - ಮೂಟೆ

Gantu - Muṭṭe

SET - E

1) ನಿಮ್ಮ ತಾಯಿಯ ಹೆಸರು ಏನು ?

Nimma tayiya hesaru ēnu ?

2) ಇವತ್ತು ಯಾವ ವಾರ?

Ivattu yaava vaara ?

3) ನೀವು ಕಾಫಿ ಅಥವಾ ಟೀ ಕುಡಿತೀರ?

Nivu Coffee athva Tea kudithira?

4) ನೀವು ಇಲ್ಲಿಗೆ ಎಷ್ಟು ಗಂಟೆಗೆ ಬಂದಿರಿ?

Nivu illige estu gantege bandiri ?

5) ನಿಮಗೆ ಯಾವಾಗಲಿಂದ ಕಿವಿ ಕೇಳಿಸುತ್ತಾ ಇಲ್ಲ?

Nimmage yaavagalinda kivi kelisutha illa ?

1) ಮೀನ — ಮೇಷ

Mina - Mesha

2) ಬೆಟ್ಟ — ಗುಡ್ಡ

Betta - Gudda

3) ಅತ್ತ — ಇತ್ತ

Atta - Itta

4) ಹೆಚ್ಚು — ಕಮ್ಮಿ

hecchu - kammi

5) ಚಿನ್ನ — ಬೆಳ್ಳಿ

Chinna - Belli

SET - F

1) ನಿಮಗೆ ಎಷ್ಟು ಮಕ್ಕಳು?

Nimage esṭu makkaḷu ?

2) ನೀವು ಇಲ್ಲಿಗೆ ಎಷ್ಟು ಗಂಟೆಗೆ ಬಂದಿರಿ?

Nivu illige esṭu gantege banḍri ?

3) ನಿಮಗೆ ಈ ತೊಂದರೆ ಯಾವಾಗಿಂದಾ ಇದೆ?

Nimage i: tonḍre yaavaginḍa iḍe ?

4) ಈ ಆಸ್ಪತ್ರೆ ಬಗ್ಗೆ ಯಾರು ಹೇಳಿದರು?

I: a:spaṭre bagge yaaru hēḷidaru ?

5) ನೀವು ಏನು ಕೆಲಸ ಮಾಡುತ್ತೀರಾ?

Nivu ēnu kelasa maḍuthira ?

1) ಕೆಲಸ — ಕಾರ್ಯ

Kelasa - Karya

2) ಗೆಜ್ಜೆ — ಪೂಜೆ

Gedze - Pudze

3) ಬಂಧು — ಬಳಗ

Banḍhu - Baḷaga

4) ಧಾನ — ಧರ್ಮ

Ḍhana - Ḍharma

5) ಆಸ್ತಿ — ಪಾಸ್ತಿ

A:sṭi - Pa:sṭi