AIDED ACCEPTABLE NOISE LEVELS (ANL): A COMPARISON ACROSS DEGREE OF HEARING LOSS, NOISE REDUCTION IN HEARING AID AND PERSONALITY TYPE

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A Dissertation Submitted in Part Fulfillment of
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ALL INDIA INSTITUTE OF SPEECH AND HEARING
MANASAGANGOTHRI, MYSORE - 570 006

Dedicated

to

my parents

and grandparents

CERTIFICATE

This is to certify that this dissertation entitled *"Aided Acceptable Noise Levels (ANL): A comparison across degree of hearing loss, noise reduction in hearing aid and personality type"* is the bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) of the student (Registration No. 06AUD008). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore

May, 2008

Dr. Vijayalakshmi Basavaraj
Director
All India Institute of Speech and Hearing
Manasagangothri,
Mysore - 570 006.

CERTIFICATE

This is to certify that the dissertation entitled ***"****Aided Acceptable Noise Levels (ANL): A comparison across degree of hearing loss, noise reduction in hearing aid and personality type"* 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.

Guide

Mysore

May, 2008

(Ms. P. Manjula)
Lecturer in Audiology
Department of Audiology
All India Institute of Speech and Hearing
Manasagangothri,
Mysore - 570 006.

DECLARATION

This is to certify that this dissertation entitled *"Aided Acceptable Noise Levels (ANL): A comparison across degree of hearing loss, noise reduction in hearing aid and personality type"* is the result of my own study under the guidance of Ms. P. Manjula, Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted in any other University for the award of any diploma or degree.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER - 1

INTRODUCTION

A major consequence of sensorineural hearing loss (SNHL) is difficulty in communication, especially in the presence of noise and/or reverberation (Dubno, Dirks & Morgan, 1984). People with cochlear hearing loss frequently complain that their hearing aids are of limited benefit. Difficulty in understanding speech in the presence of noise is the most frequent complaint of adults who use hearing aids (Kochkin, 2002; Cord, Surr, Walden & Dyrlund, 2004).

The reasons individuals either do not acquire hearing aids or reject their use are of essential interest to the audiologists. Among the major reasons identified in various surveys for dissatisfaction with hearing aids were problems with background noise (Surr, Schuchman & Montgomey, 1978) and unpleasantness of loud sounds (Franks & Beckmann, 1985; Kapteyn, 1977). The complaints related to the background noise were reported by both middle-aged participants (Surr, Schuchman & Montgomery, 1978) and by elderly participants (Franks & Beckmann, 1985; Kapteyn, 1977).

Some insight into the tolerated level of environmental noise can be gained from the examination of data on speech recognition scores (SRS) in noise. As the noise level increases, that is, as the signal-to-noise ratio (SNR) decreases, SRS becomes lesser. A decrease in the SNR affects listeners with hearing impairment (HI) as well as those with normal hearing. Some listeners with HI however, can be adversely affected by relatively low noise levels (Nabelek & Mason, 1981). Rowland, Dirks, Dubno, and Bell (1985) compared SRS in noise with assessment of communicative skills for both normal hearing and listeners with HI. For the listeners with HI they observed only weak correlations between the results of speech recognition tests and the subjective evaluation of the communicative difficulty in either quiet or noisy environments.

Nabelek, Tucker, and Letowski (1991) hypothesized that willingness to listen to speech in background noise may be more indicative of hearing aid use than speech perception scores obtained in the background noise. This hypothesis led to the development of a procedure called "Acceptable Noise Level" (ANL) which is a measure of the willingness to accept background noise while listening to speech. The ANL is defined as the difference between the most comfortable listening level (MCL) for running speech and the maximum background noise level (BNL) that a listener is willing to accept.

The ANL measure assumes that speech understanding in noise may not be as important as is the willingness to listen in the presence of noise. It has been established that people who accept background noise have smaller ANLs and tend to be "good" users of hearing aids (Nabelek, Freyaldenhoven, Tampas, Burchfield & Muenchen, 2006).

Need for the study

Although the utility of ANL as a clinical tool to assess the success of hearing aid use has been established, most of the studies have used listeners with mild to moderate hearing loss. Freyaldenhoven, Plyler, Thelin, and Hedrick (2007) investigated the effect of hearing sensitivity on ANL, by comparing Global ANL, obtained by averaging the ANLs across different presentation levels, to the pure-tone average (PTA) in listeners with hearing loss. The hearing loss of the participants ranged from mild to moderate degree. The results obtained were insignificant indicating that global ANL is not related to hearing sensitivity. However, the participants were not classified into separate groups based on the degree of hearing loss. There is a dearth in literature on how the ANL value varies as a function of hearing loss from moderate to severe degree of loss. Also, the recent development of digital hearing aids opens up substantial new possibilities with respect to the use of advanced signal-processing techniques for noise reduction (Levitt, Neuman, Mills & Schwander, 1986). Noise reduction feature can reduce the overall perception of noise, thus making hearing aid listening more pleasant and increasing the chance of listeners with mid-range ANL scores to become full-time users.

Mueller, Weber, Benjamin, and Hornsby (2006) studied the effect of digital noise reduction (DNR) on ANL on 22 adults fitted with 16-channel wide-dynamic range compression hearing aids with DNR processing. The results indicated a significant mean improvement for ANL (4.2 dB) for the DNR-on condition than DNR-off condition. However, it was not indicated as to how this improvement with noise reduction algorithm varied as a function of degree of hearing loss and/or as a function of presentation level of the speech stimulus.

Studies on ANL have used range of hearing aids from analog to digital hearing aids. The study by Nabelek, Freyaldenhoven, Tampas, Burchfield, and Muenchen (2006) assesses the usefulness of ANL as a predictor hearing aid use (both analog and digital), but does not specify the hearing aid features such as noise reduction algorithms used while assessing aided ANLs. Thus, a need for a detailed evaluation of the effect of noise reduction systems in hearing aids on ANLs was felt.

Also, as pointed by Freyaldenhoven, Plyler, Thelin, and Hedrick (2007), one limitation of ANL model is that measuring conventional ANLs at MCL does not account for the possible changes in acceptance of background noise when the signal of interest is above or below MCL. They reported of growth of ANL as the presentation level was increased and which was not significantly different for listeners with normal hearing and impaired hearing. However, further investigation on these findings was required.

Further, it would be interesting to study the effect of personality types on ANL. Cox, Alexander, and Gray (1999) studied the relationship between the personality trait and self-reported hearing aid benefit in 83 individuals with mild to moderate sensori-neural hearing loss. Participants completed the Abbreviated Profile of Hearing Aid Benefit (APHAB) and Measures of Personality on the State-Trait Anxiety Inventory (STAI) (Spielberger, 1983), the Myers-Briggs Type Indicator (MBTI) personality test (Myers & McCaulley, 1985), and a measure of locus of control (Levenson, 1981). The results indicated extroversion-introversion to be the best predictor of hearing aid benefit. More extroverted individuals reported greater hearing aid benefit on these three sub-scales of the APHAB than the more introverted individuals.

Similarly, Barry and Barry (2002) investigated the effect of personality type on perceived hearing aid benefit in 40 males in age range of 45 to 75 years (mean age= 64.97 years). The personality type of each individual was assessed with the Keirsey Four Types Sorter, which classifies an individual as artisan, idealist, guardian and rational type. A significant relationship between the personality type and perceived benefit of the hearing aid use was observed. However, there has been no literature available on the effect of personality type on ANL score. Since, ANL is indicated as an inherent characteristic of an individual, which does not change with age or acquired hearing loss (Nabelek, Freyaldenhoven, Tampas, Burchfield & Muenchen, 2006), it would be interesting to study its relation with the personality of an individual.

Objectives of the study

The present study aims to evaluate the following:

1. The relationship between the unaided and aided Acceptable Noise Levels
2. The effect of degree of hearing loss on Aided Acceptable Noise Levels.
3. The effect of digital hearing aid with and without the noise reduction scheme on Aided Acceptable Noise Levels.
4. The effect of presentation level on Aided Acceptable Noise Levels in moderate degree of hearing loss.
5. The effect of personality type on Aided Acceptable Noise Levels.

CHAPTER - 2

REVIEW OF LITERATURE

Hearing impairment is often a very handicapping condition that may go unnoticed. National Plan for Control and Prevention of Hearing Impairment and Deafness estimated that about 76.07 million people who are afflicted with hearing impairment in India (Nikam, 2003). Untreated hearing loss is associated with a general decrease in physical and psycho-social well being (Bess, Lichtenstein & Logan, 1991). The effects of untreated hearing loss on elders have been documented in several studies. These include communication difficulties (Arlinger, 2003), well-being and quality of life for individuals with hearing loss as well as their spouses (Mulrow, Tuley & Aguilar, 1992; Carabellese, et al., 2004), cognitive function (Cacciatore, Napoli, Abete, Marciano, Triassi, & Rengo, 1999), social interactions (Resnick, Brant & Verbugge, 1997), and deterioration of speech perception skills in unaided ears owing to auditory deprivation (Silman, Gelfand & Silverman, 1984; Gelfand, 1995; Arlinger, 2003).

Audiologic management such as dispensing of hearing aids and provision of counseling is critical to avoid the deleterious effects of untreated hearing loss. Hearing aids are the rehabilitation tool of choice for most adults with hearing loss. Mulrow, Tuley, and Anguilar (1992) evaluated the sustained benefits of hearing aids in a randomized and controlled prospective study. The use of hearing aids was shown to lessen depression and other negative emotions associated with hearing loss. Hearing aids provide much more benefit in some situations such as listening to a softly spoken person in a quiet place than in others such as listening to a loudly spoken person in a noisy, reverberant place (Cox & Alexander, 1983; Dillon, Birtles & Lovegrove, 1999).

Surr, Schuchman, and Montgomery (1978), identified background noise as the major reason for dissatisfaction with hearing aids. Kochkin (2000) found that in addition to dissatisfaction with the benefit provided by hearing aids, many patients reported a variety of other reasons that affect their use and non-use of hearing aids. Some of these reasons include trouble listening in background noise, an uncomfortable fit of the instrument, negative side effects from wearing the instrument (e.g. blisters, rashes, and itching in the ear canal), high price of the instrument, denial of hearing loss, broken or dysfunctional hearing aids, and poor sound quality of the instruments. Speech tests used to establish relations between measures of hearing-aid outcome (e.g., use, satisfaction, or benefit) and speech perception have obtained weak relations, indicating that speech scores in noise are poor predictors of hearing-aid outcome. Weak correlations were obtained between speech perception scores obtained with the speech in noise test (SPIN) and self-assessment of communication performance (Bentler, Niebuhr, Getta, & Anderson, 1993), between word recognition and communication performance (Erdman & Demorest, 1998), between speech-perception scores obtained with non-sense syllables and sentences with hearing-aid benefit, satisfaction, or use (Humes, Halling, & Coughlin, 1996). The hearing-aid outcome also studied with satisfaction and benefit self-assessment scales which included the Hearing Handicap Inventory for the Elderly, HHIE (Malinoff & Weinstein, 1989), the Profile of Hearing Aid Performance, PHAP (Cox & Gilmore, 1990), the Hearing Aid Performance Inventory, HAPI (Walden, Demorest & Hepler, 1984), the Client Oriented Scale of Improvement, COSI (Dillon, James & Ginis, 1997), and the Glasgow Hearing Aid Benefit Profile, GHABP (Gatehouse, 1999). However, the information about subjective satisfaction and benefit was found to be not related to hearing aid use. Also, one of the practical limitations is that these scales cannot be administered prior to the hearing-aid fitting or even during the hearing aid evaluation.

To investigate the effect of background noise on hearing aid users, Nabelek, Tucker, and Letowski (1991) assessed the "tolerated speech-to-noise ratios (S/N)", in four groups of elderly listeners (N= 15/ group) and one group of young listeners. The young participants and the elderly participants in one group with relatively good hearing were tested in comparison with the participants with HI. Elderly participants in three remaining groups had acquired hearing losses and had been fitted with hearing aids. The participants were assigned to three groups on the basis of hearing aid use. They were full-time users, part-time users and non-users. The amount of background noise tolerated when listening to speech was tested. The speech stimulus was a story read by a woman and set at an individually chosen most comfortable level (MCL). The maskers were a babble of voices, speech-spectrum noise, traffic noise, music and the noise of a pneumatic drill. There was a significant interaction between groups and noises. The full-time users tolerated significantly higher levels of music and the speech-spectrum noise than the part-time users and non-users. In addition, the full-time users, but not the part-time users, assessed themselves as less handicapped in everyday functions when they wore hearing aids than when they did not wear their hearing aids. The findings of the study led to the development of a procedure to quantify the amount of background noise that listeners are willing to accept when listening to speech, called the "acceptable noise level" (ANL). The ANL is defined as the difference between the most comfortable listening level (MCL) for running speech and the maximum background noise level (BNL) that a listener is willing to accept.

Nabelek, Tampas, and Burchfield (2004) compared ANL and Speech-In-Noise (SPIN). The aim was to establish reliability of the individual's ANL and to compare it with the reliability of SPIN scores. The second aim was to compare the ANLs and the SPIN scores a three-month period of hearing aid use. The third aim was to compare ANLs and SPIN scores with and without hearing aids, in aided and unaided listening conditions, respectively. Acceptance of background noise was assessed with a recording of running speech with a male voice as primary stimulus against a multitalker speech-babble recording as a competing background signal. SPIN was asserted with 50 sentences (25 high predictability and 25 low predictability) of a revised form of the SPIN test (Bilger, Neutzel, Rabinowitz & Rzeczkowski, 1984). The background noise of the SPIN test was multi-talker speech-babble, which was the same stimulus as that used for assessment of the ANL. The listeners were 41 full-time users and 9 part-time users who completed three test sessions. Listeners wore various hearing aids ranging from basic analog to high-performance digital technology, which were selected to best suit each listener's need. The experience of the listeners also varied. Results from 50 listeners indicated that for both good and occasional hearing aid users, the ANL was comparable in reliability to the SPIN test and that both measures do not change with acclimatization. The ANLs and the SPIN scores were unrelated. Although the SPIN scores improve with amplification, the ANLs were unaffected by amplification, suggesting that the ANL was inherent to an individual and can be established prior to the hearing aid fitting as a possible predictor of hearing aid use.

Freyaldenhoven, Nabelek, Burchfield, and Thelin (2005) evaluated ANL procedures for assessing directional benefit in hearing aids in a clinical population. The relative merits of the ANL procedure were compared with the relative merits of the masked speech reception threshold (SRT) procedure and ear canal signal to noise ratio (SNR) determined by electroacoustic analysis (i.e., SPLs in the ear canal). The electroacoustic procedure used in the study was based on front-to-back (FBR) measures (Ricketts & Mueller, 1999). FBRs for two microphone modes, omnidirectional and directional, were compared using two different stimuli (i.e., speech originating from 0^0 and background noise originating from 180^0). The benefit measured from these responses was termed FBR benefit. Twenty-seven males and thirteen females between the ages of 30 and 89 years (mean age = 69 years, SD= 12.3) with a pure tone average of 47.3 dB HL (SD= 14.6) served as experimental participants. The hearing aids were fitted to best meet the participant's amplification meets. For the ANL and the FBR, a recording of male running speech was used as speech stimulus. The speech stimulus for masked SRT was a male recording of a list of spondee words. All the speech stimuli were delivered by the loudspeaker located at 0^0 Azimuth. Revised speech perception in noise multitalker speech babble (Bilger, Neutzel, Rabinowitz & Rzeczkowski, 1984) was used as the competing background noise for all the procedures and delivered by loudspeaker located at 180^0 Azimuth. Results of the experiment showed that the mean directional benefits assessed with the ANL, masked SRT and FBR procedures are not significantly different suggesting that ANL is comparable to assess directional benefit. The ANL procedure is found to be quick, easy to administer and only required standard clinical equipment.

Nabelek, Freyaldenhoven, Tampas, Burchfield, and Muenchen (2006) studied the usefulness of ANL to predict hearing aid use for listeners fit with a variety of hearing aids. ANL was incorporated with other traditionally used predictive data such as age, gender, PTA and SPIN scores. The outcome was assessed using an adaptive questionnaire originally developed by Nabelek, Tucker, and Letowski (1991), which classify the listeners based on the pattern of hearing aid use. The secondary aim of the study were to determine the relationship between ANL and both predictive and outcome data, the reliability of the questionnaire responses, the differences in mean ANLs, predictive data, SPIN scores and hours of daily hearing aid use among the three groups of listeners and the effect of hearing aids on ANLs and SPIN scores for the three groups. The participant selection criteria included use of binaural hearing aids, which were obtained within the last three years, and no known neurological or cognitive listener's deficits. Various hearing aids ranging from analog to digital technology were used. The results showed that the SPIN scores and the listener's characteristics were not related to ANL or the hearing aid use. However, ANLs were related to hearing aid use. Specifically, full-time hearing aid users accepted more background noise than part-time users or non-users, yet part-time users and non-users cannot be differentiated. Thus, a prediction of hearing aid use was examined by comparing part-time users and non-users (unsuccessful hearing aid users) with full-time users (successful hearing aid users). Results also indicated that unaided ANL could predict a listener's success of hearing aids with 85% accuracy.

Freyaldenhoven, Smiley, Muenchen, and Konrad (2006) assessed the reliability of the acceptable noise level (ANL) measure using speech spectrum and speech-babble noise as the competing stimuli. They also examined the relationship between ANL and personal preference for the background sound. 30 adults (mean age = 23 years; SD = 1.48) in the age range from 20 to 25 years with normal hearing sensitivity at 0.5k, 1k, 2k and 4k Hz in each ear were included in the study. All the participants were native English speakers with no additional deficits. Speech and noise stimuli were delivered via a cassette tape deck and a CD player respectively. The signals were then routed through an audiometer into a sound-treated booth with ambient noise levels appropriate for testing unoccluded ears (ANSI S3.1- 1991). The signals were then delivered through one loudspeaker located at 0^0 Azimuth approximately one meter from the listener. Running speech recorded by a female talker was used as a primary speech stimulus. Twelve-person multitalker speech babble noise was used as a competing stimulus. ANL was also measured in presence of speech-spectrum noise. A questionnaire was used to determine personal preference for background sounds. Results indicate that ANLs are highly reliable over short periods of time, independent of the background noise distraction. Correlation analysis between ANLs obtained with speech-spectrum and speech babble noises showed a strong positive correlation. The results also indicated that the participant's rating of preference for background sound was consistent over time but not related to the ANL. This probably indicates that listeners cannot accurately assess their ability to accept background sounds with the questionnaire.

Freyaldenhoven, Plyler, Thelin, and Burchfield (2006) investigated the effects of monaural and binaural amplification on acceptance of noise. 39 adults (mean age= 69 years) in the age range from 30 to 89 years served as participants. The criteria for inclusion were binaural hearing instrument users who had worn hearing aids for at least three months. The participants were both analog and digital hearing aid users. Acceptance of background noise assessed for the monaural right, monaural left and binaural amplification conditions. A recording of male running speech served as the speech stimuli and was delivered from a loudspeaker located at 0^0 Azimuth. Multitalker speech babble served as the competing stimulus and was delivered by a loudspeaker located at 180^0 Azimuth. Two ANL trials were conducted for each amplification condition and the results were averaged to obtain a mean ANL for each participant. When testing monaurally, only one hearing aid was used, and the non-test ear was plugged with a pre-shaped foam earplug. The results indicated that the speech understanding in noise improved with binaural amplification; however acceptance of background noise was not dependent on monaural or binaural amplification for most listeners. It was also noticed that in some listeners, the monaural amplification resulted in greater acceptance of noise, which indicated that binaural amplification might negatively affect some individual's willingness to wear hearing aids.

Freyaldenhoven, Plyler, Thelin, and Hedrick (2007) evaluated the effect of varying the speech presentation level on acceptance of noise in listeners with normal hearing and hearing impairment. It was speculated that measuring the ANL at listener's MCL does not account for possible changes in background noise acceptance when the signal of interest is above or below the MCL. The study included 30 adults with normal hearing and 69 adults with hearing impairment. The inclusion criterion for the participants with hearing impairment was SN hearing loss of any configuration or degree with no known neurological or cognitive deficits. The effect of speech presentation level on acceptance of noise was analyzed by determining Global ANLs and ANL growth for each participant. Global ANLs were determined by averaging ANLs across the fixed presentation levels for each participant to represent an overall ANL. ANL growth was determined by conducting linear regression analyses for each participant. The results indicated that the Global ANL and ANL growth were not significantly different for listeners with normal hearing and hearing impairment. Thus, the effect of speech presentation level on acceptance of noise is not related to hearing sensitivity.

Studies on contribution of high frequency information to speech intelligibility in noise have indicated that amplified high-frequency speech information improved speech understanding in noise of listeners with sloping SNHL, regardless of the degree of hearing loss. (Hornsby & Ricketts, 2003; Turner & Henry, 2002). Plyler, and Fleck (2006) evaluated the effects of amplification beyond 2k Hz on the objective and subjective performance of hearing instrument users with varying degrees of mild to severe high-frequency SNHL. The results indicated that high-frequency amplification significantly improved speech intelligibility in noise and subjective preference in quiet.

Plyler, Madix, Thelin, and Johnston (2007) evaluated the contribution of high-frequency information to the acceptance of background noise in listeners with normal and impaired hearing. 20 adults with normal hearing sensitivity (mean age = 24.3 years, range = 18–34 years) and 20 adults with impaired hearing sensitivity (mean age = 65 years, range = 52–82 years) served as participants. Speech stimuli and multitalker babble were low-pass filtered at cut-off frequencies of 2k, 4k, and 6kHz and presented using an adaptive paradigm to determine the most comfortable level (MCL) and acceptable noise level (ANL) for four experimental conditions (unfiltered, 2k, 4k, and 6k Hz) for each listener. The results revealed that MCL for listening to speech in quiet was significantly increased when the speech stimuli were low-pass filtered at 2k Hz relative to the unfiltered and 6k Hz conditions. The results further indicated that acceptance of background noise was significantly poorer when the speech and noise stimuli were low-pass filtered at 2k Hz relative to the 6k Hz condition. However, effects for both the MCL and ANL measurements were relatively small and not significant clinically. Listeners with impaired hearing sensitivity had significantly greater MCL values than listeners with normal hearing, but ANL values were not significantly affected by the hearing sensitivity of the listener. The results also indicated that access to high frequency information resulted in a 3-dB or greater change (positive or negative) in ANL for 35% of the participants examined, suggesting that information beyond 2k Hz may potentially improve or degrade acceptance of background noise in some listeners.

Although ANLs have been found to be highly reliable within and between test sessions in individuals (Nabelek, Tampas & Burchfield, 2004), studies report of large between-subject differences in the acceptance of background noise among homogenous populations. Rogers, Harkrider, Burchfield, and Nabelek (2003) investigated gender of the listener as a possible factor contributing to the between-participant differences. Fifty adults (25 male, 25 female) between the ages of 19 and 25 years served as the experimental participants. Comfortable listening levels for speech and accepted levels of speech-babble background noise were obtained binaurally, via the sound field. Results indicated a statistical significance between the MCLs of males and females. Males on average had a 6 dB higher MCL than females. Males accepted a higher intensity of background noise while listening to speech at MCL, by approximately 7 dB, than females. However, even though male participants had a higher MCL and a higher BNL than females, the ANL was the same for the two genders. The result indicated that both males and females accept similar signal-to-noise (S/N) ratios while listening to speech presented at MCL.

To determine if individual differences in physiological activity measured from the peripheral and central auditory system account for the large inter-subject variability observed in ANL, Tampas, and Harkrider (2006) examined the auditory evoked potentials in females with high and low acceptance of background noise when listening to speech. Two groups of young, normal-hearing female adults in age range of 19 to 37 years (mean age = 24 years) were formed. Females were chosen on basis of previous research reporting robust electrophysiological responses in females than in males. One group had 11 participants with low ANLs of 6 dB or less, while the second group contained ten participants with high ANLs of 16 dB or greater. ABR, MLR, LLR were obtained from the two groups. The results indicated that difference in the responsiveness of more central regions of the auditory nervous system was related to the difference in the ANL. The high ANL group, overall, exhibited larger amplitudes across the AEP types than the low ANL group. ABR wave I and III were comparable between the two groups. However, the amplitude difference became increasingly more remarkable in wave V of the ABR as well as the MLR and LLR waves. The authors concluded that the processes occurring at more central levels of the auditory system are influencing the ANL response. The results also suggested that the central efferent mechanisms are stronger in the group with low ANLs such that sensory inputs are suppressed more than in the high ANL group and/or that central afferent mechanisms are less active in the low ANL versus the high ANL group.

In order to define the levels of the auditory system and physiological processes that contribute to ANL and phoneme recognition in noise (PRN), Harkrider, and Smith (2005) compared traditional PRN and ANL measures (monotic) with dichotic ANL measures (speech in one ear, noise in the opposite ear) from the same group of subjects. It was presumed that the dichotic ANL (ANL_d) would reflect processing from the superior olivary complex (the first place in the auditory system where information from the two ears is processed simultaneously) and higher. Thus, if monotically measured PRN or ANL (ANL_m) and dichotic ANL (ANL_d) were related, it would suggest a central mediation of the subject's PRN and ANL_m, not the periphery. Also, the authors investigated the individual differences in levels of efferent activity in the acoustic reflex (AR) arc and/or medial olivary cochlear bundle (MOCB) pathways to account for inter-subject variability tasks involving auditory performance in noise. Monotic and dichotic ANL, monotic PRN, contralateral suppression of transient evoked otoacoustic emissions, and ipsilateral and contralateral acoustic reflex thresholds were measured in 31 adults with normal hearing. Results indicated that the amount of background noise participants were willing to accept monotically (ANL_m) was correlated with the amount of background noise subjects were willing to accept dichotically (ANL_d). Also, participants accepting more background noise dichotically tended to perform better on the monotic task of recognizing phonemes in noise (PRN). The findings suggested that the ANL and PRN are mediated, to some extent, at a level at or beyond the superior olivary complex where binaural processing first occurs. The results also indicated that the intersubject variability in ANL measures could not be accounted for by individual differences in the level of efferent activity in the MOCB or AR pathways.

Harkrider, and Tampas (2006) investigated if individual differences in physiological activity measured from the cochleae to the peripheral and central auditory nervous systems of young female adults with normal hearing can, in part, account for the variability observed in ANL. Physiological responses from two groups of females (one with low ANLs and one with high ANLs) including CEOAEs, auditory brainstem responses (ABRs), and middle latency responses (MRLs) were obtained. Participants consisted of two groups of young female adults (20–37 years of age). One group consisted of seven participants with low ANLs of 6 dB or less, while the second group contained six participants with high ANLs of 16 dB or greater, for a total of 13 participants. Results indicated no differences between the groups for CEOAEs or waves I or III of the ABR. Differences between the two groups emerge for the amplitudes of wave V of the ABR and for the Na-Pa component of the MLR, suggesting that physiological variations arising from more central regions of the auditory system may mediate background noise acceptance.

The effect of stimulant medication on ANLs in individuals with Attention Deficit Hyperactivity Disorder (ADHD) and Attention Deficit Disorder (ADD) was investigated by Freyaldenhoven, Thelin, Plyler, Nabelek, and Burchfield (2005). The dependence of speech presentation level on acceptance of noise was also investigated. 15 normal hearing female college students with ADHD or ADD served as the participants. The participants were medicated in one session and unmedicated in the other session. Results showed that MCL was unaffected by the use of medication for individuals with ADHD/ADD. However, medication significantly increased the acceptance of background noise for these individuals. Results also indicated that acceptance of noise depends on speech presentation level, with ANLs decreasing significantly at all presentation levels with the use of medication, but the improvement in acceptance of noise was not dependent on medication.

Fisher, Burchfield, and Nabelek (1999) investigated the reliability of ANL and the relationship between ANL and preference for background noise in 12 young individuals with normal hearing. The ANL was measured, in dB HL, via earphones during three experimental sessions separated by one week. The participants responded consistently during each session and over the three-week period, yielding a strong positive correlation and indicating high test retest reliability. The preference for background noise was established with a questionnaire that determined the preferred type and amount of background noise when engaged in a number of daily activities including doing "chores," driving, reading, sleeping, and studying. The comparison between ANL and the reported preference for background noise resulted in a weak correlation. The results indicated that the ANL is a reliable measure but that the preference for background noise does not correspond with the ability to accept background noise. This suggested that the acceptance of background noise might be consistent over the life cycle.

According to Mueller, and Ricketts (2005), implementation of digital noise reduction (DNR) differentiates speech from noise mainly based on the amplitude changes over a short period of time (modulations). For a single talker there usually are 4–6 modulations/second, referred to as the modulation frequency. The modulation frequency and the depth of the modulations will vary over time because of the pauses between words and sentences and changes in stress patterns. Generally, signals that are modulated are classified as speech and those for which the amplitude does not vary much over time (steady-state) are classified as noise. In an attempt to assess the subjective benefit of digital noise reduction (DNR) processing in real world, Mueller, Weber, and Hornsby (2006) investigated the effect of activation of DNR processing in digital hearing aids on the aided ANLs. The participants in the study included 22 adults, 14 men and 8 women, in age-range from 23 to 76 years (mean age = 58.8 years). The participants had mild-moderate symmetrical sensorineural hearing loss, predominantly downward sloping. All participants were experienced, full-time users of bilateral hearing aids. The ANLs were assessed using Hearing in Noise test (HINT) in three conditions: unaided, aided with DNR turned-off, and aided with DNR turned-on. The results showed a significant mean improvement for the ANL (4.2 dB) for the DNR-on condition when compared to DNR-off condition. A significant correlation between the magnitude of ANL improvement (relative to DNR on) and the DNR-off ANL was also observed. However, there was no significant mean improvement for the HINT for the DNR-on condition. Also, on an individual basis, the HINT score did not significantly correlate with either aided ANL (DNR-on or DNR-off). The results, thus, indicated that DNR could significantly improve the clinically measured ANL, which may result in improved ease of listening for speech-in-noise situations.

Von Hapsburg, and Bahng (2006) hypothesized ANL as a language-independent measure and that the language related factors, such as amount of language proficiency, or language of test might not affect ANLs. The aim of the study was to determine (a) whether ANL can be obtained in a language other than English (e.g., Korean) with results similar to those obtained when English is the language of test (b) whether ANL is language dependent within Korean-English bilinguals (that is, does ANL vary within bilinguals according to language of test or according to language proficiency in second language), and (c) whether speech perception in noise is correlated with ANLs in bilingual listeners. Participants included 30 listeners, who were divided into three groups, two groups of Korean-English bilingual listeners and one group of monolingual English listeners. The ANL measure was obtained in English and Korean using procedures established by Nabelek, Tampas, and Burchfield (2004). The results showed that ANLs obtained in English (ANL-E) did not differ significantly for the bilingual and monolingual listeners. Additionally, a cross-language comparison, within bilinguals, showed that ANLs obtained using Korean (ANL-K) speech stimuli were not significantly different from ANL-E. However, speech perception in noise did not correlate with ANLs in English or Korean for the bilingual listeners. Results suggested that the ANL measure is language independent within bilinguals and may be of potential clinical use in minority language groups.

Freyaldenhoven, Plyler, Thelin, and Muenchen (2008) examined the effects of speech presentation level on acceptance of noise to differentiate full-time, part-time, and non-users of hearing aids and to predict hearing aid use. The participants were formed in three groups on the basis of the hearing aid use (a) full-time use, (b) part-time use, or (c) non-use. Acceptable noise levels (ANLs) were measured conventionally and at eight fixed presentation levels. The effects of presentation level on ANL were determined by calculating global ANL (ANL averaged across presentation level) and ANL growth (slope of the ANL function). The results indicated that global ANLs were not different for part-time users and nonusers. Compared with conventional ANL, the accuracy of the prediction for global ANL and ANL growth decreased, and the accuracy of the prediction at presentation levels of 65 to 75 dB HL was maintained. Thus, Global ANL differentiated the hearing aid groups in the same manner as conventional ANL. However, the effects of presentation level on acceptance of noise did not considerably increase the accuracy of the prediction compared with conventional ANL.

Freyaldenhoven, Nabelek, and Tampas (2008) investigated the relationship between acceptable noise levels (ANLs) and the Abbreviated Profile of Hearing Aid Benefit, APHAB (Cox & Alexander, 1995) and also the APHAB's ability to predict hearing aid use. 191 listeners with impaired hearing, separated into 3 groups based on hearing aid use: full-time, part-time, or nonuse served as participants. The ANL and APHAB data were collected. The results indicated no correlation between ANLs and APHAB scores. Results further indicated that administering both the ANL and APHAB could enhance the prediction of hearing aid use.

The previous research on ANL, thus, indicates that ANL is not affected by age, hearing sensitivity, gender, type of background noise, monaural or binaural amplification. The role of efferent activity of the medial olivocochlear bundle (MOCB) pathway, middle ear characteristics or speech perception in noise performance has also been studied. The result of these studies indicates a central mediation of ANL rather than periphery. ANL has also been established as an inherent characteristic of an individual and does not change over time. Thus, it is an effective tool to predict success with the hearing aid for naïve hearing aid users.

CHAPTER - 3

METHOD

The aim of the present study was to evaluate the effect of digital hearing aid, with and without noise reduction algorithm, on the aided Acceptable Noise Levels. The study also aimed at evaluating the effect of degree of hearing loss, effect of presentation level of speech stimuli and the effect of personality type on the aided Acceptable Noise Levels.

Participants

21 participants in the age range of 15 to 65 years (mean age = 49.78 years) were included in the study. The participants met the following criteria:

- Had hearing loss that was
  - post-lingually acquired
  - bilaterally symmetrical
  - either sensori neural or mixed
- Participants were native speakers of Kannada language.
- Participants had a speech identification scores (SIS) of ≥ 75 %.
- Participants did not have any significant neurological or cognitive listening deficits.
- Participants were naïve hearing aid users
- Participants who got a lie score of ≤4 on the Eysenck Personality Questionnaire (EPQ).

Each participant was assigned in one of the three groups based on the degree of hearing loss. Each group had seven participants. The groups were-

- Group I - Participants with moderate degree of hearing loss (PTA between 41 dB HL and 55 dB HL).
- Group II - Participants with moderately-severe degree of hearing loss (PTA between 56 dB HL and 70 dB HL).
- Group III - Participants with severe degree of hearing loss (PTA between 71 dB HL and 90 dB HL).

Equipment and Test Material

Hearing Aid

The hearing aid chosen for the purpose of study was a 15 channel digital BTE hearing aid. This hearing aid incorporated a noise reduction algorithm, high-resolution digital Noise Canceller (dNC). The frequency range of this hearing aid ranged from 100-6700 Hz and had a fitting range from mild to severe degree of hearing loss. The hearing aid was fitted to the ear of the participant using an appropriately sized eartip.

Personal Computer and Hi-Pro

The hearing aid was programmed using NOAH 3 and hearing aid specific softwares installed on a personal computer. The hearing aid was programmed through a hardware interface, Hi-Pro, which is an interface for connecting hearing aid to the personal computer.

Audiometer

A calibrated double channel diagnostic clinical audiometer was used to present the test stimulus (short stories) and speech spectrum noise. The recorded stimulus was routed through the audiometer through the auxiliary input available in the audiometer. The audiometer output was directed to a sound field speaker calibrated at 0^0 Azimuth at a distance of one meter from the participant in the test room.

Speech Material

The speech material used for the purpose of determining ANL included three standardized short stories in Kannada. The short stories were spoken in a normal vocal effort by a native Kannada adult male speaker. This was recorded on to a personal computer (PC) and was routed through the auxiliary input of the double channel audiometer. The three stories are given in the Appendix A.

Personality Assessment Questionnaire

The personality of the participants was assessed on Eysenck Personality Questionnaire (EPQ) (Eysenck & Eysenck, 1975). This questionnaire consisted of 57 items and typically requires 10 to 15 minutes to complete. It measures Extroversion (E) with 24 items; Neuroticism (N) with 24 items. A Lie (L) scale with 9 items is also included to screen out those individuals who may be responding to the questionnaire in a socially desirable way, rather than with true responses. Each item requires a ‘yes/no’ response. The EPQ is given in Appendix B.

Test Environment

All the testing was carried out in a two-room sound treated environment, with ambient noise levels within permissible limits.

Procedure

The conventional ANL procedure involved the tester adjusting the level of the story to the most comfortable listening level (MCL) of the participant. Then, a background noise was added, and the tester had to adjusted the noise to a level at which the participant would be willing to accept or "put up with" without becoming tense or tired while following the words of the story. This level was called the "background noise level (BNL)". The ANL was calculated by subtracting the BNL from MCL.

In the present study, one of the aims of the study was to evaluate the effect of presentation level on ANLs. Thus, one of the three groups in the study was chosen for fulfilling this aim. Since, the participants in Group I had the maximum dynamic range (DR) as compared to those in Group II and Group III, participants in Group I were utilized for this purpose.

The data were collected in the following five stages:

Stage 1. Establishing the unaided ANL (ANL_1).

Stage 2. Programming the hearing aid.

Stage 3. Establishing the aided ANL with noise reduction scheme turned off (ANL_2).

Stage 4. Establishing the aided ANL with noise reduction scheme turned on (ANL_3).

Stage 5. Assessment of the personality through Eysenck Personality Questionnaire

Stage 1. Establishing the unaided ANL (ANL_1).

The participant was made to sit comfortably on a chair in front of the loudspeaker in the test room. The speech stimulus was initially presented through the loudspeaker at the level of SRT, which was determined at the time of audiological assessment and gradually the level was adjusted in 5 dB steps upto the level of MCL and then in 2 dB steps until the MCL of the participant was established reliably. The step was repeated two times, and the average level was taken as the MCL. This level was noted down as MCL.

For establishing the MCL the following instructions were given:

"You will listen to a story through the loudspeaker placed in front of you. The loudness of the story will be varied. First, the loudness will be turned up until it is too loud and then down until it is too soft. You have to indicate the level at which the loudness of the story is most comfortable for you".

At this stage, a speech spectrum noise was introduced at 30 dB HL and its level raised to a point, in 5 dB steps, at which the participant was willing to accept the noise without becoming tired or tensed while listening to and following the words in the speech. This maximum level at which he/she could accept the noise without becoming tired was considered as the BNL. For the purpose of establishing BNL, the instructions used were "You will now listen to the story with a background noise. After you have listened to it for a few moments indicate the level of background noise that is the most you would be willing to accept or 'put-up-with' without becoming tense or tired while following the story. First, the noise will be turned up until it is too loud and then down until the story becomes very clear. Finally, indicate the maximum noise level that you would be willing to 'put-up-with' for a long time while following the story". This level, called the BNL, was noted down. The ANL_1 (in dB) was calculated as difference between MCL (dB HL) and BNL (dB HL) for each participant.

For the participants in Group I, the participant's dynamic range was also determined, by establishing the Speech Reception Threshold (SRT) and Uncomfortable Level (UCL) for speech. The difference between UCL and SRT determined the dynamic range (DR). The instructions used for establishing the DR was "You will be listening to a story through the loudspeaker placed in front of you. Initially the loudness of speech will be more and gradually the loudness will reduce. You have to indicate the softest level at which you are just able to follow the story. Then, the loudness of the story will be gradually increased. You have to indicate the level at which you are not able to tolerate the loudness of the speech stimulus". This procedure was repeated two times, and the average level was taken as DR. For the participants in Group I, each participant's dynamic range (DR) was measured. For this purpose, the softest level at which the participant was just able to follow the story was determined. For the purpose of the study, this level was noted down as SRT. Then, the level was gradually increased to a level at which the participant reported of discomfort. This level was noted down as UCL. ANL was obtained at three presentation levels of speech, i.e., at 5 dB SL (re: SRT), at mid value of DR and at 10 dB below UCL. The ANL_1 was calculated as difference between Presentation Level (dB HL) and BNL (dB HL). Thus, for the participants in Group I, three ANLs were obtained at three presentation levels, which were referred to as ANL_{1a}, ANL_{1b} and ANL_{1c} respectively. The global ANL was then calculated by averaging the ANLs obtained at the three presentation levels. This was in addition to the

ANL_1 that was measured, as described earlier. This was done for each participant of Group I.

Stage 2. Programming the hearing aid

The hearing aid was connected to the programming hardware (Hi-Pro) through a cable and detected by the programming software. The hearing thresholds of the participants were then fed into the programming software and target gain curves were obtained using the proprietary prescription formula of the hearing aid. The hearing aid gain was set to the default target gain and fine-tuned according to participant's preference. The hearing aid chosen for the study had three programs. Program 1 of the hearing instrument had the noise reduction algorithm, digital Noise Cancellation (dNC) turned off. In Program 2, the noise reduction algorithm (dNC) was turned on. The dNC had two degrees of noise reduction-light, and moderate. Moderate dNC was selected for the purpose of experiment. Only Program 1 and Program 2 were used in the study. The settings were saved in the hearing aid for each participant.

Stage 3. Establishing the aided ANL with noise reduction scheme turned off (ANL_2).

Only one ear, the ear with better PTA, of the participant was aided. The hearing aid was fitted in the ear with better pure tone average while the unaided ear was blocked with occlusion, when indicated. The hearing aid was set at Program 1. The participant was made to listen to a story. A different story was used to avoid any practice effect.

MCL and BNL were determined in this condition following the procedure described earlier, and the ANL was calculated. This ANL was labeled as ANL_{2}.

For the participants in Group I, the participant's SRT_2 and UCL_2 were established to obtain the dynamic range with the hearing aid called DR_2. The ANL was obtained at 3 presentation levels of speech, i.e., at 5 dB SL, mid value of DR_2 and 10 dB below UCL_2. The ANL_2 was calculated as difference between presentation level (dB HL) and BNL (dB HL). Thus, for the participants in Group I, ANLs were obtained at three presentation levels, which were referred to as ANL_{2a}, ANL_{2b} and ANL_{2c} respectively and global ANL was calculated for this condition.

Stage 4. Establishing the aided ANL with noise reduction scheme turned on (ANL_3).

To activate the noise reduction scheme in the hearing aid, Program 2 was used. This program had all the settings similar to Program 1 except for the addition of dNC noise reduction scheme at moderate level. With this program setting, the entire procedure described in Stage 3 was repeated and ANL was obtained. This was labeled as ANL_3. For the participants in Group I, three ANLs were obtained at three presentation levels, which were referred as ANL_{3a}, ANL_{3b} and ANL_{3c} respectively and global ANL was calculated for this condition.

Stage 5. Assessment of the personality through Eysenck Personality Questionnaire (EPQ).

The EPQ was administered to each participant. He/she was instructed to read each statement and if it described him or her, or, if he or she was in agreement with the statement then to draw a circle around 'Yes'. If the statement did not describe the participant, then to draw a circle around 'No'. The participant was also informed that there were no right or wrong answers and were required to give honest answers.

Scoring was done after the administration of EPQ. Each response was checked with the key. A clinical psychologist helped in scoring. If the participant's response agreed with the key, a score of '1' was given, if not a score of '0' was given. Separate scores were derived for Extroversion (E) and Neuroticism (N). Lie scale (L) was also checked and the number of responses agreeing with the key was totaled. Thus, there were three scores - E, N and L. If the L score was found to be high (≥5), the participant was not considered for the study. In the present study, two participants had to be deleted based on this criterion.

At the end of all these stages, the following data were tabulated for each participant for the purpose of analysis.

From Group I.

1. $MCL_{1,}$ PL_{1a}, PL_{1b}, PL_{1c}
2. $MCL_{2,}$ PL_{2a}, PL_{2b}, PL_{2c}
3. $MCL_{3,}$ PL_{3a}, PL_{3b}, PL_{3c}

4. $BNL_{1,}$ $BNL_{1a,}$ $BNL_{1b,}$ BNL_{1c}

5. $BNL_{2,}$ $BNL_{2a,}$ $BNL_{2b,}$ BNL_{2c}

6. $BNL_{3,}$ $BNL_{3a,}$ $BNL_{3b,}$ BNL_{3c}

7. $ANL_{1,}$ ANL_{1a}, ANL_{1b}, ANL_{1c} and Global ANL_1

8. $ANL_{2,}$ ANL_{2a}, ANL_{2b}, ANL_{2c} and Global ANL_2

9. $ANL_{3,}$ ANL_{3a}, ANL_{3b}, ANL_{3c} and Global ANL_3

10. Personality type

From Group II & III.

1. MCL_1
2. MCL_2
3. MCL_3
4. BNL_1
5. BNL_2
6. BNL_3
7. ANL_1
8. ANL_2
9. ANL_3
10. Personality type

To evaluate the objectives of the study, statistical analysis was carried out.

CHAPTER - 4

RESULTS AND DISCUSSION

The aim of the present study was to investigate the effect of digital hearing aid with and without noise reduction algorithm on the aided Acceptable Noise Levels. Also, the effect of degree of hearing loss, the effect of presentation level of speech stimuli and the effect of personality type on the aided Acceptable Noise Levels (ANLs) were investigated.

The data were collected from three groups of participants (each with seven participants) with either sensori-neural or mixed hearing loss. The ANL for each participant was obtained by subtracting background noise level (BNL) from the most comfortable level (MCL) in the unaided condition (UA) and in the aided conditions, without noise reduction (A1) and with noise reduction (A2). The following statistics were applied on the data:

1. Descriptive statistics for all the parameters measured.
2. Mixed analysis of variance (ANOVA) to compare the ANLs across the unaided and aided conditions and across severity.
3. Repeated measures ANOVA to study the effect of presentation level on ANL.
4. Post-hoc analysis to study the pair-wise difference, when ANOVA results were significant.
5. Correlation analysis to study the effect of personality on the ANL.

The Table 4.1 gives the mean and standard deviation of the ANLs for all the participants.

Table 4.1

Mean, standard deviation (SD) and range (minimum and maximum) of MCL, BNL & ANL for the participants in three groups

			Mean	*SD*	*Minimum*	*Maximum*
Group I (N=7)	*MCL*	*UA*	72.00	3.00	68.00	75.00
		A1	61.43	2.51	58.00	66.00
		A2	61.43	2.51	58.00	66.00
	BNL	*UA*	63.14	3.02	60.00	66.00
		A1	52.57	1.90	50.00	56.00
		A2	53.71	1.38	52.00	56.00
	ANL	*UA*	8.86	2.03	6.00	12.00
		A1	8.86	1.57	6.00	10.00
		A2	7.71	1.80	6.00	10.00
Group II (N=7)	*MCL*	*UA*	80.57	3.26	75.00	85.00
		A1	68.57	2.22	64.00	70.00
		A2	68.57	2.22	64.00	70.00
	BNL	*UA*	71.14	3.80	66.00	76.00
		A1	58.86	3.24	54.00	64.00
		A2	59.71	2.93	56.00	64.00
	ANL	*UA*	9.43	2.93	6.00	14.00
		A1	9.71	2.43	6.00	14.00
		A2	8.86	1.95	6.00	12.00
Group III (N=7)	*MCL*	*UA*	87.14	2.48	84.00	90.00
		A1	74.28	4.07	68.00	80.00
		A2	74.28	4.07	68.00	80.00
	BNL	*UA*	78.86	4.45	72.00	86.00
		A1	65.71	4.39	60.00	72.00
		A2	66.57	4.12	62.00	72.00
	ANL	*UA*	8.28	2.98	4.00	12.00
		A1	8.57	3.21	4.00	14.00
		A2	7.71	2.69	4.00	12.00

The Table 4.1 also provides the MCLs, BNLs and ANLs in the unaided (UA) and aided conditions (A1 and A2). The MCL values in all the conditions were higher than the BNL values as revealed in the table above.

Effect of degree of hearing loss on Aided Acceptable Noise Levels

Group I (moderate degree of hearing loss)

From Table 4.1, it can be observed that the mean ANL in individuals with moderate hearing loss group was 8.85 dB with a standard deviation of 2.03 dB in the unaided condition. In the first aided condition when the noise reduction was turned-off (A1), the mean ANL was 8.85 dB with a standard deviation of 1.57 dB. In the second aided condition when the noise-reduction was turned-on (A2), the mean ANL was lesser and was 7.71 dB with a standard deviation of 1.79 dB.

Group II (moderately-severe degree of hearing loss)

The mean ANL in those with the moderately-severe hearing loss group was 9.42 dB with a standard deviation of 2.93 dB in the unaided condition. In the first aided condition (A1), the mean ANL was 9.71 dB with a standard deviation of 2.43 dB. In the second aided condition (A2), the mean ANL was 8.85 dB with a standard deviation of 1.95 dB.

Group III (severe degree of hearing loss)

The mean ANL in those with severe hearing loss group was 8.28 dB with a standard deviation of 2.98 dB in the unaided condition. In the first aided condition (A1), the mean ANL was 8.57 dB with a standard deviation of 3.20 dB. In the second aided condition (A2), the mean ANL was 7.71 dB with a standard deviation of 2.69 dB.

To evaluate interactions between the ANLs obtained in the different unaided and aided conditions across the severity of the hearing impairment mixed analysis of variance (ANOVA) was done. There was no significant interaction effect of the ANL among the three conditions across the severity of hearing-impairment [F (4, 36) = 0.202, p > 0.05]. However, there was a significant main effect for different unaided and aided conditions [F (2, 36) = 5.66, p< 0.01]. To evaluate the significant differences in the different unaided (UA) and aided (A1 & A2) conditions, pair-wise comparison using post-hoc Bonferroni done. Table 4.2 depicts the results of post-hoc Bonferroni analysis for the UA, A1 and A2 conditions.

Table 4.2

Results of post-hoc Bonferroni analysis for the ANLs in the UA, A1 and A2 conditions

Conditions	*Significance level*
UA∗A1	p>0.05
UA∗A2	p<0.05
A1∗A2	p<0.05

Pair-wise comparisons of the UA, A1 and A2 conditions revealed non-significant difference (p> 0.05) between the ANLs obtained in the UA and A1 conditions, i.e., the

ANL obtained in the unaided condition and in the aided condition with noise-reduction algorithm turned-off were not significantly different. This implied that the hearing aid did not make any significant difference in the ANLs measured in the UA and A1 conditions. However, the ANLs obtained in the A2 condition were significantly different ($p < 0.05$) from the ANLs obtained in the UA and A1 conditions, i.e., when the noise-reduction algorithm was turned-on, the ANL values obtained were significantly lesser from those obtained in the unaided and the aided condition with noise-reduction turned-off conditions. Thus, when the noise-reduction algorithm was turned-on, it significantly affected the ANL score. The ANL values were always lower in the aided condition when the noise-reduction was turned-off.

Studies done on acceptable noise levels (ANLs) have evaluated the effect of age (Nabelek, Tucker & Letowski, 1991), gender (Rogers, Harkrider, Burchfield & Nabelek, 2003), type of background noise (Crowley & Nabelek, 1996), efferent activity of the medial olivocochlear bundle (MOCB) pathway, middle ear characteristics (Harkrider & Smith, 2005), speech perception in noise performance (Crowley & Nabelek, 1996; Nabelek, Tampas & Burchfield, 2004), unaided and aided performance (Nabelek, Tampas & Burchfield, 2004), monaural vs. binaural amplification (Freyaldenhoven, Plyler, Thelin & Burchfield, 2006). However, in most of the studies, the participant's hearing thresholds ranged from mild to moderate degree. (Nabelek, Tucker & Letowski, 1991; Freyaldenhoven, Plyler, Thelin & Burchfield, 2006; Nabelek, Tampas & Burchfield, 2004). In the present study the effect of severity of hearing loss from moderate to severe degree on ANL was studied. Results of Mixed ANOVA revealed that

ANLs were not significantly different across the degree of hearing loss in the three unaided and aided conditions.

The results of the present study are in agreement with those reported earlier (Nabelek, Tucker, & Letowski, 1991; Nabelek, Freyaldenhoven, Thelin, Burchfield & Muenchen, 2006; Mueller, Weber, & Hornsby, 2006). Participants with average thresholds in the range of mild to moderate were included in the previous studies. In the present study, it was found that the ANLs were not significantly different from moderate hearing loss group to severe hearing loss group.

Nabelek, Tucker, and Letowski (1991) assessed the "tolerated speech-to-noise ratios (S/N)", in four groups of elderly listeners and one group of young listeners. The tolerated S/Ns in each group were not related to age or hearing loss of the subjects and were independent of the MCL selected for listening to speech. Nabelek, Freyaldenhoven, Thelin, Burchfield, and Muenchen (2006) investigated the utility of ANLs as a predictor of hearing aid use. Three groups of participants based on the patterns of hearing aid use were formed. Correlational analysis was done to establish a relationship between the ANLs, gender, PTA and age. Results indicated that both unaided and aided ANLs were not related to gender and PTA. However, aided ANLs were weakly correlated with age. Similar results have also been reported in a study by Mueller, Weber, and Hornsby (2006), in which no significant relationships between either auditory threshold or programmed REIG (250- 4000 Hz) and the participants' ANLs were found. These findings support the view that the ANLs are not affected by the status of the peripheral auditory structures (i.e. cochlear hearing loss) or by habilitation by the amplification device (Harkrider & Tampas, 2006).

Harkrider, and Tampas (2006) evaluated physiological responses (CEOAE, ABR and MLR) on those with low- and high- ANLs. They found no differences in CEOAE amplitudes or in the amplitudes and latencies of waves I or III of the ABR in two groups of participants with low- and high- ANLs. However, group differences were found in the amplitudes of wave V of the ABR and Na-Pa component of the MLR. This suggested that more central regions of the auditory system might account for variability in willingness of the listeners to accept background noise.

Harkrider, and Smith (2005) investigated the individual differences in the efferent activity in medial olivocochlear bundle (MOCB) and acoustic reflex (AR) pathways to account for inter-subject variability in ANL and phoneme recognition in noise (PRN). They indicated that the amount of background noise the participants were willing to accept in monotic condition was directly related to that in dichotic listening condition. This suggested that non-peripheral factors, beyond the level of the superior olivary complex -where binaural processing first occurs, mediate ANL. Thus, in the present study even when the degree of hearing loss is varying across the groups, the ANL obtained for the participants was not dependent on the severity of hearing loss, indicating a central mediation of ANL.

The effect of digital hearing aid with and without the noise reduction scheme on Aided Acceptable Noise Levels and it's relationship with the unaided ANLs

As observed from Table 4.2, results of pair-wise comparison indicate a significant difference between the ANLs obtained in A2 condition than in UA and A1 conditions. Also, no significant difference between UA and A1 condition was noticed. The results are in agreement with the findings of Nabelek, Tampas, and Burchfield (2004) who compared the speech perception in background noise (SPIN) with the acceptance of background noise in the unaided and the aided conditions. The results indicated that ANLs were independent of hearing-aid amplification. The ANLs and SPIN scores were found to be unrelated as there was a significant improvement in the SPIN scores with amplification.

In the present study, the participants were divided into three groups based on the degree of hearing loss. The mean MCL value in Group I (moderate hearing loss group), was 72 dB in the unaided condition while it was 61.4 dB in the aided condition with noise-reduction algorithm turned-off. The improvement in MCL value reflected the effect of amplification. When the noise-reduction algorithm was turned-on, the mean MCL value was found to be the same as in the first aided condition i.e., 61.4 dB, which indicates no effect of noise reduction algorithm on the MCL for speech. The mean BNL values for the moderate group in the UA, A1 and A2 conditions were 63.1 dB, 52.5 dB and 53.7 dB respectively. Thus, reduction in the BNL was observed with the use of hearing aid. However, when the noise-reduction is turned-on, the BNL further increases by 1.2 dB, which is reflected as a lower ANL in the A2 condition than in A1 condition. A similar trend was seen in Group II and Group III. It should be noted that in a study by

Nabelek, Tampas and Burchfield (2004), the full-time and part-time groups had similar MCLs and the main contributor for the difference in ANL was the BNL. In contrast, in the present study, the groups were formed on basis of the degree of hearing loss and both the MCLs and BNLs were found to vary in each group. However, the ANLs were found to be similar in each group.

In the present study within the group, as revealed from Table 4.2, the ANLs in the A2 condition were significantly different from the ANL obtained in the UA and A1 conditions. This was revealed on the mixed ANOVA results [$F (2, 36) = 5.66$, $p< 0.01$]. This indicates a significant effect of noise-reduction algorithm on the ANLs and specifically on the BNLs (as the MCLs were unaffected with the noise-reduction algorithm). The results of the present study are in consensus with the results of the study by Mueller Weber, and Hornsby (2006), in which a significant mean improvement of 4.2 dB was observed on ANLs with the noise-reduction turned-on. However, in the present study, the mean improvement in ANL was 1.1 dB in Group I, 0.9 dB in Group II and 0.8 dB in Group III, which was significant. The discrepancy between the mean improvement in the study by Mueller Weber, and Hornsby (2006) and the present study can be accounted for by the differences in the hearing instrument used and the lesser number of participants in each group in the present study. It has been reported that the listeners often demonstrate a strong tendency for subjective preference for DNR algorithms (Boymans & Dreschler, 2000), and actual improvement in speech perception is reportedly minimal.

Mueller, Weber, and Hornsby (2006) also reported that the improvement of 4.2 dB with the use of DNR feature was equivalent to the benefit reported by Freyaldenhoven, Nabelek, Burchfield, and Thelin (2005) for directional technology when the noise was presented from 180^0 Azimuth. However, studies comparing the benefit from directional microphones and noise-reduction algorithm have often reported a lesser benefit from noise-reduction algorithm as compared to use of directional microphones. (Nordrum, Erler, Garstecki & Dhar, 2006) which support lesser improvement seen with noise-reduction algorithm in the present study. Also, it can also be noted that, the mean improvement observed with the noise-reduction feature gradually reduced as the severity of the hearing loss increased. Although, this reduction in benefit with severity is very small, it might indicate the inability of the participants, to make use of the benefit of noise-reduction scheme, as the hearing loss progresses. This slight but significant difference between the A1 and A2 conditions could be because of the type of strategy used for noise reduction in the hearing aid.

Effect of presentation level on Aided Acceptable Noise Levels in moderate degree of hearing loss

To study the effect of presentation level on the ANLs, the ANL was obtained at three presentation levels of speech, 5 dB SL (re: SRT), mid range of dynamic range (DR) and at 10 dB below UCL for Group I only. Table 4.3 gives the mean and standard deviation (SD) of the ANL values obtained at the three presentations levels under the unaided and two aided conditions. The results indicate that the ANL value increased as the level of presentation increased.

Table 4.3

Mean and standard deviation (SD) for the ANLs obtained at three presentation levels under different unaided and aided conditions

	Mean	*Std. Deviation*
UA ANL1	8.86	2.61
UA ANL2	10.00	1.73
UAANL3	11.71	1.38
A1 ANL1	8.28	1.70
A1 ANL2	10.71	2.98
A1 ANL3	11.86	1.95
A2 ANL1	7.71	2.50
A2 ANL2	9.00	2.89
A2 ANL3	9.28	2.43

The Global ANLs were also calculated by taking the sum of ANLs obtained at three presentation levels and averaging it. Table 4.4 shows the mean and standard deviation for the Global ANLs across the unaided and the two aided conditions.

The results indicate that the mean Global ANL was 10.19 dB in the unaided condition (UA), 10.28 dB in the first aided condition (A1) and 8.66 dB in the second aided condition (A2). To determine the effect of presentation level on ANL, repeated measures ANOVA was carried out. The results revealed a significant main effect for the presentation levels [$F(2, 12) = 20.705$, $p<0.05$]. Table 4.5 reveals the results of Bonferroni pair-wise comparison of ANLs obtained at three presentation levels.

Table 4.4

Mean, standard deviation and range of the Global ANL in the unaided (UA) condition, A1 condition and in A2 condition

	Global ANL			
Condition	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
UA	10.19	1.44	8.86	11.71
A1	10.28	1.82	8.29	11.86
A2	8.67	.837	7.71	9.29

The results of the Bonferroni pair-wise comparisons indicate a significant difference between the ANLs obtained at the three presentation levels ($p<0.05$), i.e., the ANL obtained at the three presentation levels is significantly different from each other. The ANL values gradually increased as the presentation level is increased from 5 dB SL (re: SRT) to 10 dB below UCL.

Table 4.5

Bonferroni pair-wise comparison of ANLs obtained at three presentation levels

Presentation level (PL)	*Significance level*
PL1∗PL2	p<0.05
PL1∗PL3	p<0.05
PL2∗PL3	p<0.05

The results are in agreement with the study by Freyaldenhoven, Plyler, Thelin, and Hedrick (2007) determining the effect of presentation level on ANLs. They measured the effects of speech presentation level on the acceptance of noise in listeners with normal and impaired hearing to determine whether these effects were related to the hearing sensitivity of the listener. The effect of speech presentation level on acceptance of noise was analyzed by determining Global ANLs (i.e., ANL averaged across speech presentation levels) and ANL growth (i.e., the slope of the ANL function) for each participant. The results demonstrated that Global ANLs and ANL growth were not significantly different for listeners with normal and impaired hearing, and neither ANL measure was related to pure-tone average (PTA; i.e., average of 0.5, 1, 2, and 4 kHz) for listeners with impaired hearing. In addition, conventional ANLs were significantly correlated with both Global ANLs and ANL growth for all listeners.

Freyaldenhoven, Plyler, Thelin, and Muenchen (2008) further evaluated the effects of speech presentation level on the hearing aid users. The participants formed into different groups based on the hearing aid use were tested at eight presentation levels in the aided condition. Results indicated similar findings as reported by Freyaldenhoven, Plyler, Thelin, and Hedrick (2007). The results of the present study also support the findings of Nabelek, Tampas, and Burchfield (2004) that amplification without the noise-reduction does not affect the ANLs. This holds valid even when the speech is presented at different presentation levels rather than at MCL. It is observed that the different presentation levels yield similar ANL growth in both unaided and aided conditions. The findings imply that ANLs are inherent to an individual and can be used as a tool to assess the hearing aid outcome.

Effect of personality type on Aided Acceptable Noise Levels

To investigate the effect the personality type on the ANL value, Pearson's correlation analysis was carried out. The personality scores were obtained as Extroversion score and Neuroticism score and compared with ANLs separately. Table 4.6 gives the results of correlation analysis between ANL (in different conditions) and Extroversion score.

Table 4.6

Pearson's correlation between ANL and Extroversion score

Condition	*N*	*Pearson Correlation*	*Level of significance*
UA ANL	*21*	*-0.288*	*p>0.05*
A1 ANL	*21*	*-0.118*	*p>0.05*
A2 ANL	*21*	*-0.288*	*p>0.05*

The results indicate a non-significant negative correlation between the ANLs and the Extroversion score ($p>0.01$). Thus, for all the conditions, the participants with higher ANL scores achieved a lower score on Extroversion scale and vice versa. However, this negative correlation was low and non-significant. It is thus possible that, an individual scoring higher on extroversion is likely to tolerate more amounts of background noise and thus obtaining a lower ANL.

Table 4.8 give the results of correlation analysis between ANL (in different conditions) and Neuroticism score. The results indicate a non-significant positive correlation between the ANLs and the Neuroticism score (p>0.01).

Table 4.8

Results of correlation analysis between ANL and Neuroticism score

Condition (N=21)	*Pearson Correlation*	*Level of significance*
UA ANL	*0.196*	*p>0.05*
A1 ANL	*0.122*	*p>0.05*
A2 ANL	*0.101*	*p>0.05*

Thus, for all the conditions, the participants with higher ANL scores achieved a higher score on Neuroticism scale and vice versa. However, this correlation was low and also non-significant. According to Costa, and McCrae (1997), individuals scoring low on Neuroticism are more relaxed and calm, and are better able to cope with stressful situations in their lives. Thus, participants who scored low on neuroticism were capable of tolerating more amount of background noise, which represents a stressful condition for an individual with hearing impairment.

The results on the effect of personality, thus, indicate that the individual's acceptance of background noise is related to his personality. The relationship was however, non-significant, which may be because of the limited number of participants in the study. Cox, Alexander, and Gray (1999) investigated the relationship between the personality trait and self-reported hearing aid benefit in individuals with mild to moderate sensori-neural hearing loss. The results indicated extroversion-introversion to be the best predictor of hearing aid benefit. More extroverted individuals reported greater hearing aid benefit on these three sub-scales of the APHAB than the more introverted individuals. In addition, individuals who reported greater anxiety also reported more problems in communication as measured on the aided condition of the 'Ease of Communication' sub-scale of the APHAB.

Summary of the findings of the present study:

The present study investigated the effect of digital hearing aid with and without noise reduction algorithm on the aided Acceptable Noise Levels and the relationship between the unaided and aided ANLs. The effect of degree of hearing loss, presentation level of speech stimuli, and the effect of personality type on the aided Acceptable Noise Levels (ANLs) were also investigated. The findings of the study indicate:

1. ANLs across the severity of hearing loss were found to be non-significant, indicating that ANLs are not affected by the peripheral hearing loss.
2. ANLs obtained in the unaided and aided conditions are not significantly different.
3. Digital noise-reduction feature significantly decreased the ANL by increasing the amount of tolerance for background noise. However, as the hearing loss increased, this decrement in ANL reduced.

4. When ANL was measured at different presentation levels of speech rather than MCL, there was a gradual increment in the ANL with increase in the presentation level.
5. The personality of the participant influenced the ANLs. The higher extroverted personality obtained, lower was the ANL. While the participant high on neuroticism obtained a higher ANL. However, these correlations were weak and not significant.

CHAPTER-5

SUMMARY AND CONCLUSION

Acceptable Noise Level" (ANL) is a measure of the willingness to accept background noise while listening to speech. The ANL is defined as the difference between the most comfortable listening level (MCL) for running speech and the maximum background noise level (BNL) that a listener is willing to accept. Studies on ANL have investigated the effect of age, hearing sensitivity (Nabelek, Tucker & Letowski, 1991), gender (Rogers, Harkrider, Burchfield & Nabelek, 2003), type of background noise(Crowley & Nabelek, 1996), efferent activity of the medial olivocochlear bundle (MOCB) pathway(Harkrider & Smith, 2005), middle ear characteristics or speech perception in noise performance (Nabelek, Tampas & Burchfield, 2004). However, in most the studies, the hearing loss of the participants ranged from mild to moderate degree. Also, there is a dearth in literature investigating the effect of noise-reduction algorithm on the ANLs. The study by Mueller, Weber, Benjamin, and Hornsby (2006) reported an improvement of 4.2 dB in ANL with use of noise-reduction algorithm. However, it was not indicated that how this improvement with noise reduction algorithm varied as a function of degree of hearing loss and/or as a function of presentation level of the speech stimulus. Also, there is no literature investigating the effect of personality on the ANLs. Studies report that the personality of the individual affects the perceived hearing aid benefit (Cox, Alexander & Gray, 1999). Since, ANL is a tool to predict hearing aid benefit for the user, the need to study the relation between the individual's personality and ANL was also felt.

The present study, thus, aimed to evaluate the following:

1. The relationship between the unaided and aided Acceptable Noise Levels
2. The effect of degree of hearing loss on Aided Acceptable Noise Levels.
3. The effect of digital hearing aid with and without the noise reduction scheme on Aided Acceptable Noise Levels.
4. The effect of presentation level on Aided Acceptable Noise Levels in moderate degree of hearing loss.
5. The effect of personality type on Aided Acceptable Noise Levels.

For the purpose of the study, three groups of participants (sensori-neural or mixed) based on the degree of hearing loss, were formed (seven in each group). The degree of hearing loss for the three groups were moderate, moderately-severe, and severe degrees. The participants were assessed in the unaided and two aided conditions. The two aided conditions included fitting of an appropriate digital hearing aid with noise-reduction feature turned-off in the first aided condition and the feature turned-on in the second aided condition.

To assess the effect of presentation level, only participants with the moderate degree (Group I) were considered, as they had the maximum dynamic range (DR) among the three groups. The ANLs were obtained at three presentation levels, at 5 dB SL, mid-value of DR and 10 dB below the UCL. Testing was carried out in the unaided and the two aided conditions.

To assess personality of the participant, Eysenck Personality Questionnaire (EPQ), was administered which assesses the individual's personality on the domains of extroversion and neuroticism.

Appropriate statistics were applied to analyze the parameters of the study. The results indicated that the following:

1. ANLs obtained in the unaided and aided conditions were not significantly different.
2. The difference in ANLs across the severity of hearing loss was found to be non-significant, indicating that ANLs are not affected by the peripheral hearing loss.
3. Digital noise-reduction feature significantly decreased the ANL by increasing the amount of tolerance to background noise. Thus, this feature in a hearing aid might have an influence on the consistent use of hearing aid by the users. However, as the hearing loss increased, this decrement reduced.
4. When ANL was measured at different presentation levels of speech rather than MCL, there was a gradual increment in the ANL with increase in the presentation level.
5. On personality assessment, the higher extroverted personality obtained a lower ANL while the participant high on neuroticism obtained a higher ANL. However, this correlation was not significant. Thus, the personality of the participant might influence the ANLs.

The results are, thus, in agreement with the previous research carried on ANL. The present study also highlights the effect of personality on ANL. Since, ANL is an effective tool to predict success with use of hearing aid, the personality of the individual should also be considered as a factor, which can affect ANL. This information will be useful during the counseling as an indicator of benefit from the hearing aid.

Clinical implications

The present study highlights the efficacy of ANLs as a clinical tool to evaluate the benefit from hearing aid. ANL can be obtained on a routine basis in a regular audiological set-up. ANL does not require any sophisticated instrumentation for assessment and is less time-consuming. The study also indicates the utility of having noise-reduction feature in a digital hearing aid, use of which can increase the probability of the hearing aid wearer to become a successful user. Also, personality of the individual should be considered as a factor that might influence the prediction of success with the hearing aid. Knowing about the client's ANL will help the clinician in effective counseling about the realistic expectations with the hearing aid.

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APPENDIX A

Story 1

bengaḷu:ru namma: rad↗jada: dıoḍḍa u:ru:. i: u:rannu namma: rad↗jadıa: bamba:i: ennuvaru:. inḍijadıa: doḍḍa nagaragaḷalli: idıu ondıu. i: urannu noḍalu d↗anaru bere bere rad↗jagaḷindıa baruvaru. i: dıaḷḷadıe namma: rad↗jadıalliruva: belu:r, d↗og, nandıi:, i:vugaḷannu: noḍalu d↗anaru baruvaru:. i:na:ḍinalli re:⊲mejaṇṇu beḷejuvaru.

Story 2

kri⊲na: nadıiju: sahja:dıri: parvatagaḷalli mahabale⊲waradıa hatıtıira: huṭṭutıade. idıu huṭṭuwa pradıe⊲avu: ramaṇi:ja stıa:na:. idıu maha:ra:⊲ṭra, karna:ṭaka: matıtıu a:nd^{h}ra: pradıe:⊲agaḷalli haridıu ba.·˙ga:ḷa kollij≜nnu se:rutıtıadıe. idıakke: upanadıi:gaḷu halavu. koina, tıungab^{h}adıra:, g^{h}aṭaprabha:, b^{h}i:ma, malaprab^{h}a, avugaḷalli kelavu: koina: nadıige aṇekaṭṭannu kaṭṭi vidıjutıannu utıpa:dı≜ne ma:ḍutıa:re.

Story 3

ondıu haḷḷijalli hobba kuruba: huḍuga: va:sava:gidıdıanu. avanu mund↗a:nje edıdıu ka:ḍige hogi: alli jed↗harialli: sna:na ma:di sand↗ejavarege kurijannu meisi sand↗e haḷḷigewa:pasa:gutıidıdıa. omme avanu kuri meisuva:ga idıdıakkidıantıeje hatıtıiradıa: holadallii kel≙sa: maḍutıtıidıa ra:itıarannu tıama:⊲e maḍabeku indıukonḍa antıeje avanu aiyyo huli huli ka:pa:di endıu ku:gatıoḍagidıa: idıannu keḷidıa raitıaru khadgagaḷḷannu tegidıukonḍu hulijannu kollalu sidıdıara:gi o:ḍibandıaru. idıannu noḍidıa huḍuga nakku biṭṭa: raitıaru ko:pa gondu wa:pasa:dı≙ru. huḍuga: idıe:ri:tıi a:idıaru ba:ri maḍidıa. raitıaru a: hudugana melina nambike kaḷedıu konḍaru. omme suma:ru hanneredu ghanṭe bisilu ta:ḷala:radıe huduga: t⊲hatı≙rijannu hiḍidıu kuḷitıtıidıa idıdıakkidıantıe nid↗ava:giju thakkahuli bande biṭṭidıu. huḍuga matıtıe ka:pa:ḍi ka:pa:ḍi indıu t⊲irida. a:dı≙re ja:rusaha: avan≙ sahajakke baraḷilla. huliju avana: saṇṇa saṇṇa, kurigaḷannu koll≙larambisitıu. adıannu ka:pa:ḍalu ho:dıa a: huḍuganamele a: huliha:ri avanannu: konditıu. i: katıejani:tıi jennandıare suḷḷuga:ranige ⊲ik⊲e tıappadıu.

APPENDIX B

L¸ÉAPÉ ªÀåQÛvÀé ¥Àæ±ÁßªÀ½

ºÉ¸ÀgÀÄ:

ªÀAiÀÄ¸ÀÄì:

GzÉÆåÃUÀ: UÀA-ºÉA:

¸ÀÆZÀ£É

E°è ¤ªÀÄä C¤¹PÉ, ªÀÄ£ÉÆÃ¨sÁªÀ, ºÁUÀÆ ªÀvÀð£ÉUÀ¼À PÀÄjvÀÄ PÉ®ªÀÅ ¥Àæ±ÉßUÀ¼À£ÀÄß PÉÃ¼À¯ÁVzÉ. ¥Àæw ¥Àæ±ÉßAiÀÄ £ÀAvÀgÀ `ºËzÀÄ' ªÀÄvÀÄÛ `E®è' JA§ GvÀÛgÀUÀ½UÁV eÁUÀªÀ£ÀÄß ©nÖzÉ. F GvÀÛgÀUÀ½AzÀ ¤ÃªÀÅ ¸ÁªÀiÁ£ÀåªÁV ªÀwð¸ÀÄªÀ jÃw CxÀªÁ ¨sÁªÀ£ÉUÀ¼À£ÀÄß wÃªÀiÁð¤¸À®Ä ¥ÀæAiÀÄwß¹. £ÀAvÀgÀ `ºËzÀÄ' CxÀªÁ `E®è' JA§ÄzÀ£ÀÄß DªÀgÀtzÀ°è UÀÄgÀÄvÀÄ ºÁQ. AiÀiÁªÀÅzÉÃ ¥Àæ±ÉßAiÀÄ ªÉÄÃ¯É ºÉZÀÄÑ ¸ÀªÀÄAiÀÄ vÉUÉzÀÄPÉÆ¼ÀîzÉ eÁUÀævÉ GvÀÛj¹. AiÀiÁªÀ ¥Àæ±ÉßAiÀÄ §UÉÎAiÀÄÆ ¢ÃWÀðªÁV D¯ÉÆÃa¸À¨ÉÃPÁ¢Ý®è. ¥Àæ±ÉßAiÀÄ §UÉÎ ¤ªÀÄä ªÉÆzÀ® ¥ÀæwQæAiÉÄ K£ÉA§ÄzÀÄ ªÀÄÄRå. ErÃ ¥Àæ±ÁßªÀ½UÉ GvÀÛj¸À®Ä ¤ªÀÄUÉ PÉ®ªÉÃ ¤«ÄµÀUÀ½VAvÀ ºÉZÀÄÑ ¸ÀªÀÄAiÀÄ »rAiÀÄ¨ÁgÀzÀÄ. AiÀiÁªÀ ¥Àæ±ÉßAiÀÄ£ÀÆß ©qÀzÉ GvÀÛj¹.

EzÀÄ §Ä¢Þ±ÀQÛAiÀÄ ¥ÀjÃPÉë K£À®è. ¤ÃªÀÅ ªÀwð¸ÀÄªÀ jÃwAiÀÄ£ÀÄß ªÀiÁvÀæ ¸ÀÆa¸ÀÄvÀÛzÉ. ¤ÃªÀÅ ¸Àj CxÀªÁ vÀ¥ÀÄà EªÀÅUÀ¼À°è AiÀiÁªÀÅzÉÃ GvÀÛgÀªÀ£ÀÄß PÉÆlÖgÀÆ ¸ÀjºÉÆAzÀÄvÀÛzÉ.

J£ï	E	J¯ï

		ºËzÀÄ	E®è
1.	¤ÃªÀÅ ¥ÀzÉÃ ¥ÀzÉÃ GzÉéÃUÀUÉÆ¼ÀÄîwÛÃgÁ?	( )	( )
2.	¥ÀzÉÃ ¥ÀzÉÃ ¤ªÀÄUÉ GvÉÛÃf¸ÀÄªÀ ¸ÉßÃ»vÀgÀÄ ¨ÉÃPÉAzÉ¤¸ÀÄvÀÛzÉAiÉÄÃ?	( )	( )
3.	¸ÁªÀiÁ£ÀåªÁV ¤ÃªÀÅ AiÀiÁªÀ «ZÁgÀzÀ §UÉÎAiÀÄÆ vÀ¯É PÉr¹PÉÆ¼ÀîzÉ EgÀÄwÛÃgÁ?	( )	( )
4.	D¸ÀQÛ¬ÄA¢gÀÄªÀ «µÀAiÀÄPÉÌ AiÀiÁgÁzÀgÀÆ CqÀZÀuÉ vÀAzÀgÉ ¤ªÀÄUÉ ¨ÉÃ¸ÀgÀªÉ¤¸ÀÄvÀÛzÉAiÉÄÃ ?	( )	( )
5.	AiÀiÁªÀÅzÉÃ PÉ®¸ÀªÀ£ÀÄß ªÀiÁqÀÄªÀ ªÀÄÄ£Àß DUÀÄºÉÆÃUÀÄUÀ¼À §UÉÎ ¤ÃªÀÅ aAw¸ÀÄwÛÃgÁ ?	( )	( )
6.	¤ªÀÄUÉ JµÉÖÃ CqÀZÀuÉUÀ¼ÀÄ §AzÁUÀÆå EvÀgÀjUÉ ¤ÃªÀÅ ªÀµÀ£À PÉÆlÖAvÉ £ÀqÉAiÀÄÄwÛÃgÁ ?	( )	( )
7.	¤ªÀÄä ªÀÄ£ÀB¹ÜwAiÀÄ°è DUÁUÉÎ Kj½vÀUÀ¼ÀÄ GAmÁUÀÄªÀÅzÉÃ ?	( )	( )
8.	¸ÁªÀiÁ£ÀåªÁV ¤ÃªÀÅ AiÉÆÃa¸ÀzÉÃ ªÀiÁvÀ£ÁqÀÄªÀÅzÁUÀ°Ã PÉ®¸À ªÀiÁqÀÄªÀÅzÁUÀ°Ã ªÀiÁqÀÄwÛÃgÁ ?	( )	( )
9.	AiÀiÁªÀ ¸ÀjAiÀiÁzÀ PÁgÀtªÀÇ E®èzÉ fÃªÀ£ÀzÀ°è fUÀÄ¥Éì ºÉÆA¢¢ÝÃj JA§ ¨sÁªÀ£É GAmÁUÀÄvÀÛzÉAiÉÄÃ ?	( )	( )
10.	PÉÃªÀ® ¸ÁºÀ¸À ¥ÀæzÀ±Àð£ÀPÁÌV ¤ÃªÀÅ K£ÀÄ ¨ÉÃPÁzÀgÀÆ ªÀiÁqÀ®Ä ¹zÀÞgÁVgÀÄwÛÃgÁ ?	( )	( )
11.	DPÀµÀðPÀ C¥ÀjavÀ ªÀåQÛAiÉÆqÀ£É ªÀiÁvÀ£ÁqÀ®Ä ¸ÀAPÉÆÃZÀ ¥ÀqÀÄwÛÃgÁ ?	( )	( )
12.	MªÉÆäªÉÄäAiÀiÁzÀgÀÆ vÁ¼ÉäUÉlÄÖ PÉÆÃ¥ÀUÉÆ¼ÀÄîwÛÃgÁ ?	( )	( )

13.	¤ÃªÀÅ PÉ®¸ÀUÀ¼À£ÀÄß vÀqÀ ªÀiÁqÀzÉÃ D PÀëtzÀ¯ÉèÃ ªÀiÁqÀÄwÛÃgÁ ?	( )	( )
14.	ºÀ®ªÉÇªÉÄä ¤ÃªÀÅ »ÃUÉ ªÀiÁqÀ¨ÁgÀ¢vÀÄÛ CxÀªÁ »ÃUÉ ºÉÃ¼À¨ÁgÀ¢vÀÄÛ JAzÀÄ aAvÉUÉÆ¼ÀUÁUÀÄwÛÃgÁ ?	( )	( )
15.	¸ÁªÀiÁ£ÀåªÁV EvÀgÀgÀ£ÀÄß ¨sÉÃn ªÀiÁqÀÄªÀÅzÀQÌAvÀ NzÀÄªÀÅzÀ£ÀÄß ºÉZÀÄÑ EµÀÖ¥ÀqÀÄwÛÃgÁ ?	( )	( )
16.	¤ªÀÄä ªÀÄ£À¹ìUÉ ¨ÉÃUÀ£É £ÉÆÃªÀÅAmÁUÀÄvÀÛzÉAiÉÄÃ ?	( )	( )
17.	ªÀÄ£É¬ÄAzÀ ºÉÆgÀVgÀÄªÀÅzÀ£ÉßÃ ¤ÃªÀÅ vÀÄA¨Á EµÀÖ ¥ÀqÀÄwÛÃgÁ ?	( )	( )
18.	¤ªÀÄä ªÀÄ£À¹ì£À°ègÀÄªÀ «ZÁgÀUÀ¼ÀÄ ¨ÉÃgÉAiÀÄªÀjUÉ UÉÆvÁÛUÀ¨ÁgÀzÀÄ JA§ C©ü¥ÁæAiÀÄ PÉ®ªÀÅ ¨Áj ¤ªÀÄUÉ §gÀÄvÀÛzÉAiÉÄÃ ?	( )	( )
19.	PÉ®ªÉÇªÉÄä ¤ÃªÀÅ vÀÄA¨Á GvÁìºÀ¨sÀjvÀgÁVzÀÄÝ ªÀÄvÉÛ PÉ®ªÉÇªÉÄä vÀÄA¨Á D®¸Àå¢A¢gÀÄwÛÃgÁ ?	( )	( )
20.	PÉ®ªÀgÉÃ DzÀgÀÆ D¥ÀÛ ¸ÉßÃ»vÀgÀ£ÀÄß Ej¹PÉÆ¼Àî®Ä §AiÀÄ¸ÀÄwÛÃgÁ ?	( )	( )
21.	¤ÃªÀÅ vÀÄA¨Á ºÀUÀ®ÄUÀ£À¸ÀÄ PÁtÄwÛÃgÁ ?	( )	( )
22.	EvÀgÉAiÀÄªÀgÀÄ ¤ªÀÄä£ÀÄß PÀÄjvÀÄ UÀzÀj¹zÀgÉ ¤ÃªÀÅ ¥ÀæwAiÀiÁV UÀzÀj¸ÀÄwÛÃgÁ ?	( )	( )
23.	¤ÃªÀÅ PÀ¼ÀAQvÀgÉA§ ¨sÁªÀ£ÉAiÀÄÄ ¤ªÀÄä°è DUÁUÉÎ GAmÁUÀÄvÀÛªÉAiÉÄÃ ?	( )	( )
24.	¤ªÉÄä¯Áè ºÀªÁå¸ÀUÀ¼ÀÄ M¼ÉîAiÀÄªÀÅ ªÀÄvÀÄÛ C¥ÉÃPÀëtÂÃAiÀÄªÁzÀÄªÉÃ ?	( )	( )
25.	¸ÀAvÉÆÃµÀ ¸ÀªÀiÁgÀA¨sÀUÀ¼À°è ¤ªÀÄä£ÀÄß ¤ªÉÃ ªÀÄgÉAiÀÄÄªÀµÀÄÖ vÀ°èÃ£ÀgÁV ¸ÀAvÉÆÃµÀUÉÆ¼ÀÄîwÛÃgÁ ?	( )	( )
26.	¤ÃªÀÅ «±ÉÃµÀªÁV ©UÀÄ ªÀÄ£À¹ì£ÀªÀgÉÃ ?	( )	( )
27.	EvÀgÀgÀÄ ¤ÃªÀÅ vÀÄA¨Á G¯Áè¸À¢A¢gÀÄªÀªÀgÀÄ JAzÀÄ	( )	( )

	¨sÁ«¸ÀÄvÁÛgÉAiÉÄ ?		
28.	¤ÃªÀÅ MAzÀÄ ªÀÄÄRå PÉ®¸ÀªÀ£ÀÄß ªÀiÁrzÀ £ÀAvÀgÀ CzÀ£ÀÄß E£ÀÆß ZÉ£ÁßV ªÀiÁqÀ§ºÀÄ¢vÀÄÛ JAzÀÄ PÉÆ¼ÀÄîwÛÃgÁ ?	( )	( )
29.	EvÀgÀgÉÆqÀ£É EgÀÄªÁUÀ ¤ÃªÀÅ ªÀiË£À¢A¢gÀÄwÛÃgÁ ?	( )	( )
30.	PÉ®ªÉÇªÉÄäAiÀiÁzÀgÀÆ ¤ÃªÀÅ ºÀgÀmÉ ºÉÆqÉAiÀÄÄªÀÅzÀÄAmÉÃ ?	( )	( )
31.	¤zÁæ¨sÀAUÀ vÀgÀÄªÀAvÀºÀ «ZÁgÀUÀ¼ÀÄ ¤ªÀÄä ªÀÄ£À¹ìUÉ §gÀÄvÀÛªÉAiÉÄÃ ?	( )	( )
32.	¤ÃªÀÅ PÉ®ªÀÅ «µÀAiÀÄUÀ¼À£ÀÄß w½AiÀÄ®Ä EvÀgÀgÉÆqÀ£É ZÀað¸ÀÄªÀ §zÀ®Ä ¥ÀÄ¸ÀÛPÀUÀ¼À ªÉÆgÉ ºÉÆÃUÀÄwÛÃgÁ ?	( )	( )
33.	¤ªÀÄä ºÀÈzÀAiÀÄzÀ°è DUÁUÉÎ qÀ¨sÀqÀ¨sÀ ±À§Þ CxÀªÁ PÀA¥À£À GAmÁUÀÄvÀÛzÉAiÉÄÃ ?	( )	( )
34.	¤ÃªÀÅ ºÉZÀÄÃÑ UÀªÀÄ£À PÉÆqÀ¨ÉÃPÁzÀAvÀºÀ PÉ®¸ÀUÀ¼À£ÀÄß ªÀiÁqÀ®Ä EaÒ¸ÀÄwÛÃgÁ ?	( )	( )
35.	¤ÃªÀÅ £ÀqÀÄPÀ ªÀÄvÀÄÛ PÀA¥À£ÀUÀ½VÃqÁV¢ÝÃgÁ ?	( )	( )
36.	¸ÀÄ¼ÀÄî ºÉÃ½zÀgÀÆ ¹QÌ ºÁQPÉÆ¼ÀÄîªÀÅ¢®è JA§ £ÀA©PÉ EzÀÝgÀÆ ¤dªÀ£ÉßÃ ºÉÃ¼ÀÄwÛÃgÁ ?	( )	( )
37.	M§âgÀ£ÉÆ§âgÀÄ ºÁ¸Àå ªÀiÁqÀÄwÛgÀÄªÀ UÀÄA¦¤AzÀ zÀÆgÀ«gÀ®Ä EaÒ¸ÀÄwÛÃgÁ ?	( )	( )
38.	¤ÃªÀÅ ¹qÀÄQ£À ¸Àé¨sÁªÀzÀªÀgÉÃ ?	( )	( )
39.	ºÉZÀÄÃÑ AiÉÆÃa¸ÀzÉÃ PÉ®¸ÀUÀ¼À£ÀÄß ªÀiÁqÀÄªÀÅzÀÄ ¤ªÀÄä ¸Àé¨sÁªÀªÉÃ ?	( )	( )
40.	¤ÃªÀÅ ªÀÄÄAzÉ ¸ÀA¨sÀ«¸À§ºÀÄzÁzÀ «¥ÀvÀÄÛUÀ¼À §UÉÎ aAw¸ÀÄwÛÃgÁ ?	( )	( )
41.	AiÀiÁªÀÅzÉÃ PÉ®¸ÀªÀ£ÀÄß ¤ÃªÀÅ ¸ÁªÀzsÁ£À¢AzÀ PÉÊUÉÆ¼ÀÄîwÛÃgÁ ?	( )	( )
42.	JAzÁzÀgÀÆ ¤ÃªÀÅ £ÉÆAiÉÆÃavÀ PÁgÀåªÀ£ÀÄß ¤zsÁ£ÀªÁV PÉÊUÉÆArzÀÄÝAmÉÃ ?	( )	( )
43.	¤ÃªÀÅ ¨sÀAiÉÆÃvÁàzÀPÀ PÀ£À¸ÀÄUÀ¼À£ÀÄß PÁtÄwÛÃgÁ ?	( )	( )
44.	¤ÃªÀÅ EvÀgÀgÉÆqÀ£É ªÀiÁvÀ£ÁqÀÄªÀÅzÀ£ÀÄß	( )	( )

	JµÀÄÖ EaÒ¸ÀÄwÛÃgÁgÉAzÀgÉ AiÀiÁªÀ C¥ÀjavÀ ªÀåQÛAiÉÆqÀ£ÉAiÀÄÆ ¸ÀA¨sÁ¶¸ÀÄªÀÅzÀ£ÀÄß vÀ¦à¹PÉÆ¼ÀÄîªÀÅ¢®èªÉÃ ?		
45.	¢ÃWÀðPÁ®zÀ AiÀiÁvÀ£ÉUÀ¼ÀÄ ªÀÄvÀÄÛ £ÉÆÃªÀÅ ¤ªÀÄä£ÀÄß ¨Á¢ü¸ÀÄvÀÛzÉAiÉÄÃ ?	( )	( )
46.	§ºÀÄ ªÉÃ¼É ºÉZÀÄÑ d£ÀgÀ£ÀÄß PÁt¢zÀÝgÉ vÀÄA¨Á ¤gÁ±ÀgÁUÀÄwÛÃgÁ ?	( )	( )
47.	¤ÃªÀÅ zÀÄ§ð® ªÀÄ£À¹ì£ÀªÀgÉAzÀÄ ¨sÁ«¸ÀÄwÛÃgÁ ?	( )	( )
48.	¤ªÀÄUÉ UÉÆwÛgÀÄªÀ ªÀåQÛUÀ¼À°è ¤ÃªÀÅ RArvÀªÁVAiÀÄÆ EµÀÖ ¥ÀqÀzÀ PÉ®ªÀÅ ªÀåQÛUÀ¼ÁzÀgÀÆ EzÁÝgÉAiÉÄÃ ?	( )	( )
49.	¤ªÀÄä°è CxÀªÁ ¤ÃªÀÅ ªÀiÁrzÀ PÁgÀåUÀ¼À°è EvÀgÀgÀÄ vÀ¥ÀÄà PÀAqÀÄ »rzÀgÉ ¤ªÀÄUÉ ¨ÉÃUÀ £ÉÆÃªÁUÀÄvÀÛzÉAiÉÄÃ ?	( )	( )
50.	¸ÀAvÉÆÃµÀ ¸ÀªÀiÁgÀA¨sÀUÀ¼À°è ¤ÃªÀÅ ¤dªÁVAiÀÄÆ ¸ÀAvÉÆÃµÀ¢A¢gÀÄªÀÅzÀÄ ¤ªÀÄUÉ PÀµÀÖªÉÃ ?	( )	( )
51.	¤ªÀÄä §UÉV£À QÃ¼ÀÄ ¨sÁªÀ£ÉUÀ¼ÀÄ ¤ªÀÄä£ÀÄß ¨Á¢ü¸ÀÄvÀÛªÉAiÉÄÃ ?	( )	( )
52.	CµÉÖÃ£ÀÆ PÀ¼É¬Ä®èzÀ ¸ÀªÀiÁgÀA¨sÀUÀ¼À°è ¤ÃªÀÅ ¸ÀÄ®¨sÀªÁV PÀ¼É vÀÄÄA§§°ègÁ ?	( )	( )
53.	¤ªÀÄUÉ w½AiÀÄ¢gÀÄªÀ «µÀAiÀÄUÀ¼À §UÉÎ PÉ®ªÉÇªÉÄäAiÀiÁzÀgÀÆ ªÀiÁvÀ£ÁqÀÄwÛÃgÁ ?	( )	( )
54.	¤ªÀÄä DgÉÆÃUÀåzÀ §UÉÎ PÀ¼ÀªÀ¼À ¥ÀqÀÄwÛÃgÁ ?	( )	( )
55.	EvÀgÀgÀ §UÉÎ PÀÄZÉÃµÉÖ ªÀiÁqÀÄªÀÅzÀ£ÀÄß EaÒ¸ÀÄwÛÃgÁ ?	( )	( )
56.	¤ªÀÄUÉ ¤zÉÝ ¸ÀjAiÀiÁV ¨ÁgÀzÉÃ ?	( )	( )

J¯Áè ¥Àæ±ÉßUÀ¼À£ÀÆß GvÀÛj¹gÀÄ«gÉA§ÄzÀ£ÀÄß ªÀÄvÉÆÛªÉÄä ¥ÀjÃQë¹ RavÀ¥Àr¹PÉÆ½î.