ACCEPTABLE NOISE LEVEL: EFFECT OF NUMBER OF TALKERS IN NATIVE AND NON-NATIVE SPEECH BABBLES IN OLDER ADULTS WITH HEARING IMPAIRMENT

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CERTIFICATE

This is to certify that this dissertation entitled **"Acceptable Noise Level: Effect of Number of Talkers in Native and Non-Native Speech Babbles in Older Adults with Hearing Impairment"** is a bonafide work submitted in part fulfillment for degree of Master of Science (Audiology) of the student Registration Number: **15AUD023**. 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.

Mysuru
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This is to certify that this dissertation entitled **"Acceptable Noise Level: Effect of Number of Talkers in Native and Non-Native Speech Babbles in Older Adults with Hearing Impairment"** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Acceptable Noise Level: Effect of Number of Talkers in Native and Non-Native Speech Babbles in Older Adults with Hearing Impairment"** is the result of my own study under the guidance of **Dr. Geetha. C**, Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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"Bless the Lord, O my soul: and all that is within me bless His Holy name.

Bless the Lord, O my soul, and forget not all His benefits"

Psalm 103:1,2

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ABSTRACT

Acceptable noise level is the amount of background noise that listeners are willing to accept when listening to speech signal. It is especially used to predict the outcome of a hearing aid. The most common noise present in our environment is speech babble which varies from time to time between known and unknown languages. Thus, the present study aimed to study the effect of number of talkers in native and non-native speech babble on the acceptable noise level in older adults with hearing impairment. A group of 22 older adults were taken within the age group of 55-70 years. ANL was estimated using target Kannada sentences in the presence of 2-talker, 4-talker, 8-talker, 10-talker and 12-talker Kannada and English babbles. The results showed that 4-talker Kannada babble resulted in best ANL score. In non-native English language, the best score was found in 2-talker babble. The reason for best score in Kannada language could be due to the informational masking in 2-talker babble. The best score in English language was 2-talker babble and the reason was that the low proficiency in unknown language which tends to suppress the masker effect. In the presence of both Kannada and English babbles, ANL was poorer as the number of talkers in the babble increased. It can be concluded from the results of the current study that there is an effect of number of talkers in babble on ANL with 4-talker babble resulting in the best ANL in the native language. In the presence of non-native language babble, ANL is the best with 2-talker babble indicating that information masking is predominant in the presence of native language. This suggests a possible influence of language of the background speech babble on ANL.

CHAPTER 1

INTRODUCTION

Hearing impairment is one of the most common chronic health problems of older individuals. It has been reported that, among older adults, the prevalence of hearing impairment among those aged 65 years and over may be increasing (Cruickshanks et al., 1998). Hearing impairment in older individuals is associated with adverse effects on the quality of life of older individuals. These effects are reported to be perceived as severe handicap by older individuals with only mild to moderate degrees of hearing loss (Mulrow, 1990). The complex nature of hearing problems in older adults involves changes in the auditory periphery as well as in the central mechanisms for processing sound input (Jerger, 1995).

Hence, studies on intervention of hearing impairment in this group have increased drastically in the past few years. Hearing aid is the intervention option in most of the older individuals. Nevertheless, one of the major dissatisfaction by hearing aid users is the problem with the background noise (Surr, Schuchman & Montgomy, 1978). The complaints related to the background noise have been reported by many older individuals (Franks & Beckmann, 1985; Kapteyn, 1977).

Acceptable Noise Level (ANL) is a measure that quantifies an individual's acceptance of background noise while listening to speech (Nabelek, Freyaldenhoven, Tampas, Burchfield & Muenchen, 2006; Nabelek, Tucker & Letowski, 1991). ANL also has been reported to provide an estimate of the outcome of a hearing aid (Nabelek et al., 2006; Nabelek et al., 1991).

There are a number of factors that affects the ANL (Franklin, Thelin, Nabelek & Burchfield, 2006). Among those factors, background noise used in ANL is an important factor to be considered, as the sound environment of each individual with hearing impairment may not be always the same.

Nabelek et al. (1991) conducted a study to see the effect of different types of noise and the individual's acceptability to different types of noises such as speech spectrum noise, multi-talker speech babble, traffic noise, noise of a pneumatic drill and music as background noise. They reported no significant difference in ANL for different background noises except for music. The reason for no difference in ANL between the speech babble and other signals could be because of the number of babble used. They had used 12-talker babble. The spectrum of 12-talker is very similar to other broadband noises. Since 1991, the use of ANL has been very extensive, and, most of the studies on ANL have used 12-talker speech babble as the background noise (Ho et al., 2013; Van Engen, 2010).

However, Gordan-Hickey, Moore and Estis (2012) studied the impact of listening conditions on background noise acceptance for adults with normal hearing sensitivity. The number of background talkers was changed as 1-talker, 4-talker, and 12-talker babbles and studied the acceptance of noise. The mean of ANL was higher/poorer for 1 talker-babble when compared between different numbers of talkers in speech babbles. However, this was not seen in 4-talker babble and 12-talker speech babble.

There have been a few reports on the effect of language of speech babbles also on ANL. Brännström et al. (2012) compared ANL obtained from Danish, Swedish, and non-

semantic (ISTS) materials. Danish and Swedish individuals with normal hearing sensitivity were included in the study. ANL was measured with both the groups using all the three materials. There was a significant difference in the ANL results between the two language groups. The authors reported that this difference could be due to factors such as the type of noise, the high speaker rate, instructions given and the attitude of the examiner.

Von and Bahng (2006) measured ANL in English and Korean languages with different language groups of monolingual (English) and bilingual (Korean-English) listeners and it was seen that the group of bilingual listeners did not have any statistical difference. Hence, they concluded that ANL can be independent of language.

Whereas Nayana, Keerthi and Geetha (2016) reported a difference in ANL between native (Kannada) and non-native (English) babbles. They measured the effect of number of talkers and the language (native vs. non-native) of speech babble on ANL in individuals with normal hearing sensitivity. The results showed that the ANL values were higher in 2-talker and 12-talker babble while the ANL was the least with 4-talker babble. The increase in 2-talker babble as reported could be due to informational masking in Kannada. However, the effect was seen only with Kannada babble, not in English babble.

1.1. Need for the study

Acceptable noise level (ANL) measures a listener's reaction to background noise while listening in speech (Nabelek et al., 2006; Nabelek et al., 1991) and can provide an estimate of the outcome of a hearing aid (Nabelek et al., 2006; Nabelek et al., 1991). Since ANL represents the ability of the individual to accept the background noise, the

effect of type of background noise is a concern. In addition, in most acoustic environments, speech is present as the background noise. The number of talkers may vary depending on the situation. India being a multilingual country and having English as the official language of communication in most set-ups, the background is expected to be not always the native language.

In real life situation, the hearing impaired individuals with hearing aids face difficulty in understanding speech. In our environment, most of the competing background noise is speech babble of known and unknown language/s. The number of speech babble of the background language/s varies in the environment from time to time in daily life situation.

There are only a few reports available on the effect of number of talkers in speech babble on ANL and the background language. While most of the studies on ANL have used 12-talker speech babble as the background noise (Ho et al., 2013; Van Engen, 2010), there are only a handful of studies assessing the effect of number of talkers in speech babble on ANL (for eg., Gordan-Hickey, Moore & Estis, 2012; Nayana, Keerthi & Geetha, 2016). The results of these studies are equivocal. Even, the studies assessing ANL with native and non-native speech babbles as background noise have reported equivocal results. Thus, studying the effect of varying the number of talker babbles in native and non-native language as background noise in hearing impaired population is essential.

In the present study, older adults with hearing loss were included as there exists a significant difference between young adults and older adults in the extent of difficulty in

perception of speech in the presence of noise (Ahlstrom, Horwitz & Dubno, 2009; Glyde & Hickson, 2011) and the way the background noise is accepted (Gordon-Salant & Fitzgibbons, 2004). This makes it essential to study the effect of number of talkers in each babble and the background language on ANL in older individuals with hearing impairment.

1.2. Aim of the study

The present study aimed to study the effect of number of talkers and the effect of background language (native and non-native) speech babbles on the acceptable noise level in older adults with hearing impairment.

1.3. Objectives of the study

The objectives of the present study were-

1) To find out ANL in the presence of 2-talker, 4-talker, 8-talker and 12-talker Kannada speech babble.
2) To find out ANL in the presence of 2-talker, 4-talker, 8-talker and 12-talker English speech babble.
3) To compare the ANL across different number of talkers in babble (2-talker, 4-talker, 8-talker and 12-talker babbles) in older adults with hearing impairment within each language.
4) To compare the ANL across Kannada and English speech babbles for different number of talkers of speech babble.

CHAPTER 2

REVIEW OF LITERATURE

Hearing impairment is a chronic handicapping condition which develops in older individuals. The quality of life of these older adults is affected in most individuals. Even a mild to moderate degree of hearing loss can affect the quality of life causing severe handicapping conditions for older adults (Murlow, 1990). Fitting of hearing aids followed by counseling avoids the delirious effect of untreated hearing loss. Nevertheless, there are a group of individuals who reject hearing aids mainly due to intolerance of background noise. Measuring the individual's tolerance level has been reported to be helpful in predicting the outcome with hearing aid. Acceptable noise level (ANL) is such a measure that can be used to predict the outcome (Nabelek et al., 1991). The present study focuses ANL and the effect of different language babbles and different number of talkers in babble on ANL. Hence, the literature has been reviewed under the following headings:

2.1. Acceptable Noise Level

2.2. Factors affecting ANL

2.2.1. Effect of background noise on ANL

2.2.2. Effect of different number of talker babbles on ANL

2.2.3. Effect of language on ANL

2.2.4. Effect of age on ANL

2.1. Acceptable Noise Level

ANL is defined as "the procedure that quantifies the amount of background noise that listeners are willing to accept while listening to speech." (Nabelek et al., 2006). Nabelek et al. (1991) gave a hypothesis that rejecting hearing aids is because of the background noise that is involved while using the hearing aids. Hence, Nabelek et al. (1991) aimed to study the "tolerated speech to noise ratios" in three groups of hearing impaired older adults with different amount of usage of hearing aid. Different types of background noises were included for the study. They reported that ANL was the best for full-time hearing aid users when compared to part-time users and non-users of hearing aids.

Although ANL was described first by Nabelek et al. (1991), soon the ANL gained its importance and many other studies were carried out to study the factors of ANL. Nabelek et al. (2006) aimed to assess ANL as a predictor of hearing aid use and to correlate the same with SPIN. The study also aimed at finding the relationship of ANL with age, gender and PTA. They fitted 119 individuals with hearing impairment with hearing aids from the same audiology clinic at the University of Tennessee in order to reduce bias. ANL was measured using 12-talker speech babble which was consistent with the noise used in SPIN test. There were three group of listeners based on hearing aid use similar to Nebelek et al's study conducted in 1991. They were full-time users, part-time users, and non-users of hearing aids. The results of their study showed that the aided ANL had significant correlation with duration of usage of hearing aids. However, there was no correlation seen between SPIN and ANL.

Freyaldenhoven et al. (2006) described a detailed procedure for ANL. According to the authors, in order to calculate ANL, the most comfortable level (MCL) and then the background noise level (BNL) of the participants are first estimated. The difference between the MCL and BNL was considered as the ANL. Freyaldenhoven et al. (2006) also assessed the reliability of ANL. Thirty adults with age ranging from 20 to 25 years with normal hearing sensitivity were taken for the study. A recorded running speech was presented and 12-talker babble was presented as background noise. The results of their study showed that ANL was able to predict hearing aid outcome with 85% accuracy.

Besides the above studies, there are many studies analyzing different factors affecting ANL (Nabelek et al., 1991; Freyyaldenhoven et al., 2006; Nabelek et al., 2006). Many factors such as age, gender, hearing loss, type of background noise and presentation level have been studied by various authors.

When Nabelek et al. (1991), Rogers et al. (2003), Nabelek et al. (2006), Plyler et al. (2011) and Gordon-Hickey, Moore and Estis (2012) studied the effect of speaker and listener gender. The results showed no significant difference between the male and female speakers and listeners.

Freyaldenhoven et al. (2007) and Recker and Edwards (2013) studied the effect of different presentation levels on ANL. There was again no significant difference between the different presentations levels. The listeners were able to give the same ANL response from lower presentation level to higher presentation levels.

There are many other factors such as Background noise, language, number of talker in background signal have been studied extensively. The literature review of these factors is discussed below.

2.2. Factors affecting ANL

As mentioned earlier, there are a number of studies on factors affecting ANL. Among them, the factors related to the current study are discussed below.

2.2.1. Effect of background noise on ANL

One of the first studies on evaluating the effect of different type of background noise on ANL was by Nabelek et al. (1991). They compared ANL in the presence of traffic noise, music, 12-talker speech babble, speech spectrum noise and noise of a pneumatic drill. They reported of no difference in ANL between any of background noises except for music. The later studies however, gave evidence that there might be an interaction of ANL with background noise such as when music is used as background noise and the speech babbles are mixed with males and female talkers had some significant difference (Gordan-Hickey, Moore & Estis 2012).

Gordan-Hickey, Moore and Estis (2012) studied the impact of listening condition on background noise acceptance for adults with normal hearing sensitivity. They aimed to evaluate the different speech conditions on background noise acceptance. They also varied the gender composition of the background noise as female, male and mixed. ANL and measured the different babble conditions. The participants taken in this study were 15 normal hearing female and male young adults. Lower scores in ANL were obtained with

female primary talker and conditions with multi-talker backgrounds. There was an interaction between the primary talker and the background noise composition of the male and female talker compositions.

Moore (2011) also studied the effect of background noise on ANL. Nineteen normal hearing individuals within the age group of 18 to 30 years (23.7 years average) were the participants. The main signal used was a running speech of a story by a female speaker. Three background signals (12-talker babble, music, phone ring) were presented through sound field at 180° only and surround (0°, 90°, 180°, 270°). There was no significant difference across different noise or stimulus type, in the ANL scores reported in their study. Hence, it is clear that there are equivocal results obtained across studies with reference to the influence of the background noise. Nevertheless, there have been more studies on the influence of different speech babbles on ANL. The review on the same is given below.

2.2.2. Effect of different number of talkers babble on ANL

Gordan-Hickey, Moore and Estis (2012) studied the impact of listening condition on background noise acceptance for adults with normal hearing sensitivity. In their study the number of background talkers used were varied between 1-talker, 4-talker and 12-talker babbles. Other background talker conditions were also used.

The Acceptable noise level was evaluated and the results showed that the mean of ANL was higher/poorer for 1-talker babble (0.32). However, this scenario was not seen in 4-talker babble (-0.13 to 3.86) and 12-talker babble (0.04-3.43).

A 12-talker babble has been commonly used for the measurement of ANL and other studies related to background noise. The spectrum of 12-talker babble is similar to that of a spectrum of non-speech noise such as white noise as the modulations inherent to speech gets masked. If the number of talkers is less in number the modulations become more evident and the influence might be different on ANL. Nayana et al. (2016) conducted a study to find the effect of number of talkers and the background language of speech babble on Acceptable noise level. The objective of Nayana et al's study was to find out the ANL in the presence of 2-talker, 4 talker, 8 talker and 12 talker speech babbles in Kannada and English language. Thirty participants were taken in this study within the age group of 18-24 years who were bilinguals Kannada and English but had Kannada as their native language.

Their results revealed that there was a significant increase in ANL as the number of talkers increased in Kannada speech babble, except for 2-talker babble which was similar to 10-talker and 12-talker babble. In English, the ANL was similar across different number of talkers. This was consistent with the results obtained from Shi et al. (2015). The results suggested that increasing the number of talkers increases the annoyance. However, with 2-talker babble there was high ANL which could be due to informational masking.

When the ANL was compared between Kannada and English, there was significant difference between the two languages for different number of speech babbles except for 2-talker and 12-talker babbles. The reason for the difference was attributed to the differences between the two languages in terms of the sentence structure; more occurrences of long vowels and difference in occurrence of phonemes have caused this

difference in results. From the above studies, it can be seen that varying the number of talkers can have an effect on the ANL obtained.

2.2.3. Effect of language on ANL

ANL is usually obtained with passages and sentences as the stimuli. There are studies evaluating the effect of stimulus language on ANL. Brännström et al. (2012) aimed to compare the effect of ANL obtained in Danish, Swedish, and non-semantic (ISTS) materials. They included 40 Danish speaking individuals and 40 Swedish individuals with normal hearing sensitivity. ANL was measured with both the groups using all the three materials. There was a significant difference in the ANL results between the two groups. The authors reported that this difference could be due to the factors such as the type of noise, the high speaker rate, instructions given and the attitude of the examiner.

Von and Bahng (2006) also studied ANL in bilingual Korean-English listeners. In this study, 30 individuals with normal hearing sensitivity were taken. The listeners were divided into three groups. Two groups were Korean-English bilinguals and one group was monolingual English listeners. Under the monolingual English speaking group, there were 10 individuals between the age group of 24 to 34 years with English as their first language. There was very less or no knowledge about second language including reading, writing, speaking and listening.

The bilingual listeners were divided into two groups. All the listeners were native Korean speakers. In order to obtain ANL the recording of a running speech by a male speaker in English and Korean for English ANL and Korean ANL respectively was used.

Standardized English and Korean speech babbles were used as the primary competing stimulus of multi-talker babble.

The ANLs obtained for English (ANL-E) for the monolingual English group was 6.4 dB (Range = -2 to 20). For moderate proficiency group, ANL was 8.0 dB (range = 4 to 14 dB) and for low proficiency group was 6.8 dB (range = 4 to 10 dB). Though the range was constrained, there was no statistically significant difference between the groups.

The ANL results obtained for Korean (ANL-K) bilingual listeners was also not statistically significant between the moderate proficiency group with 7.3 dB ranging from 4 to 14 dB and for low proficiency group was 7.7 dB ranging from 4 to 12 dB. This suggests that ANL is independent of language in bilinguals and it can be used clinically in minority language groups.

Shi et al. (2015) also studied ANL in monolingual and bilingual listeners. They included 55 adults aged from 19 to 41 years. Three groups were included. The first group had English monolingual listeners, the second group was 16 Russian-English bilingual, and the third group had 24 Spanish-English bilingual listeners. ANL was obtained in these individuals using 12-talker babbles. It was found that Russian-English bilingual listeners obtained poorer ANL scores by 4-5 dB than the other English speaking groups. The Spanish speaking group had negligible difference of 0.5 dB with English speaking group. This finding shows that ANL is not completely independent of language and population. The linguistic/cultural background should be observed before conducting an ANL study.

As it can be seen from the above studies, initially the language did not have an effect. However, the later study conducted by Shi et al. (2015) gave a notion that it is important to keep the linguistic/cultural background before conducting ANL study. While it is important to be careful with the linguistic/cultural background for conducting ANL studies, it is important to know the listener, thus age is an important factor that has to be reviewed. Many studies were conducted to find if there is a significance of age when it comes to the estimation of ANL. Although older individuals are said to have poorer cognitive skills which leads to decline in understanding and tolerating noise (Surr, Schuchman & Montgomery, 1978), there is no significance with elderly individuals when it comes to ANL which is further reviewed below in section 2.5.

2.2.4. Effect of age on ANL

Surr, Schuchman and Montgomery (1978) identified background noise to be a major reason for dissatisfaction while using hearing aids. These complaints were mainly raised by older adults followed by middle aged individuals. This could be associated with the complex nature of hearing problems in older adults that involves changes in the auditory periphery as well as in the central mechanism for processing sound input. These changes, along with speech recognition in noise, also affect the social and emotional impact of the hearing disorder (Jerger, 1995).

Another study done by Nabelek et al. (1991) studied the relationship between hearing aid use and ability to tolerate background noise in young and elderly adults. A total of 30 individuals of young adults and 30 individuals of older adults were included in the study. ANL was measured in these four groups with 12-talker speech babble was used

as the background noise. The results showed a significant interaction between groups when the different types of noises were involved. The ANL was independent of age and hearing loss as the MCL for both the groups selected were based on the comfort of the listener.

From the above review, it can be seen that the ANL is an important factor that can predict the use of hearing aids by estimating the tolerance towards background noise (Nabelek et al., 1991; Nabelek et al., 2006 & Freyaldenhoven, (2006). There are several factors that affect ANL. Some of the important factors are number of talkers in babble and the language of the background speech babble (Gordan-Hickey, Moore & Estis, 2012; Nayana et al. 2016). Thus, in the present study, ANL in older adults with hearing impairment, using different number of speech babbles in both native and non-native language was estimated and compared between the two languages.

CHAPTER 3

METHODS

The objectives of the present were to find the effect of number of talkers in speech babbles and the effect of language (native vs. non-native) of speech babble on the acceptable noise level in older adults with hearing impairment. A within subject research design was used to test the above objectives. Following are the participants, materials and methods used.

3.1. Participants

A total of 22 individuals with mild to moderate post-lingual sensorineural hearing loss in the age range of 55 to 70 years (Corso, 1963; International Standards Organization, 2000) were included in the study. The participants met the following criteria:

- All the participants were native Kannada speakers,
- The SIS scores were not less than 70%,
- The participant did not have any middle ear pathology,
- The participants did not use any hearing aids,
- The participants did not have any neurological disorders, vestibular disorders (which can cause discomfort during testing due to presence of giddiness or nausea) or any illness that hindered the performance for the study and
- All of them had the educational qualification of SSLC.

3.2. Equipment used

Following were the equipment used for routine audiological assessment:

- A calibrated two channel diagnostic audiometer Inventis Piano was used to do pure-tone audiometry and speech audiometry.
- Air conduction thresholds were measured using a TDH-39 headphone.
- Bone conduction thresholds were measured using B-71 bone vibrator.
- GSI-Tympstar was used to measure the middle ear functioning.

Following were the equipments used for ANL testing:

- The recorded stimulus was routed through the calibrated two channel audiometer Invents Piano using a HP laptop.
- The stimulus was routed through the auxiliary input available in the audiometer.
- The audiometer output was directed to the calibrated sound field loudspeakers at 0° Azimuth at a distance of 1 meter from the participant in the test room.

3.3. Stimuli

- Speech recognition thresholds (SRT) were obtained using spondees which were developed at the Department of Audiology, All India Institute of Speech and Hearing, Mysuru.
- Speech identification scores (SIS) were obtained by the phonetically balanced words developed by Yathiraj and Vijayalakshmi (2005).

- For obtaining ANL, standardized sentences developed by Geetha, Kumar, Manjula and Pavan (2014) were used as the target stimuli.
- 2-talker, 4-talker, 8-talker, 10-talker and 12-talker speech babbles in Kannada and English developed by Nayana, Keerthi and Geetha (2016) were used as the background noise.

3.4. Test Environment

The complete testing was done in a double sound treated room setup where the ambient noise levels were within the permitted levels as per the ANSI S3.1 (1999) standards.

3.5. Procedure for routine audiological evaluation

Routine hearing evaluation was carried out for all the participants. Pure-tone hearing thresholds were measured with a calibrated double channel audiometer Inventis Piano. The procedure that was followed was modified Hughson-Westlake procedure. The thresholds were obtained for 250 Hz to 8 KHz. The bone conduction thresholds were traced for 250 Hz to 4 KHz.

Speech audiometry was carried out using the same calibrated double channel audiometer. SRT was obtained by presenting spondees. SIS was obtained using the phonetically balanced words developed by Yathiraj and Vijayalakshmi (2005) in both the ears.

The tympanometric assessment was done using GSI Tympstar with 226 Hz probe tone frequency. Reflex thresholds were traced for 500, 1000, 2000 and 4000 Hz, for both ipsilateral and contralateral measurements.

3.6. Procedure to obtain ANL

The participants who met the inclusion and exclusion criteria mentioned in section 3.1 were considered for further testing. The consent to conduct the study was taken from all the participants. The procedure described by Freyaldenhoven (2006) was followed in order to obtain an ANL. According to Freyaldenhoven (2006) in order to obtain ANL, the Background Noise Level (BNL) should be subtracted from the Most Comfortable Level (MCL) i.e., ANL = MCL - BNL. Hence, in order to obtain ANL, MCL, and BNL were measured using the following procedure.

The participants were asked to be seated in a comfortable chair in the test room, where the loudspeaker was placed in front of the listener. The instructions were given to the participants for establishing the MCL were as follows: "You will listen to few sentences in Kannada through the loudspeaker kept in front of you. The loudness of the sentences 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 sentences is comfortable for you".

The target sentences were presented to the listener at the level of SRT which was presented through the loudspeaker. This level of SRT was already obtained while doing the speech audiometry during routine audiological evaluation. From this level onwards, the intensity of the target stimulus was gradually adjusted in 5 dB steps until the listener says that the target sentences are heard in their most comfortable level. The steps were repeated two times, and the average level was taken as the MCL.

In order to establish the BNL, the following instructions were given. “You will now listen to the sentences 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 sentences. First, the noise was turned up until it was too loud and then down until the story becomes very clear. Finally, indicate the maximum noise level that you were willing to ‘put-up-with’ for a long time while following the sentences”. For measuring BNL, speech babble (background noise) was introduced at 30 dB HL and its level was increased in 5 dB steps to a point where the participant was willing to tolerate the background noise, but, could follow the target sentences without causing any tiredness or tension. The maximum level at which the listener was able to tolerate the background speech babble at ease was taken as BNL. When the speech babbles presented were in Kannada language, the marking was BNL-K while BNL for the speech babbles in English language was marked as BNL-E.

The target sentences were presented through a double-channel audiometer Inventis Piano. The BNL was measured for different number of talkers of speech babble as background noise in both Kannada as well as English to find the effect of language and number of speakers in Kannada speaking older adults with hearing impairment. Different stimuli were presented in a random order.

The ANL, in dB, was calculated by subtracting the BNL from the MCL (ANL = MCL - BNL) given by (Nabelek et al., 2006; Nabelek et al., 1991). ANL was obtained for different number of talkers of speech babble in Kannda and English. Reliability check

was performed for 10% of the participants wherein ANL was measured twice, with an interval of one-two weeks.

3.7. Statistical Analysis

The data obtained from the above study was subjected to statistical analysis using (SPSS Version 23.0) software. Shiparo-Wilk test of normality was performed along with Friedman test and Wilcoxon Singed-rank tests to compare the difference in ANL between different number of talkers of speech babble, and the difference in ANL between native and non-native language.

CHAPTER 4

RESULTS

The aim of the current study was to evaluate the effect of number of talkers in speech babble on acceptable noise level (ANL) and the effect of native and non-native speech babbles on ANL in older adults with hearing impairment. ANL was obtained in individuals with mild to moderate sensorineural hearing loss using different number of talkers (viz. 2-talker, 4-talker, 8-talker, 10-talker and 12-talker babble) in Kannada and English languages. The ANL scores were computed using SPSS, version 23.0 and the results are reported under the following headings:

4.1. Effect of different number of talker in Kannada (Native language) babble on ANL

4.2. Effect of different number of talker in English (Non-Native language) babble on ANL

4.3. Effect of native vs. non-native speech babble on ANL

4.1. Effect of different number of talker in Kannada (Native language) babble on ANL.

The mean, median and standard deviation (SD) of ANL scores across different babble conditions are given in Table 4.1. It can be observed from the Table 4.1 that the mean of ANL obtained for 2- talker, 4-talker and 8-talker speech babbles was lower than that of 10-talker and 12-talker Kannada babble. The ANL for 12-talker babble was the highest followed by 10-talker babble. Lower the ANL, better is the acceptance to the background noise.

Table 4.1

Mean, median and SD of ANL obtained for different number of talkers in Kannada babble (N = 22)

Different Babble conditions	ANL in the presence of Kannada babble		
	Mean	**Median**	**SD**
2-talker	6.54	6.00	2.84
4-talker	6.09	6.00	2.79
8-talker	6.63	7.00	3.82
10-talker	7.63	8.00	3.47
12-talker	8.09	8.00	3.35

Shaphiro-Wilks test of normality was carried out in order to find if the data were normally distributed. The results revealed that the data did not follow normal distribution (i.e., $p > 0.05$) in most conditions. Hence, Friedman (a non-parametric) test was carried out to compare the ANL across different number of talkers in Kannada babble. The results of Friedman's test showed that there was a significant difference ($\chi^2 = 14.93$; $p < 0.01$) in ANL between different number of talkers in Kannada speech babble. In order to further analyze pair-wise differences, Wilcoxon Signed-Rank test was done. The results of Wilcoxon Signed-Rank test are given in the Table 4.2.

Table 4.2

Comparison of ANL obtained for different number of talkers in Kannada babble using Wilcoxon Signed-Rank test

Babble Conditions Compared	Z	*P*
4-talker vs. 2 talker	-0.576	0.499
8-talker vs. 2 talker	-0.024	0.981
10-talker vs. 2-talker	-2.11	0.034*
12-talker vs. 2-talker	-2.53	0.011*
8-talker vs. 4-talker	-1.07	0.284
10-talker vs. 4-talker	-2.37	0.018*
12-talker vs. 4-talker	-2.87	0.004**
10-talker vs. 8-talker	-1.18	0.237
12-talker vs. 8-talker	-2.24	0.025*
12-talker vs. 10-talker	-0.802	0.547

Note. *$p < 0.05$; ** $p < 0.01$.

It can be seen in the Table 4.2 that 10-talker and 12-talker Kannada babbles had statistically significant differences when compared to 2-talker, 4-talker and 8-talker speech babbles. That is, 10-talker and 12-talker Kannada babbles resulted in poorer ANL when compared to all the other babble conditions. However, there was no such statistically significant difference when the 2-talker, 4-talker and 8-talker babbles were compared between themselves.

4.2. Effect of different number of talker in English (Non-Native language) babble on ANL

The mean, median and SD of ANL in the presence of speech babble in non-native language (English) are given in Table 4.3. It can be observed from the Table 4.3 that the ANL was better for 2-talker English babble and the mean scores were similar for 4-talker, 8-talker and 12-talker English babbles.

Table 4.3

Mean, median and SD of ANL obtained for different number of talkers in English babble (N=22)

Different babble conditions	**ANL in the presence of English Babble**		
	Mean	Median	SD
2-talker babble	5.63	4.00	3.24
4-talker babble	7.00	6.00	3.36
8-talker babble	7.45	7.00	3.60
10-talker babble	7.63	8.00	3.93
12-talker babble	7.00	6.00	2.81

Friedman test was done to compare ANL across different English babble conditions as the data did not follow normality on Shapiro-Wilks test of normality. The results of Friedman test showed that there was a significant difference ($\chi^2 = 12.27$; $p < 0.05$) between different number of talkers in English babble. Further, pair-wise comparison was done using Wilcoxon Signed-Rank test. The results of the same are given in Table 4.4.

Table 4.4

Comparison of ANL obtained for different number of talkers in English babble using Wilcoxon Signed-Rank test

Babble conditions Compared	Z	*P*
4-talker vs. 2-talker	-1.65	0.097
8-talker vs. 2-talker	-2.07	0.038*
10-talker vs. 2-talker	-2.51	0.012*
12-talker vs. 2-talker	-1.58	0.112
8-talker vs. 4-talker	-0.72	0.466
10-talker vs. 4-talker	-0.55	0.579
12-talker vs. 4-talker	-0.14	0.885
10-talker vs. 8-talker	0.00	1.000
12-talker vs. 8-talker	-0.54	0.549
12-talker vs. 10-talker	-0.57	0.563

Note :- *$p < 0.05$

The results of Wilcoxon signed rank test (as seen in the Table 4.4) showed that the 8-talker and 10-talker English babbles had significantly poorer ANL scores when compared to 2-talker English babble. There were no statistically significant differences among 2-talker, 4-talker and 12-talker English babbles.

4.3. Comparison of ANL obtained for native (Kannada) vs. non-native (English) babble

The effect of background language on ANL across 2-talker, 4-talker, 8-talker, 10-talker and 12-talker babble was studied. The mean and SD of ANL obtained using Kannada and English babbles are given in Figure 4.1.

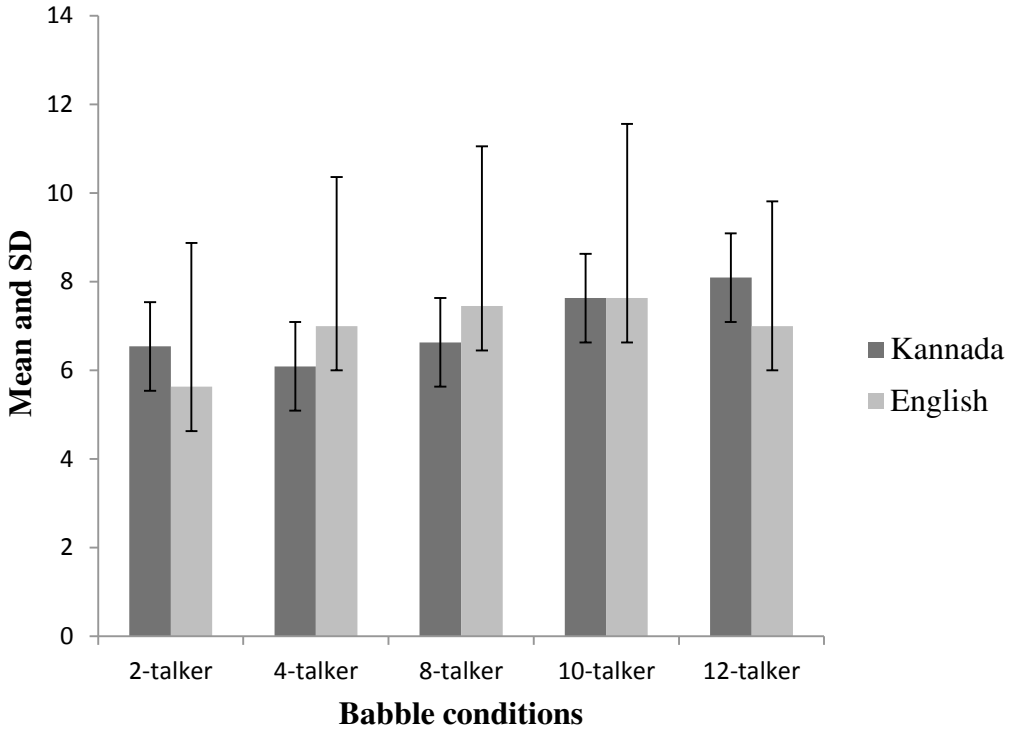

Figure 4.1 Mean and SD of ANL obtained for different number of talkers in Kannada and English babbles

As it can be seen from the above Figure 4.1, the mean of 2-talker and 12-talker babbles were higher for Kannada babble when compared to English babble. Whereas, ANL obtained for 4-talker and 8-talker babbles were higher for English babble when compared to Kannada babble. The ANL for 10-talker babble did not have any language effect as the mean obtained for both Kannada and English babbles were the same. However, the variation in SD was higher for much English babble than Kannada babble.

In order to statistically compare the effect of background language on ANL, non-parametric tests were done as the data did not follow normality on Shapiro-Wilk's test of normality. Friedman's test was done and the results showed that there is a significant difference ($\chi^2 = 25.85$; $p < 0.01$) between the ANL obtained for Kannada babbles and

English babbles. Wilcoxon Signed-Rank test was done for pair-wise comparison between native and non-native language across different number of talker babbles.

Table 4.5

Comparison of ANL obtained for different number of talkers across native and non-native language babble using Wilcoxon Signed-Rank test

Different babble conditions	**Conditions compared**	**Z**	***P***
2-talker babble	Native language vs. Non-native language	-1.32	0.186
4-talker babble	Native language vs. Non-native language	-1.27	0.204
8-talker babble	Native language vs. Non-native language	-1.14	0.265
10-talker babble	Native language vs. Non-native language	-1.32	0.895
12-talker babble	Native language vs. Non-native language	-1.68	0.092

The results of Wilcoxon Signed-Rank test are given in the Table 4.5. As it can be seen in the Table 4.5, there was no statistical difference between Kannada and English babbles across any of the babble conditions. In addition, the results of reliability check showed a very good reliability.

CHAPTER 5

DISCUSSION

The objectives of the current study were to compare the ANL obtained from different of talkers in babbles across native and non-native language in older adults with hearing impairment. The results for the above objectives are discussed below.

5.1. Effect of different number of talker in Kannada (Native language) babble on ANL

It was found in the current study that higher the number of babbles poorer was the ANL, that is 10-talker babble and 12-talker babble resulted in poorer ANL. These results are in agreement with the results of other studies done by Crowly and Nabelek (1996) and Rosen et al. (2013). The reason for this could be that the higher the number of babbles, the background noise replicates a broad band noise. This lead to no difference between the 12-talker babble and other type of noises such as speech spectrum noise, traffic noise and noise of a pneumatic drill (Nabelek, Tucker, & Letowski, 1991). Crowly and Nabelek (1996) found that 12-talker babble and steady state speech shaped noise did not have a significant difference in ANL.

In the current study, the best performance was seen with 4-talker babble. The scores were poorer for 2-talker babble than 4-talker babble. Rosen et al. (2013) also studied the effect of 1-talker, 2-talker, 4-talker, 8-talker and 16-talker talker babbles. The ANL was higher in 1-talker and 2-talker babble. This phenomenon was reported to be because of the intelligibility of the masker that is present in 2-talker babble resulting in

information masking and then there is a sharp decline in ANL (better ANL) for 4-talker babble as there is no informational masking happening. This result is also in accordance with the results of Nayana, Keerthi and Geetha (2016) for adults. However, the ANL obtained in their study for 4-talker babble in adults was better (ANL = 4.16) when compared to the current study in older adults (ANL = 6.09).

The current study also showed that the scores became poorer with 8-talker babble which further worsened with 10-talker and 12-talker babble. Other studies have also shown that increasing the number of talkers of babble from 6-talker to 8-talker, the ANL scores gradually worsened although higher scores were seen in 2-talker babble. Increasing the number of talkers can cause lower tolerance to noise in older adults causing increased scores (Rosen et al., 2013; Simpson & Cooke, 2005).

5.2. Effect of different number of talker in English (Non-Native language) babble on ANL

It was found in the present study that the best ANL scores were obtained in the 2-talker babble in English non-native language. The 4-talker, 8-talker, 10-talker and 12-talker babbles had higher values in English language babble.

Kilman, Zekveld, Hällgren and Rönnberg (2014) studied the influence of non-native language proficiency by using 2-talker babble in native and non-native language wherein the native language provided more informational masking. However, when the non-native language was studied, the informational masking was reduced and thus reducing the understanding of masker, making it easier to suppress the effect of the

masker. This is in accordance with the present study having better scores in 2-talker babble.

In the presence of English babble, ANL increased as the number of babbles increased in contrast to Kannada babble as the ANL was better in 4-talker babble. This effect was also documented by Nayana et al. (2016) while estimating ANL for non-native English babbles on native Kannada speaker adults with normal hearing sensitivity.

In addition, although there was no difference between the Kannada and English ANL, there were differences in the mean ANL between the two languages for 2-talker babble. That is, ANL in Kannada language was higher than English language for 2-talker babble. The reason for the higher scores in Kannada language can be correlated to the informational masking that is present in a high-proficient language than a low proficient language (Kilman et al., 2014).

ANL in all the other babble conditions were slightly higher/poorer in English babble when compared to Kannada babble though there was no statistically significant difference. Goldman, (2009) and Shi et al. (2015) also have provided similar results. Though several studies have showed no significant difference between different languages and reported that the ANL has a property which is independent of language (Brännström et al. 2012; Nebalek et al. 199; Von & Bahng, 2006), the slight variation in ANL between the two languages in the current study might have been due to the difference in sentence structure; more occurrences of long vowels and difference in occurrence of phonemes.

CHAPTER 6

SUMMARY AND CONCLUSION

The aim of the current study was to find the effect of number of talkers in native and non-native speech babble on the acceptable noise level (ANL) in older adults with hearing impairment. In order to find the effect of number of talkers, a group of 22 older adults between the age group of 55 to 70 years were taken. The individuals had mild-moderate sensorineural hearing loss.

ANL was obtained in all the individuals in the presence speech babble in native and non-native languages. The number of talkers in speech babble was varied from 2-talker, 4-talker, 8-talker, 10-talker and 12-talker babble. The babbles were recorded in two different languages- one in native (Kannada) language and another in non-native (English) language.

The results revealed that the 4-talker babbles gave the best ANL scores in Kannada language and the ANL increased with increase in number of talker babble. 2-talker babble also had higher ANL score which might be due to the phenomenon of informational masking in a high proficient native language.

The results of comparison of ANL obtained in the presence of English babble revealed that the best score was obtained from 2-talker babble which might be due to the low proficiency in non-native English language that suppresses the effect of masker. It was also found that there were slight different in ANL between Kannada and English babble, though these differences were not statistically significant.

To conclude, there was an effect of number of talkers in babble on ANL with 4-talker babble resulting in the best ANL in the native language. In the presence of non-native language babble, ANL is the best with 2-talker babble indicating that information masking is predominant in the presence of native language. This suggests a possible influence of language of the background speech babble on ANL.

6.1. Implications

The results of the present study throw light on the possible influence of number of talkers in babble and the background language on ANL. This information will enable in fine-tuning the parameters for obtaining ANL, thus, resulting in reliable ANL testing. The study can influence better counseling for older adults getting hearing aids for the first time.

6.2. Future Directions

- The same study can be done with running speech as target speech signal rather than narrative speech to give a realistic experience.
- The ANL of different number of babbles could be tested after the use of hearing aids.

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