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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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 to 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 and 4- talker babble resulted 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.

Key words: *Acceptable Noise Level, Native and Non-Native speech babbles, Informational masking*

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). 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).

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 talkers 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).

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However, Gordan-Hickey, Moore and Estis (2012) studied the impact of listening conditions on background noise acceptance for adults with normal hearing sensitivity. They changed the number of background talkers viz. 1-talker, 4-talker, and 12-talker babbles and studied the acceptance of noise. The mean of ANL was poorer for 1-talker babble when compared to other numbers of talkers in speech babbles.

ANL is usually obtained with passages and sentences as the stimuli. There are studies evaluating the effect of stimulus language on ANL. 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 with English babble.

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. 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.

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) babbles on the acceptable noise level in older adults with hearing impairment.

Objectives of the study

The objectives of the present study were to find out ANL in the presence of 2-talker, 4-talker, 8-talker and 12-talker Kannada speech babble; to find out ANL in the presence of 2-talker, 4-talker, 8-talker and 12-talker English speech babble; 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; and to compare the ANL across Kannada and English speech babbles for different number of talkers of speech babble.

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.

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 were all Kannada speakers with SIS scores not less than 70%. They had a minimum qualification of SSLC. The participant did not have any middle ear pathology or 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.

Equipment used

A calibrated two channel diagnostic audiometer Inventis Piano was used to conduct 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. For ANL testing, the recorded stimulus was routed through the calibrated two channel Inventis piano audiometer using a laptop through auxiliary input of the audiometer directed through a loud speaker kept at 0° Azimuth.

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.

Procedure to obtain ANL

The participants who met the inclusion and exclusion criteria were considered for further testing. The procedure described by Freyaldenhoven (2006) was followed in order to obtain an ANL where 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 target sentences were presented to the listener at the level of SRT which was presented through the loudspeaker. The intensity of the target stimulus was gradually adjusted in 5 dB steps until the listener said

that the target sentences were heard in their most comfortable level. The steps were repeated two times, and the average level was taken as the MCL.

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 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 Kannada and English. Test re-test reliability was assessed on10% of the participants, wherein ANL was measured twice with an interval of one-two weeks.

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.

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.

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

The mean, median and standard deviation (SD) of ANL scores across different babble conditions are given below in Table 1. It can be observed that the mean ANL obtained for 2-talker, 4-talker and 8-talker 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 1: Mean, median and SD of ANL obtained for different number of talkers in Kannada babble (N =22)

Babble	ANL in Kannada		
	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 analyse pair-wise differences, Wilcoxon Signed-Rank test was done which can be seen in Table 2.

Table 2: Comparison of ANL obtained for different number of talkers in Kannada babble using Wilcoxon Signed-Rank test

Conditions Compared	Z	Significance
4-talker – 2 talker	-.576	.499
8-talker – 2 talker	-.024	.981
10-talker – 2-talker	-2.11	.034*
12-talker – 2-talker	-2.53	.011*
8-talker – 4-talker	-1.07	.284
10-talker – 4-talker	-2.37	.018*
12-talker – 4-talker	-2.87	.004**
10-talker – 8-talker	-1.18	.237
12-talker – 8-talker	-2.24	.025*
12-talker – 10-talker	-.802	.547

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

It can be seen 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 presented.

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 3. It can be observed from the Table 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 3: Mean, median and SD of ANL in Non-native language (N=22)

ANL in English (non-native language)	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 in Table 4 below shows that there was a significant difference ($x2 = 12.27$; $p < 0.05$) between different number of talkers in English babble. Further pair-wise comparison was done using Wilcoxon's Signed Rank test.

Table 4: Comparison of ANL obtained for different number of talkers in English babble using Wilcoxon Signed-Rank test

Conditions compared	Z	Significance
4-talker – 2 talker	-1.65	.097
8-talker – 2 talker	-2.07	.038*
10-talker – 2 talker	-2.51	.012*
12-talker – 2 talker	-1.58	.112
8-talker – 4-talker	-.72	.466
10-talker – 4-talker	-.55	.579
12-talker – 4-talker	-.14	.885
10-talker – 8-talker	.00	1.00
12-talker – 8-talker	-.54	.549
12-talker – 10-talker	-.57	.563

Note. *p < 0.05

The results of Wilcoxon signed rank test (as seen in the Table 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.

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

The effect of language influence over ANL across different talker babbles from 2-talker, 4-talker, 8-talker, 10-talker and 12-talker babble was studied. The mean and SD between native and non-native language babbles were compared.

As it can be seen, the mean of 2-talker and 12-talker babbles was similar and they were higher in native Kannada language. In case of 4-talker and 8-talker babbles, the ANL for non-native babble was higher. The

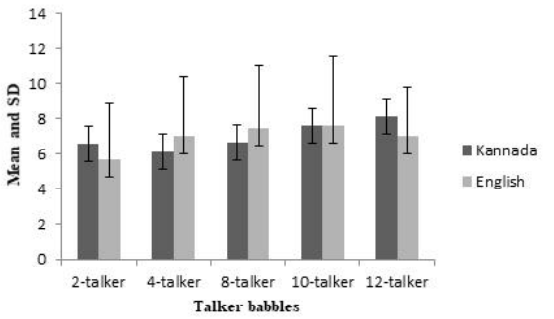

Figure 1. Mean and SD of speech babbles between native and non-native languages.

10-talker babble did not have any language effect as the mean obtained for both native and non-native language were same. The SD, however, varied more for non-native babbles than native babbles.

Further to compare the effect of native and non-native language from the data obtained from ANL of different number of speech babbles, non-parametric tests were done as the data did not follow normality in Shapiro-Wilk's test of normality. The results of Friedman's test showed that there is a significant difference ($x2 = 25.85$; $p < 0.01$) between the native Kannada language and non-native English language. Further Wilcoxon Signed-Rank test was done for pair-wise comparison between native and non-native language across different numbers of speech talker babbles.

As it can be seen in the Table 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.

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.

Table 5: Wilcoxon Signed-Rank Test for pair-wise comparison across native and non-native language speech babbles

Conditions	Conditions Compared	Z	Significance
2-talker speech babble	Native language Non-native language	-1.32	.186
4-talker speech babble	Native language Non-native language	-1.27	.204
8-talker speech babble	Native language Non-native language	-1.14	.265
10-talker speech babble	Native language Non-native language	-1.32	.895
12-talker speech babble	Native language Non-native language	-1.68	.092

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 on 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 informational masking in 2-talker babble. 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).

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 language. 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 statistical 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).

CONCLUSION

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.

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