THE INFLUENCE OF PROFICIENCY OF THE NON-NATIVE BACKGROUND LANGUAGE ON SPEECH RECOGNITION OF NATIVE LANGUAGE

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This Dissertation is submitted as part fulfillment
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CERTIFICATE

This is to certify that this dissertation entitled **"The Influence of Proficiency of The Non-Native Background Language on Speech Recognition of Native Language"** is the bonafide work submitted in part fulfillment for the Degree of Master of Science (Audiology) of the student with Registration No: **16AUD021**. 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.

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This is to certify that this dissertation entitled **"The Influence of Proficiency of The Non-Native Background Language on Speech Recognition of Native Language"** has been prepared under my supervision and guidance. It is also certified that this 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 Master's dissertation entitled **"The Influence of Proficiency of The Non-Native Background Language on Speech Recognition of Native Language"** is the result of my own study under the guidance of Dr. Geetha C, Reader in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in other University for the award of any Diploma or Degree.

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"In the memory of our beloved brother wantei"

So here I am, writing my acknowledgment after all the dissertation works, compiling the chapters, hectic page numbers...

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ABSTRACT

Speech perception is commonly referred as the process by which the sounds are heard, interpreted and understood. Speech in speech perception is a common phenomenon. The present study aimed to the influence of native vs. non-native language babble and the effect of language proficiency in the Kannada sentence recognition. Forty Kannada-English bilinguals were selected and subjected to Kannada sentence recognition task in the presence of two-talker Kannada babble, two-talker English babble, two-talker Tamil babble, two-talker Telugu babble and two-talker Nepali babble. The presentation level was 75 dB SPL at 0 dB SNR. Comparison of the recognition scores across five babble conditions revealed significantly better scores in presence of two-talker Nepali babble followed by Tamil babble, English babble and Telugu babble, when compared to two-talker Kannada babble, implying the release of masking in the presence of non-native language babble. Further, the effect of language proficiency in speech recognition was studied by correlating the proficiency scores with Kannada sentence recognition scores in the presence of the respective babbles. Significant correlation was found only in the Kannada and Tamil language conditions. It can be inferred that the linguistic similarities between the target and the background babble might have more role in masking than the proficiency of language.

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CHAPTER 1

INTRODUCTION

The process by which the sounds of a language is heard, interpreted and understood is commonly referred as speech perception. In the presence of noise or with one or more competing speech streams, the speech recognition will become poor due to informational masking. This scenario, also known as speech in speech recognition is a commonly occurring scenario. The background speech can be of different language and varying in a multilingual country like India.

In the past, several studies have been done to evaluate the influence of one language (usually non-native language) on speech perception of other language (native language). Researchers have shown that unfamiliar language masker leads to more masking release compared to native language or a familiar language (Brouwer, Engen, Calandruccio, & Bradlow, 2012; Jain, Konadath, Vimal, & Suresh, 2014). Further, decreasing similarity between the target and masker decreased the speech recognition scores (SRS). For example, English language sentence recognition in two-talker babble of Mandarin resulted in better scores as Mandarin is dissimilar to English, when compared to that of English babble (Calandruccio, Brouwer, Van Engen, Dhar, & Bradlow, 2013).

Brouwer and Bradlow (2014) investigated the effect of variation in the target background language relationship (contextual variation) on the speech in speech recognition on 48 native English speakers. Two experiments were carried out where the SRS in English were tested. The first experiment had speech recognition in the presence of pure English two-talker babble (English in English), pure Dutch two-talker babble

(English in Dutch) and mixed language condition (English in English + Dutch). In the mixed condition, the English and Dutch Babble were interleaved such that it switched languages 30% of the time. The second experiment had two test conditions, English in English and English in Dutch babble. They reported poorer scores in the condition where babble was a mixture of both the languages.

Studies on speech in speech recognition of Indian languages have shown varied results. Anitha (2003) studied the effect of 10-talker babble of different languages (Kannada, Hindi, Malayalam) on SRS of Kannada phonetically balanced words on 40 Kannada speakers. SRS in the presence of 10-talker babble was poorer when compared to SRS in speech noise, whereas no significant difference was obtained across different language babbles. Since the number of talkers were very high, the major factor for masking could be the spectrum of the masker not the linguistic or semantic content in the babble.

Jain et al. (2014) aimed to study the speech recognition in using multitalker babble of native and non-native language at different SNRs. Two Dravidian languages (Kannada and Malayam) were selected. Sixty participants in the age range of 18 to 30 years completed speech perception task in the presence of six and ten-talker babbles. They showed that the Kannada speakers performed better in the presence of Kannada multi-talker babble than non-native Malayalam multi-talker babble. The authors speculate the reason for the better performance by Kannada group in the presence of native multi-talker babble as cognitive factors, where the participants get distracted by non-native language, leading to poorer scores in presence of non-native multi-talker babble.

Preeta (2015) studied the speech recognition in the presence of two-talker Kannada babble, English babble and two-talker mixed and interleaved babble. The results revealed that the performances were better in the presence of two-talker English babble than Kannada babble in all SNRs. Additionally there was a significant reduction in the score when two-talker mixed babble was used and for the higher SNRs scores were higher than the lower SNRs. Similar study was carried out by Shashank (2017), in which the effect of target and masker mismatch in Kannada speech recognition task was seen. The results revealed that the scores were better when the non-native babble (Hindi) was used compared to native babble (Kannada) in all SNRs.

1.1 Need of the study

Miller (1947) stated the speech recognition in the presence of one or more competing speech streams has been topic of interest for some time. There are several studies done to assess the effects of babble on the listeners' recognition of sentences and words in their native language. Studies have shown that linguistic content of masker can influence speech recognition.

In Indian context, there are a few studies that have been done to assess the influence of background language on speech perception. Some of the studies have used multitalker babble (four, six or ten-talker babble) (eg. Anitha, 2003; Jain et al., 2014). In such cases the semantics of the multitalker babble will be lost and hence, it will be perceived as speech noise. If the number of competing speech streams are small (then it produces more informational masking than a multitalker babble which is composed of many different speech streams. In case of an open-set sentence recognition test, two

competing talkers have been observed to cause significant amounts of informational masking (Freyman, Balakrishnan, & Helfer, 2004).

Speech-on-speech recognition for two-talker maskers consisting of different languages than the target speech has also shown large reductions in informational masking (Freyman, Balakrishnan, & Helfer, 2001; Van Engen & Bradlow, 2007). Freyman, Balakrishnan, and Helfer (2004) found that maximum informational masking occurs in two-talker babble background. Hence, it is important to study the effect of speech babble with lesser number of talkers in order to test the influence of language content of the masker.

While Preeta (2015) and Shashank (2017) have used two-talker babbles, they have chosen a non-native language that is quite familiar to the listeners. For example, in Preeta's study, English was chosen as non-native language. The listeners in her study were Kannada-English bilingual talkers with Kannada as native language. Though, in Karnataka, in most regions and schools, English and Hindi are taught, the exposure to other languages is abundant, especially, that are spoken in south India such as Tamil, Telugu and Malayalam. This is due to modern mass media like cinema, newspaper and television. The degree to which the listener's knowledge of the target and the background language modulate the size of the release from masking (Brouwer & Bradlow, 2014). Hence, there is a need to study the influence of the familiarity/proficiency of the language on the information masking. Therefore the present aimed to check the effect of Language familiarity/proficiency of the language in Speech perception. In the present study, along with the south Indian languages (Tamil and Telugu) Nepali was used, as the exposure to this language in Kannada listeners is

almost nil. Even though Tamil, Telugu and Kannada belongs to Dravidian language family, the linguistic and phonetic dissimilarities are present between the languages. Nevertheless, the linguistic distance between Telugu and Kannada less compared to Tamil. Hence, the five different background languages represent different degree of proficiency.

1.2 Aim of the study

The present study aimed to check the influence of two-talker babbles of native (Kannada) and non-native languages (Tamil, Telugu, Nepali and English) on speech recognition. The study also aimed to study the relationship between familiarity of each of the background language and speech recognition of Kannada sentences in Kannada speakers.

1.3 Objectives of the study

The objectives of the present study were,

1. To study the effect of native and non-native maskers (Tamil, Telugu, Nepali, English) on the native language perception.
2. To evaluate the relationship between the proficiency of each of the background languages on speech recognition of Kannada sentences.

CHAPTER 2

REVIEW OF LITERATURE

The listening needs of an individual depends on the information from the speech signals which are perceived even after masked by competing signals. Several research studies have been carried out to evaluate the effect of various types of competing maskers like narrow band noise, broadband noise, pink noise, speech spectrum multitalker babble on speech perception (Anitha, 2003; Carhart, Johnson, & Goodman, 1975; Carhart, Tillman, & Greetis, 1969; Cherry, 1953; Cullington & Zeng, 2008). Among these maskers, speech babble has been reported to be more effective in masking (Carhart et al., 1969; Chen, Li, Li, Wu, & Moore, 2015; Cherry, 1953; Cullington & Zeng, 2008; Engen, Bradlow, Engen, & Bradlow, 2012; Hall III, Grose, Buss, & Dev, 2002).

Carhart (1969) and Pollack (1975) made attempts to differentiate the between the effects of energetic and informational masking in speech in speech recognition task. Energetic masking (EM) refers to masking at the peripheral auditory system and is related to the audibility of the target signal. This causes partial or complete loss of information due to spectral and temporal overlap between the masker and the target (Brungart, Simpson, Ericson, & Scott, 2001). Informational masking (IM) refers to the masking beyond what contributes to energetic masking and could also be associated with central masking. IM is not about the presence of overlap of the signals, rather it is a competitive aspect interfering in the later processing of speech signal. In IM, some amount of EM also occurs (Brouwer et al., 2012; Brungart et al., 2001; Durlach et al, 2003). The authors have concluded that intelligible speech babble or synthesized speech signals give raise to greater masking than speech modulated noise or reverberated

speech. Speech in speech perception is one of the common phenomenon in daily living. There were many factors which would affect speech in speech perception. To list out, linguistic content of the competing speech would affect the perception more compared to other factors (Simpson & Cooke, 2005; Wiley, Sperry, Wiley, & Chial, 1997), native or familiar language would also more masking than the unfamiliar language (Brouwer, et al., 2012; Jain et al., 2014), even the mismatch between the target and the masker language would lead to better performance (Brouwer et al., 2012; Calandruccio et al., 2013; Engen, Van & Bradlow, 2007).

The aim of the present study is to determine the effect of different language maskers, and to study the role of language proficiency on speech recognition. Hence, the literature was reviewed and presented in the following topics.

2.1 Effect of the language of the masker on speech recognition

2.1.1 Native vs. non-native language

2.1.2 Familiar vs. unfamiliar language

2.1.3 Effect of accent

2.2 Number of takers

2.3 Other factors

2.3.1 F_0 and gender of the talker

2.3.2 Attention and Memory

2.1 Effect of Language of the masker on speech recognition

According to Chen et al. (2015), various types of background noise affected the speech perception differently depending on whether the masker had linguistic content

or not. Further, studies have also assessed the speech perception of native language in the presence of native language and non-native language babble or unfamiliar language (Brouwer et al., 2012; Calandruccio et al., 2013; Calandruccio & Zhou, 2014; Cooke, Lecumberri, & Barker, 2008; Jain et al., 2014; Vineetha et al., 2013). Most studies have reported an improvement in speech recognition when the languages of masker and target are mismatched (Brouwer et al., 2012; Calandruccio et al., 2013; Engen & Bradlow, 2007), and a few studies have reported no such improvement (Mattys, Brooks, & Cooke, 2009; Vineetha et al., 2013). The reason for the influence of type of masker may be due to two reasons: one is the language similarity that is the more similar the target and the masker speech, harder to segregate into two speech streams; and the second reason is the familiarity of the background language babble. Due to inability of the listener to understand the background language masker leads to lesser interference in the processing of the target speech (Brouwer et al., 2012; Van Engen, 2010).

2.1.1 Native vs. non-native language

There were researchers, who studied the linguistic contributions of the native and non-native language on speech perception. Effect of native language perception of bilinguals in the presence of native and non-native language babble (Calandruccio & Zhou, 2014; Engen & Bradlow, 2007; Jain et al., 2014) and the perception of non-native language in the presence of native and non-native language babble (Brouwer et al., 2012; Mattys, Carroll, Li, & Chan, 2010; Van Engen, 2010; Vineetha et al., 2013) also has been studied.

Engen and Bradlow (2007) studied the speech recognition of English sentences by English-Mandarin bilinguals in the presence of two-talker English and Mandarin

babble. Similarly, Calandruccio and Zhou (2014) studied English sentence recognition in English-Greek bilinguals in the presence of two-talker babble of English and Greek. Both the studies reported a significant improvement in the speech recognition scores when the target and the masker were mismatched linguistically. Similarly, Engen and Bradlow (2012) studied the second language recognition in the presence of the first (English) and second language (Mandarin) two-talker babble. They revealed that the non-native English speakers had more difficulty in identifying the English target sentences in presence of English two-talker babble when compared to Mandarin two-talker babble. Further, the amount of release in the presence of two-talker Mandarin babble was less in Mandarin listeners. Brouwer et al. (2012) studied English sentence recognition in the presence of two-talker English and Dutch babble in Dutch-English bilingual listeners. The results revealed that there was a release from masking when the competing speech was different from target speech i.e., better scores of L2 recognition in the presence of L1 masker. The above finding indicates that both similarity between the target and masker, and the language experience of the listener contribute to the interference experienced during speech perception in noise.

On the contrary, Mattys et al. (2010) studied English phrase recognition in Cantonese-English bilinguals in the presence of competing speech in Cantonese and English language (one-talker). They reported no difference in the scores and postulated that the listeners in their study relied on the acoustic cues of the target to recognize and not on the lexical semantic competitor of the background language. The reason behind the different findings in this study could be the material used in this study is different from others. Other studies have used English sentences as target signal and had two talker babble as a masker in open recognition task, whereas in this study the author used

a competing talker as a masker and two word phrases as the target stimuli in closed set task. The author stated that the difference they got in the performance might be because of the higher cognitive load on the task in the other studies, so that slowing the cognitive process could have reduced the speech perception ability in non-native language.

Few studies have been done on speech-in-speech recognition in Indian languages and they reported no such benefit from linguistic mismatch (Vineetha et al., 2013). The subjects used in this study were Kannada and English bilinguals. The language proficiency of the non-native language could be equal to the native language, which could have affected the results.

2.1.2 Familiar vs. unfamiliar language

There were a few reports on the effect of familiar and unfamiliar language background. Engen and Bradlow (2007) studied English sentence recognition in native English monolingual listeners in the presence of two-talker babble in English and Mandarin. They reported that native English listeners received a release of masking in English recognition in presence of two-talker Mandarin versus English background babble. Similarly, such release of masking has been reported in other languages like Dutch (Calandruccio et al., 2013), Croatian (Calandruccio et al., 2010) and Spanish (Lecumberri & Cooke, 2006).

Further, studies have also investigated the masking release for foreign speech maskers that vary in the degree of linguistic similarity to the target. Calandruccio et al. (2013) investigated target-masker linguistic similarity in three conditions: identical target-masker (English in English recognition); linguistically close target-masker

(English in Dutch recognition); and linguistically distant target masker (English in Mandarin recognition). English and Dutch belongs to the same linguistic family of Indo-European, whereas, Mandarin belongs to the Sino-Tibetan family. They reported that the performance of monolingual English speakers to be most affected in the presence of English masker followed by Dutch and least by Mandarin. Hence, smaller masker release is observed when a linguistically similar language is used to mask the target.

The authors reported that this cannot be wholly accounted to the informational masking as the difference in the spectral properties does exist between languages which could contribute to less or more Energetic masking along with Informational masking in the above mentioned study.

Kilman, Zekveld, Hallgren & Ronnberg (2014) examined the extent of proficiency in a non-native language influences speech perception, in four conditions, including two energetic and two informational masking conditions (two-talker Swedish babble, two-talker English babble), the results of this study revealed that the high proficiency in the non-native (English) language had an effect in the non-native target (English), SRT's were lower compared to the listeners with low English proficiency scores. The effect of non-native language (English) proficiency did not had any influence on the native target (Swedish) speech.

In Indian studies, the influence of unfamiliar languages have shown varied results. Anitha (2003) studied the effect of ten-talker babble of different languages (Kannada, Hindi, Malayalam) on SRS of Kannada phonetically balanced words on 40

Kannada speakers. SRS in the presence of ten-talker babble was poorer when compared to SRS in speech noise, whereas no significant difference was obtained across different language babbles. The authors' opinion about the result was that the major factor for masking was the spectrum of the masker not the linguistic or semantic content in the babble. Hence, using a less number of talker babble could have produced Informational masking.

The results of the study done by Jain et al. (2014) showed that the Kannada speakers performed better in the presence of Kannada six and ten-talker babble than non-native Malayalam six and ten-talker talker babble. The authors speculate the reason for the better performance by Kannada group in the presence of native multitalker babble as cognitive factors, where the participants get distracted by non-native language, leading to poorer scores in presence of non-native multitalker babble.

The above mentioned studies (Anitha, 2003; Jain et al., 2014) report no release of masking in the presence of non-native language. Various factors could have led to these results. The numbers of talkers used were six-talker and ten-talker babbles. This could have led to more of energetic masking than Informational masking, leading to no significant release of masking across different language of babble. It could also be that the languages chosen for the experiment are from the same family causing no difference in the masking.

2.1.3 Effect of accent

The accent of the native language influences the native language acoustically and phonetically (Sirsa & Redford, 2013), this would lead to less masking. Calandruccio et al, (2010) reported that the English sentence recognition scores were

significantly better in the presence of Mandarin accented English babble than native English two-talker babble in native English monolinguals, and this was because of the influence of mandarin accent on English language which was causing a release in masking.

2.2 Number of talkers

In the informational masking studies, one of the major variables that affect the influence of the Informational masking is the number of talkers used in the study. Broersma (2012) Cullington & Zeng (2008), Engen & Bradlow (2007), Hall III et al (2002), Simpson & Cooke (2005) stated that the strongest masking effect would there when there are two or four talkers used in a multitalker babble (MTB). This effect becomes less prominent as the number of talkers further increases and saturates when there are twelve or more talkers as it reduces the semantic interference on perception of target speech (Cullington & Zeng, 2008; Simpson & Cooke, 2005).

Miller (1947) was the first to investigate the effect of number of talkers in the MTB. Miller measured the intelligibility of words with 1, 2, 4, 6, and 8-talker speech babble, the results revealed that the difference in masking effect for a single talker over two talkers was equivalent to an SRT difference of about 8 dB. Babble with 4, 6, 8 talkers produced an additional 3-4 dB of masking over the two-talker condition. The study reported a monotic decrease in performance as the number of talkers increased. Similarly, Carhart et al. (1969) found that a two-talker masker was more effective than continuous white noise in masking the recognition of spondee words.

Carhart et al. (1975) measured the intelligibility of spondees in the presence of speech babble with 1, 2, 3, 16, 32, 64, 128 talkers, and modulated noise. The difference between the speech babble and modulated noise was found to be 6.2 dB with the one talker and 7.2 dB with the two-talker and the maximum (9.8 dB) was reached with three-talkers. Thereafter, the difference decreased, stabilizing at about 3 dB with 64 talkers. Hence, they concluded that the two, three and four-talker babbles to be effective for Informational masking. Hoen et al. (2007) also concluded that lexical masking occurs for low number of talkers and diminishes with more talkers.

Similarly, Boulenger, Hoen, Ferragne, Pellegrino, and Meunier (2010) reported a decrease in performance as the number of talkers increase. They measured the recognition of target words in terms of reaction time using real-time word recognition paradigm in presence of Multitalker babble with 2, 4, 6, and 8 talkers. They found significantly faster reaction times in two-talker condition and the reaction time reduced systematically as number of talker increased from four to eight, but, it was not significant. Hence, they stated that with increase in number of talkers there was increased spectral and temporal saturation.

To conclude, majority of the studies on Informational masking suggested to use two, three or four-talker babble (Brouwer & Bradlow, 2014; Brouwer et al., 2012; Calandruccio et al., 2013; Calandruccio & Zhou, 2014; Van Engen, 2010; Wu et al., 2015 among others). Higher number of talkers leads to more energetic masking and less informational masking as the lexical and semantic content of the masker would be less intelligible to compete with the target.

2.3 Other factors influencing speech-in-speech recognition

2.3.1 F_0 and gender of the talker

Several studies revealed that the difference between the F_0 of the target and masker would lead to less masking. Brungart et al., (2001) studied the speech masking using two, three and four-talker babbles varying in terms of talker and gender, and the results revealed that less masking (better scores), when the talker of the target and masker were different and more masking (poor scores), when the same talker spoke the target and the masker. The authors attribute that the masking could be due to the EM, as because the target and the masker were spoken by the same talker. There could be IM also due to qualitative similarities between the target and masker leading to more interference at the lexical-semantic recognition of the target (Brungart et al., Cooke et al., 2008).

With regard to gender, poorer scores were reported when the target and the masker was spoken by same gender and there were deterioration of the scores when one of the talker in the masker was replaced by the opposite gender (Mattys et al., 2009; Mattys & Wiget, 2011). Cullington & Zeng (2008) stated reported that the maskers recorded by female speakers were less susceptible to masking when compared to males and child talkers. Further, Bradlow and Bent (2002) also conveyed that the target by female talker is less susceptible to noise than the male recorded target speech. In general, the vocal characteristics of the speaker (target and the masker) affects IM differentially. Therefore in the present study, the gender of the talkers of the babble was kept constant throughout the conditions.

2.3.2 Attention and Memory

The attention tend to get affected by various reasons in normal listeners. The listeners' attention could be divided by the presence of a distractor or babble and these could have an effect in IM (Cooke et al., 2008; Lecumberri & Cooke, 2006). The disturbance might have several reasons, such as the change in the semantic content or might be cross modality distracters, for e.g., multi-tasking conditions which reduce attention capacity due to divided attention. Kahneman (1973) stated that attention resources used to get exhausted or depleted, if the task had to be simultaneously executed with a speech task. In consort with attention resources, memory loads could also influence the performance. Such as, listening to various talkers sequentially, is shown to engage more working memory resources than listening to a single target (Nusbaum & Morin, 1992). Authors reported that the representation of speech maintained in working memory is likely to be phonological (Mattys et al., 2012) which means that reduced memory capacity affects sub-lexical processes as well. Hence, reduced attention or divided attention can affect sub-lexical and lexical processes thereby affecting speech perception.

In summary, subsequently reviewing the factors which influenced the speech in speech recognition, informational masking is a central level processing which can be affected by the peripheral processing also. Hence, the studies on speech in speech recognition showed varied results. The proficiency of non-native language on Kannada speech perception has not been researched extensively earlier. Therefore, the current study aimed to determine the effect of proficiency of background language babbles on SRS of Kannada sentences in Kannada-English bilinguals.

CHAPTER 3

METHOD

The study was intended to see the effect of native (Kannada) and non-native language babbles (English, Tamil, Telugu and Nepali) on speech recognition scores in native language (Kannada). The study also intended to evaluate the effect of language proficiency of native and non-native languages on speech recognition scores. The study included three different phases. The first phase was to develop the native and the non-native babbles, second phase was to measure the speech recognition scores in presence of the native and non-native babble conditions and the third phase was the assessment of language proficiency among the subjects. All the phases had been elaborated in the following sections.

3.1. Participants

A group of 40 participants in the age range of 18-25 years (20 males and 20 females; mean age = 21.3; SD = 1.58) were included in the present study. The following selection criteria were used:

3.1.1. Selection criteria

- All the listeners were native speakers of Kannada with English as their second language.
- All the participants had a minimum of 12^{th} grade of education in English medium school and had Kannada as their second language or Kannada medium school with English as their second language.

- The participants had hearing sensitivity less than or equal to 25 dB HL at 250 to 8000 Hz for air conduction (Indrani, 1981). Their mean PTA was 12.21 (*SD* = 2.33).
- They had ‘A’ or ‘As’ type tympanogram with ipsi and contra reflexes present (Jerger, 1970).
- They had SPIN scores above 60% at 0 dB SNR.
- They had presence of oto-acoustic emissions in both the ears.
- The participants had no history of otological or neurological problems and no other speech and language problems.
- Informed consent was obtained from all the participants.

3.2. Instrumentation

- A calibrated two channel diagnostic audiometer (MAICO-MA 53) was used for pure tone audiometry and speech audiometry. TDH-39 headphones and B-71 bone vibrator were the transducers used.
- Calibrated GSI-Tympstar immitance meter was used for tympanometry and acoustic reflex measurement.
- For the experimental task, a HP Notebook with software Adobe Audition v3 was used for recording the speech babbles, processing and mixing was done using MATLAB. MOTU Microbook II, an audio interface, was connected to the notebook and was used to record the Native (Kannada) and non-native (Tamil, English, Telugu and Nepali) passage for the construction of the babble.

3.3. Material Used

- The speech recognition thresholds were obtained using Kannada paired words developed at the Department of Audiology, AIISH.
- Speech Identification Scores and SPIN test were done using Kannada Phonemically Balanced word list developed by Yathiraj and Vijayalakshmi (2005).
- Kannada sentence lists developed by Geetha, Kumar, Manjula and Pavan (2014) were used to find speech recognition scores (SRS) for sentences in quiet and in presence of two-talker babble. This test consists of twenty five similar lists with ten sentences under each list.
- Sentences from standardized passage of 300 words in Kannada, Tamil, Telugu developed Savithri & Jayaram (2005) by English sentences from the standardized English rainbow passage (Fairbanks, 1960) and Nepali sentences from the Nepali reading passage from a textbook was used. It was a non-standardized passage as Nepali language did not have any standardized reading passage.
- Two-talker babbles in five different languages (Kannada, English, Tamil, Telugu and Nepali) speech babbles used as a masker in the test conditions.
- Language Proficiency Questionnaire-An adaptation of LEAP-Q in Indian context (Ramya, 2009) was used to assess the language proficiency of all participants.

3.4. Test environment

The test was carried out in sound treated double room suite. The ambient noise levels were within permissible limits (ANSI, 1991).

3.5. Procedure

3.5.1. Phase 1: Development of two-talker native (Kannada) and Non-Native (Tamil, English, Telugu and Nepali) babbles

For the construction of two-talker babble, sentences from passage of Kannada, Tamil, Nepali, English and Telugu were used. Two native speakers of the respective languages were selected (one male and one female, because in two-talker babble if both the speakers were females, the masker would be less susceptible and could be influenced by the target, to avoid this, one male and female talker was selected).

The recording microphone was placed 10 cm in front of the mouth of the speaker and the speaker was asked to articulate the words clearly. The passage was recorded digitally in a sound proof booth using MOTU Microbook II and mixed using Adobe Audition version 3 at a sampling rate of 44.1 kHz with 24-bit resolution.

The sentences were normalized with the help of Adobe Audition version 3.0. The Kannada sentence list (Geetha et al., 2014) was mixed with the two-talker babble (Tamil, Telugu, Kannada, English and Nepali), at 0 dB SNR using Adobe audition version 3.0. Hence, there were five target sentence lists with 5 different languages babbles.

The LTASS of the target and 5 different language babbles were analyzed and the LTASS was shown in Figure 3.1. The test conditions were illustrated in Figure 3.2.

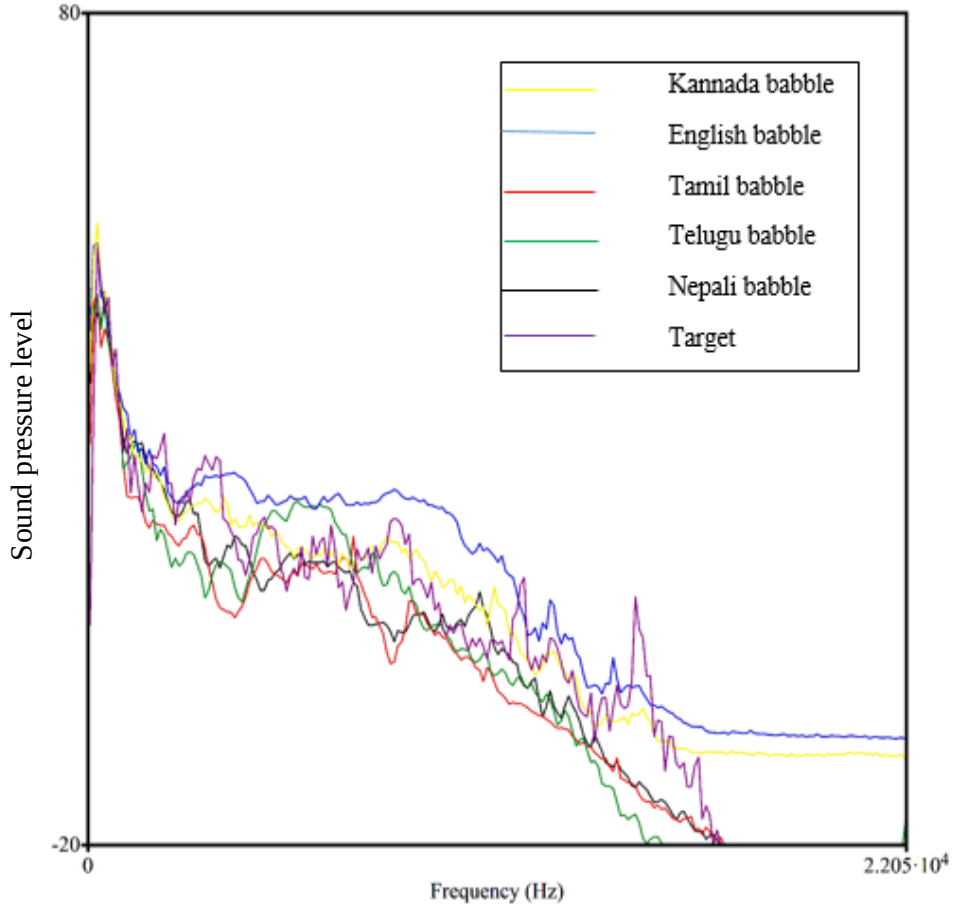

Figure 3.1. LTASS of different babbles and the target sentence

As the figure depicts, LTASS of the different babbles were compared to the target sentences. The energy concentration was almost same at the lower frequencies. At the higher frequencies the energy across the babbles and the stimuli were scattered. However the stimuli and the babbles were still comparable.

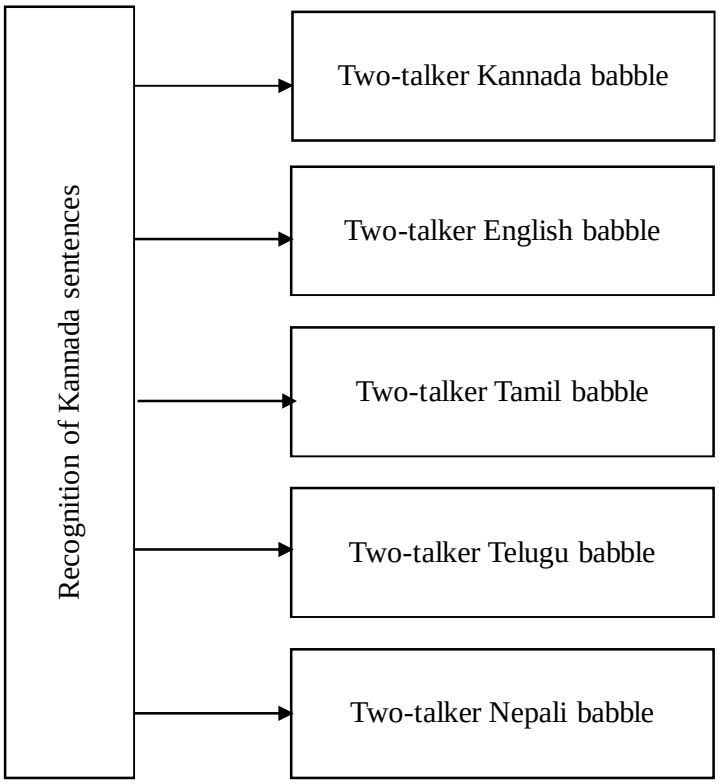

Figure 3.2 Illustration of the test conditions.

3.5.2. Phase 2: Measurement of SRS in the presence of the two-talker babble conditions

The participants were seated in a comfortable chair and the sentences were presented through HP notebook and calibrated TDH-39 headphones diotically in the right ear (because of the Right ear advantage). All the participants were instructed to repeat the target sentences orally in all five conditions. The tester scored the words identified correctly in the score sheet containing the target sentences. Every sentence in the sentences list had four key words and scoring was based on the correct identification of the key words in each sentence. The maximum number of keywords for each SNR condition was 40.

The sentences were never repeated for any of the conditions to avoid practice effect. The order of the presentation of different conditions was random so as to avoid order effect.

3.5.3. Phase 3: Assessment of Language proficiency

For assessing the language proficiency of an individual, Language Proficiency Questionnaire-An adaptation of LEAP-Q in Indian context (Ramya, 2009) was used. The level of proficiency chapter was selected to assess the proficiency in four categories (understanding, speaking, reading, and writing). The participants were asked to rate themselves. The rating ranged from 1 to 5 for each category, '1' indicates zero proficiency and '5' indicated native like proficiency. The overall scores were 20 for the 4 categories.

3.6. Statistical analysis

The sentence recognition scores were entered in Statistical Package for the Social Sciences (SPSS) version 20.0 for each condition and non-parametric tests were used to analyze the data. Friedman test was used to find the main effect of SRS in different speech babble and further, Wilcoxon signed rank test was done to carry out pair-wise comparisons. Spearman correlation coefficient was used to correlate the Language proficiency and their effect on SRS.

CHAPTER 4

RESULTS

The objectives of the study were to assess the effect of native and non-native speech babble on speech recognition of native sentences and to study the influence of familiarity of each of the background language (Kannada, English, Tamil, Telugu and Nepali) on speech recognition of Kannada sentences in Kannada-English bilinguals.

4.1. Effect of Language proficiency on SRS scores

The language proficiency of five different languages was assessed using Language Proficiency Questionnaire-An adaptation of LEAP-Q in Indian context (Ramya, 2009), in which level of proficiency chapter was selected to assess the proficiency in four categories (understanding, speaking, reading, and writing). The overall proficiency scores were fed into SPSS version 20.0. The maximum scores were obtained for Kannada (Mean = 19.90, *SD* = 0.37), followed by English (Mean = 18.47, *SD* = 1.037), Telugu (Mean = 8, *SD* = 1.519), Tamil (Mean = 5.88, *SD* = 1.09) and zero proficiency for Nepali (Mean=4, *SD* = 0).

Friedman test was used to determine the effect of Language proficiency on SRS. The results revealed that there was a significant effect of the language proficiency scores [(χ^2 (4) =155.959, $p < .01$)] on SRS.

Table 4.1

Results of Wilcoxon Signed test of Language proficiency scores among individuals

	Z value				
Conditions	Kannada Proficiency	English Proficiency	Tamil Proficiency	Telugu Proficiency	Nepali Proficiency
Kannada Proficiency		4.938**	5.567**	5.540**	6.125**
English Proficiency			5.561**	5.532**	5.590**
Tamil Proficiency				5.173**	5.380**
Telugu Proficiency					5.540**
Nepali Proficiency					

Note. **$p < .01$.

Wilcoxon signed rank test used to check the pair-wise comparison across the language proficiency scores. The results of this are given in Table 4.1. The results revealed that there was a significant difference between the language proficiency scores. The participants selected for the study was Kannada-English bilinguals. Their language proficiency scores were at the maximum levels in Kannada, all of the subjects had zero proficiency in Nepali. The participants had significantly low scores on English proficiency compared to Kannada proficiency. Tamil and Telugu had similar proficiency scores, both were significantly low compared to Kannada and English.

4.2. Effect of native vs. non-native language on Kannada sentence recognition

Speech recognition scores (SRS) for sentences were obtained in the presence of two-talker Kannada, English, Tamil, Telugu and Nepali babbles. The same was tabulated and given in Table 4.2.

Table 4.2

Mean, SD, median and the range of the SRS in the presence of two-talker Kannada, English, Tamil, Telugu and Nepali babble.

Conditions	Mean	SD	Median	Range
Two talker Kannada Babble	32.7500	1.25576	33.0000	30-35
Two talker English Babble	36.3750	1.33373	36.0000	34-39
Two talker Tamil Babble	37.0750	0.99711	37.0000	34-38
Two talker Telugu Babble	34.8750	1.24422	35.0000	33-38
Two talker Nepali Babble	37.4000	1.21529	38.0000	33-39

Note. Maximum number of keywords = 40

It can be seen in the Table 4.2 that the best SRS was obtained when the background language was Tamil, and the least SRS was observed when the background language was Kannada. The SRS between other language babbles was similar. For statistical analysis of the data, the data were subjected to Shapiro-Wilks normality test and the results of that revealed that ‘p’ value was less than 0.05 for all conditions implying non-normality of the data. Hence, non-parametric tests were used to statistically analyze the data.

Friedman test was done to determine the effect of five two-talker babble conditions on the SRS. The results of Friedman test revealed a significant main effect of different babble conditions [($\chi 2(4) = 120.027$, $p < .05$)]. Hence, Wilcoxon signed rank test was used for pair-wise comparison between different conditions. The results of Wilcoxon signed rank test are given in Table 4.3.

Table 4.3

Results of Wilcoxon Signed test of SRS obtained with different speech babbles.

	Z value				
Conditions	Kannada babble	English babble	Tamil babble	Telugu babble	Nepali babble
Kannada babble		5.541**	5.542**	4.865**	5.535**
English babble			2.552*	4.404**	3.162**
Tamil babble				5.077**	1.592
Telugu babble					5.273**
Nepali babble					

Note. **$p < .01$, *$p < .05$.

The results revealed that there was a significant difference across all conditions except between SRS obtained in the presence of Tamil babble and Nepali babble. SRS in the presence of Tamil and Nepali babble was significantly higher than other two-talker babbles (i.e., Kannada, Telugu and English). Moreover, the SRS in the presence of Telugu babble was also significantly different from the other conditions, the scores were lower compared to other babbles except Kannada. In the presence of English babble, the subjects were able to perform the task better, hence their SRS was

significantly higher than Kannada and Telugu two-talker babble condition. The lowest SRS was observed in the presence of Kannada two-talker babble.

Spearman correlation coefficient was used in this study to measure the correlation between language proficiency and SRS. The results of the same are given in Table 4.4.

Table 4.4

Spearman correlation coefficient between language proficiency and the SRS scores

Conditions	Kannada two-talker babble	English two-talker babble	Tamil two-talker babble	Telugu two-talker babble	Nepali two-talker babble
Kannada Proficiency	-0.42**				
English Proficiency		-0.043			
Tamil Proficiency			-0.66**		
Telugu Proficiency				-0.246	
Nepali Proficiency					--[a]

Note. ** $p < .01$, [a] correlation could not be done

The results revealed that there was a significant negative correlation between proficiency level of Kannada and SRS as well as level of proficiency of Tamil and SRS. That is, as the proficiency level increased the SRS decreased. Whereas no significant correlation was observed between the degree of proficiency of English, Telugu and SRS.

The participants had high proficiency scores in the native language than other languages, and their SRS were less in presence of the native language babble with a significant negative correlation. It was vice-versa in case of Tamil. The subjects had poor scores in Tamil language proficiency and the SRS was significantly high compared to all other conditions, in the presence of Tamil babble. On the contrary, English language proficiency was high compared to other non-native languages but SRS in the presence English babble had significantly higher scores than Kannada and Telugu babble conditions. This implies that English two-talker babble did not have much masking effect. Remarkably, the SRS in the presence of Telugu babble had significantly poorer scores than the other non-native babble conditions and the Language proficiency scores were significantly lower than English and Kannada. On the other hand, correlation analysis could not be done because all the subjects had same scores in Language proficiency and the SD was ‘0’.

CHAPTER 5

DISCUSSION

The present study assessed the speech recognition scores of Kannada sentences in the presence of two-talker Kannada, English, Tamil, Telugu and Nepali babbles on Kannada-English bilinguals. The scores were compared across babble conditions and the effect of language proficiency on speech recognition scores was also evaluated.

5.1 Effect of native vs. non-native language on SRS

It was found that Kannada sentence recognition scores were significantly better in the presence of English, Tamil, Telugu and Nepali speech babbles and were significantly poorer in the presence of native language babble, i.e., Kannada babble. Similar results had been found in other studies (Brouwer & Bradlow, 2014; Calandruccio & Zhou, 2014; Stibbard & Lee, 2006). They reasoned that the linguistic mismatch between the masker and the stimulus would contribute to less informational masking, when non-native babble is presented. In contrast to these findings, Anitha (2003) and Vineetha et al. (2013) stated no release of masking in the presence of non-native language MTB. Both these studies used multitalker babbles, these babbles would resemble a speech noise as the number of talker was more (Carhart et al., 1975; Simpson & Cooke, 2005; Cullington & Zeng, 2008), and it would be more of an energetic masking (EM) than informational masking (IM). In order to exclusively attribute the results to the non-native babble, one needs to rule out the other possible contributing factors such as F_0 of the speaker, gender of the speaker and LTASS of the speech babble (Brouwer et al., 2012; Calandruccio et al., 2010; Caludruccio et al., 2013; Calundruccio & Zhou, 2014).

The difference between the masker and the target with respect to F_0, could have an effect in the release of masking. This would make the listener to differentiate the target and the masker instead of IM (Calandruccio et al., 2010; Brouwer et al., 2012; Calandruccio et al., 2013; Calandruccio & Zhou, 2014). Even though the present study had several talkers for the different languages, the F_0 across different babbles were very similar. Hence, the F_0 difference did not influence the SRS (Brungart et al., 2001; Cooke et al., 2008). Another probable factor which could have an effect on the release of masking was the LTASS of different babbles. Differences in the speech recognition task in the presence of speech babble could also be contributed by the differences in LTASS (Calandruccio et al., 2010; Calandruccio & Zhou, 2014). Hence, LTASS of different speech babble was analyzed and it was observed that only minimal differences were present in the LTASS of the five two-talker babble when compared to the target stimuli. This is given in Figure 3.1. in Chapter 3. Therefore the impact of the LTASS would be considered as minimal or none. Hence, the role of IM was evident in the native language in the presence of native and non-native language babble in the current study.

5.2 Effect of language proficiency on SRS

The second objective of the study was to find the effect of degree of language proficiency on SRS. Correlation analysis was done between the degree of language proficiency of five languages and the SRS in the presence of five babbles. It was found that there was a good correlation between the two when Kannada babble was used as background signal. This result could be due to the fact that native listeners were more adversely affected by the native language babble than non-native language babble and the linguistic similarity between the target and the masker would lead to more masking (Brouwer et al., 2012, 2016; Calandruccio & Bradlow, 2010). Except for Tamil

language, other non-native languages didn't have significant correlation between the language proficiency and the speech recognition scores. The subjects had very low proficiency scores in Tamil language and their SRS was significantly higher than other language babbles. This results could be contributed to the linguistic mismatch between the target and the masker and the exposure of Tamil language could have been less. Even though both the languages belong to the Dravidian family, both the languages have different phonological features, this reason could have contributed for the better SRS in the presence of Tamil babble. In addition, the subjects had better English proficiency compared to Tamil, Telugu and Nepali and yet the SRS in the presence of English babble was higher than Kannada and Telugu babble condition. First of all, English being a non-native language would lead to less masking compared to the native language. The spectral and phonetic properties would be different from the target for English which increases the dissimilarity between the masker and the target (Calandruccio et al., 2013; Calandruccio & Zhou, 2014). It was expected that in the other language babbles i.e., Telugu and Nepali would also have the similar results like Tamil. Indeed the SRS performance was higher in the presence of Nepali babble, but there was no significant correlation between the proficiency and the SRS in the presence of Nepali babble.

The proficiency of Telugu language was significantly lower than the Kannada proficiency, yet the SRS was low compared to other babble conditions except Kannada. This could be attributed to the similarities between the languages, both the languages belongs to Dravidian family and both the languages have similar linguistic and semantic characteristics than any other language included in the present study. Calandruccio et

al. (2013) supported the above view by reporting that the listener's performance would be decreased if the target to masker linguistic distance decreased.

CHAPTER 6

SUMMARY AND CONCLUSION

The present study was aimed to check the effect native and non-native speech babble on SRS of Kannada sentences and the role of language proficiency in SRS of Kannada sentences. The participants included in this study were Kannada-English bilinguals.

The SRS was obtained on 40 Kannada-English bilinguals in the presence of two-talker Kannada, English, Tamil, Telugu and Nepali babble. The influence of native and non-native language was studied by comparing the SRS in the presence of two-talker Kannada babble and other non-native speech babbles (English, Tamil, Telugu and Nepali). The results revealed that lowest SRS was obtained in the presence of Kannada two-talker babble followed by Telugu, English, Tamil and Nepali two-talker babble conditions.

Further, the effect of language proficiency on SRS in Kannada sentences were also studied. The results revealed that there were was a significant negative correlation between the Kannada language proficiency and SRS in presence Kannada two-talker babble (High language proficiency and Low SRS), similarly negative correlation was present in the Tamil two-talker babble condition (Low language proficiency and High SRS). There was no significant correlation between the Language proficiency scores and the SRS in the other conditions (English and Telugu proficiency and SRS in the presence of the respective babbles). The correlation analysis could not be done for Nepali language proficiency and the SRS in the presence of Nepali babble.

From the above results, it can be concluded that, if target and masker was form the same language, the speech recognition could be poor compared to non-native language. In addition, the language proficiency did not have significant correlation effect in SRS in the presence non-native languages except Tamil. It can be inferred that the linguistic similarities between the target sentences and background babble might have more role in masking than the proficiency of language.

6.1 Clinical Implications

- Measurement of speech recognition using speech babble will be helpful in simulating real life situation.
- The study gives an insight into how different languages with different proficiency could influence speech perception.
- This study will also be helpful in selecting appropriate masker for experiment using Speech recognition test.

6.2 Future Directions

- A similar study can be carried in older adults with normal hearing and compare the results with younger adults.
- Other Indian languages can be taken as target and check the effect of different languages on SRS.

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