COMPARISON OF PERFORMANCE ON SPIN-K BETWEEN NON-NATIVE KANNADA SPEAKERS HAVING HINDI AS NATIVE LANGUAGE AND NATIVE KANNADA SPEAKERS

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CERTIFICATE

This is to certify that this dissertation entitled **'Comparison of performance on SPIN-K between non-native Kannada speakers having Hindi as native language and native Kannada speakers'** is a bonafide work submitted as a part for the fulfilment for the degree of Master of Science (Audiology) of the student Registration Number: 16AUD011. This has been carried out under the guidance of the 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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DECLARATION

This is to certify that this dissertation entitled **'Comparison of performance on SPIN-K between non-native Kannada speakers having Hindi as native language and native Kannada speakers'** is the result of my own study under the guidance of Dr. Asha Yathiraj, Professor of Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Gratitude is the healthiest of all human emotions…..
-Zig Ziglar

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Enjoy the little things, for one day you may look back and realize they were the big things.

-Robert Brault

ABSTRACT

Aim: The aim of the study was to compare speech perception in noise between native speakers of Kannada and non-native speakers of Kannada having Hindi as their native language. The study also aimed to check the equivalence of the lists of a phonemically balanced test in noise that were found to have equivalent lists in quiet. Additionally, the word and phoneme scores of the speech and noise tests were correlated with the proficiency of the participants in Kannada.

Methods: Two groups of participants in the age range of 18 to 40 years, who had normal hearing, were included in the study. While one group included 40 native speakers of Kannada language, the other group included 30 non-native speakers of Kannada with Hindi as their native language. The non-native speakers of Kannada had acquired the language during early adolescence as compared to native speakers who were exposed to the language since childhood. They were assessed for speech perception abilities in noise using the four lists of the Speech-Perception-in-Noise test in Kannada (SPIN-K) developed by (Vaidyanath & Yathiraj, 2012). The groups were scored for both word as well as phoneme scores for all the lists of SPIN-K. The proficiency of Kannada language was assessed using the 'Modified Language Proficiency Questionnaire', developed as part of the current study. Additionally, the Linguistic Profile Test in Kannada was also administered on the non-native group to check for their usage of Kannada language.

Results: The four lists were found to be equivalent for word scores in both the groups of participants. However, there was a significant difference obtained for phoneme scores across the lists in both the groups. The non-native group obtained significantly poorer word and phoneme scores than the native group SPIN-K. Further, a significant strong correlation was obtained between word scores and language proficiency and moderate correlation between phoneme scores and language proficiency.

Conclusions: Thus, from the present study we can conclude that the four lists are equivalent irrespective of the groups they are administered on, when word scores are calculated. However, not all the lists were equivalent when the phoneme scores were calculated. Also, the speech perception in noise abilities of non-native speakers of Kannada who are native speakers of Hindi are significantly poorer as compared to native speakers of the language. Further, the study indicated that there was a significant moderate to strong correlation between language proficiency and speech perception in noise abilities for native Kannada speakers and non-native Kannada speakers having Hindi as their native language.

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Chapter 1

INTRODUCTION

Speech perception in quiet has been reported to be different from perception in the presence of noise. It has been observed that as the signal-to-noise-ratio decreases, performance on speech perception tasks deteriorates (Miller, Heise, & Lichten, 1951). It has been established that native speakers of a language, do face difficulties in perceiving speech in acoustically challenging environments like noise and reverberation (Boothroyd, 2004; Bradley, Sato, & Picard, 2003; Duquesnoy & Plomp, 1980; Helfer, 1992, 1994). Thus, speech perception tests used to evaluate individuals in quiet have been found to not reflect speech perception in noise. In order to evaluate speech perception in the presence of noise, specific tests have been developed. One of the earliest tests of speech intelligibility in noise was developed by Kalikow, Stevens, and Elliot (1977).

It has been observed that bilingual listeners comprehend speech-in-noise better in their native than non-native language (Shi, 2010). While non-native language speakers have been found to demonstrate speech recognition in quite like native speakers, in the presence of background noise they have been found to have a lot more difficulty than native language speakers (Bergman, 1980; Buss, Florentine, Scharf, & Canevet, 1986; Florentine, 1985; Roussohatzaki & Florentine, 1990; Spolsky, Sigurd, Sato, Walker, & Arterburn, 1968; Takata & Nábělek, 1990).

Much of the evidence for a bilingual disadvantage comes from studies assessing sequential language learners, who are considered as late bilinguals, on speech-in-noise perception abilities in their second, nonnative language (Bradlow & Alexander, 2007; Mayo, Florentine, & Buus, 1997; Rogers, Lister, Febo, Besing, & Abrams, 2006). It has been observed that bilinguals require larger signal-to-noise ratios for better speech perception compared to monolinguals (Mayo et al., 1997; Shi, 2010). Larger signal-to-noise ratios have been found to increase the clarity and predictability of speech stimuli (Bradlow & Alexander, 2007).

The reason for the discrepancy between native and non-native speakers of a language is unclear. However, it is thought to arise from greater use of top-down linguistic information that helps in degraded speech comprehension in native language users. Differences between native and non-native phonological performance was considered to exist as a reflection of less developed phonetic categories in non-native listeners. This phonological categorization was thought to be important to acquire second language at an early age to maximize a listener's ability to understand that language in noise. However, it has been observed that speech understanding under degraded acoustic conditions is difficult even in those who learned both languages early in life (Meador, Flege, & Mackay, 2000). Studies have shown that when speech is degraded by noise, subjects often produce responses that are acoustically similar to the stimuli but also have a higher frequency of occurrence in the non-native language (Howes, 1957; Owens, 1961; Pollack, Rubenstein, & Decker, 1959; Savin, 1963). Besides non-native language processing being taxed by difficulties in listening in degraded situations and requiring higher level knowledge of morphological, syntax, semantics and pragmatic structures of that language, it is also burdened by attentional overload while perceiving it (Bradlow & Bent, 2002; Cutler, Weber, Smits, & Cooper, 2004).

The performance of non-native listerners is thought to be influenced by several variables. These include duration of non-native language study (Florentine, 1985; Roussohatzaki & Florentine, 1990), the age of the listener (Bergman, 1980) and the listening conditions (Takata & Nábělek, 1990). Furhter, it has been reported that the level of clarity is not only influenced by age of acquisition of the non-native language, but also the proficiency in the language. However, it was observed that these factors alone cannot fully contribute for the disadvantage bilingual listeners face when perceiving speech-in-noise. The influence of proficiency and acquisition age on non-native speech perception was found to result in deficits in both quiet and noise conditions (Shi, 2010). It has also been noted that the speech perception in quiet of early, near-native proficient bilinguals were found to be comparable to monolinguals. However, a larger performance drop was evident for the bilinguals than their monolingual peers when perceiving speech in the presence of noise (Rogers et al., 2006).

1.1 Need for the study

While communicating, the speech signal is not always present in isolation but occurs in the presence of background noise. It has been established that the presence of noise affects non-naitve speakers more than native speakers (Florentine, 1985; Gat & Keith, 1978). As the number of bilingual speakers is very high, with most being more fluent in their native language than in their non-native language, it is important to quantify the effect of non-native language on speech perception in noise. Speech-in-noise tests have been developed with norms that are established on native speakers. Thus, it is possible that the scores may differ in non-native speakers. Thus, it needs to be ascertained whether the norms developed for native language speakers can be used for non-native speakers too.

A large number of Hindi speakers have settled in Karnataka and have learnt the local langugage. These inidviduals are often evauated with available speech tests. Thus, they are evaluated using Kannada tests, including when being assessed for their speech perception in noise. It is speculated that there would be a difference in performance in native Kannada speakers and non-native Kannada speakers who are native Hindi speakers, as the two language groups produce speech sounds differently. It has been reported that phonemic contrast between aspirated and non-aspirated consonants is almost merged in spoken Kannada unlike Hindi (Chengappa & Devi, 2002). Hence, there is a need to establish whether the norms obtained on native Kannada speakers can also be used on non-native Kannada speakers with Hindi as their native language.

1.2 Aim of the study

The study aims to compare the speech perception in noise of native Kannada speakers with non-native Kannada speakers having Hindi as their native language. Additionally, the study aimed to check the equivalence of the lists of the test in the two groups as well as ascertain the influence of proficiency of the language on speech identification in the presence on noise.

1.3 Objectives of the study

The objectives of the study are as follows:

- To check if the equivalence of the lists of a speech identification test is maintained in the presence of noise in native and non-native speakers having Hindi as their native language.
- To compare native Kannada speakers with that of non-native Kannada speakers who are native Hindi speakers on the scores (word & phoneme) of the Speech-Perception-in-Noise Test in Kannada (SPIN-K).
- To correlate SPIN-K scores (word and phoneme) with language proficiency for both the groups.

Chapter 2

REVIEW OF LITERATURE

In day-to-day situations, people are surrounded by speech along with other environmental and artificial sounds. Thus, while communicating, speech signal is not present in isolation but it occurs in the presence of background noise. The ability to understand speech in the presence of background noise is affected for every listener, including those with normal peripheral hearing. This has been attributed to destructive effects that are caused due to noise on the neural synchrony and which results in degraded representation of speech not only at cortical levels but also subcortical levels (Anderson, Skoe, Chandrasekaran, & Kraus, 2010). Perception of speech in the presence of noise is considered a multi-step process. This process includes steps of precise sensory processing and then matching the utterances which are present in the signal to their correct phonological, lexical and semantic representations (Lecumberri, Cooke, & Cutler, 2010; McClelland & Elman, 1986; Norris & McQueen, 2008). Extracting correct information from a signal in the presence of noise depends on various factors like the signal-to-noise ratio (Bradlow & Alexander, 2007; Rogers et al., 2006; Van Engen & Bradlow, 2007), language of testing (Buss et al., 1986; Gat & Keith, 1978; Mayo et al., 1997), type of masker that is present (Lecumberri et al., 2010), attentional allocation (Cooke, 2006).

Speech is reported to deteriorate in the presence of noise either due to energetic masking or informational masking caused by the maskers that are used (Lecumberri et al., 2010). The overall information available about the target speech is noted to not solely depend on the signal-to-noise ratio (SNR) but also on the properties of the masker (Lecumberri et al., 2010). To evaluate these deleterious effects of noise on the intelligibility of speech, Kalikow, Stevens & Elliott (1977) developed the Speech in Noise (SPIN) test. The test has been used to evaluate performance in noise using sentences with controlled word predictability. Some researchers have used perception of key words in the presence of sentences to assess speech perception in the presence of noise (Bradlow & Alexander, 2007; Kalikow et al., 1977; Shi, 2010, 2012). While a few researchers have used word identification tasks (Black & Hast, 1962; Gat & Keith, 1978; Rogers et al., 2006), others have used vowel-consonant-vowel token identification (Cutler, Garcia Lecumberri, & Cooke, 2008; Lecumberri & Cooke, 2006) and a few others have used perception of consonant-vowel syllables (Cutler et al., 2004; Polka, 1992) to assess the perception in the presence of noise.

It has been observed that speech percpetion differes depending on the type of stimuli used (Boothroyd & Nittrouer, 1988; Dapretto & Bookheimer, 1999; Miller & Nicely, 1955; Savin, 1963), type of masking noise (Lecumberri & Cooke, 2006; Lecumberri et al., 2010), as well as SNR (Bradlow & Alexander, 2007; Rogers et al., 2006). Additonally, speech perception in noise is also reported to be influenced by whether the stimuli are in the native language of the individual or not (Bradlow & Bent, 2002; Cutler et al., 2008; Florentine, 1985; Shi, 2009; Takata & Nábělek, 1990). The review provided below focuses on the impact of speech perception in the presence of noise in native and non-native speakers.

2.1 Speech Perception in Noise in native speakers

Speech perception is a complex process that not only involves identification of different speech sounds but also successful integration of successively heard sounds, words or phrases. This helps in arriving at a coherent and accurate representation and thus, interpretation of the message conveyed (Pichora-Fuller, Schneider, & Daneman, 1995). This requires integration of information over a short period. Hence, any deterioration in the cognitive processes, such as working memory, selective attention or the speed of processing affects speech understanding (Pichora-Fuller et al., 1995). Thus, when acoustically challenging situations are present, listeners are reported to rely on different cues present in their native language that help them to perceive speech better. These cues include redundancies at different levels like phonemic, semantic or syntactic level (Boothroyd & Nittrouer, 1988; Dapretto & Bookheimer, 1999). These cues optimize speech perception in native language as they limit the number of phonetically and/or lexically different alternatives (Dapretto & Bookheimer, 1999; Morton, 1969). Thus, this helps in speech perception in acoustically challenging environments.

Native speakers, even with high fluency in their native language have been shown to perform poorly in comprehending speech in acoustically challenging environments like noise and reverberation (Boothroyd, 2004; Bradley et al., 2003; Duquesnoy & Plomp, 1980; Helfer, 1992). It has been reported that perception of speech in the presence of noise is known to be influenced by signal-to-noise ratios. It has been reported that performance on speech perception tasks deteriorates as SNR reduces (Miller et al., 1951). It has also been observed that for words slightly below the threshold of intelligibility, certain features are heard while certain are not. In this situation, the listener is thought to make greater use of top-down linguistic information to assist in degraded speech comprehension (Pichora-Fuller, 2008; Savin, 1963).

Researchers have also found that performance on SPIN deteriorates as age increases even for native older speakers of a language (Pichora-Fuller et al., 1995). This is mainly attributed to either difficulty in perceptual processing due to reduced hearing or detriment of cognitive processes important for speech understanding in difficult situations (Pichora-Fuller et al., 1995).

Thus, speech perception in noise is affected even in native speakers of a language due to decline in the processes underlying the task. Non-native speakers of a language are noted to have considerably more difficulty compared to native speakers due to their native language influencing their performance.

2.2 Speech Perception in Noise by non-native speakers

Non-native language speakers have been known to demonstrate native-like speech understanding abilities in quiet. However, the same has not been observed in the presence of noise (Buss et al., 1986; Florentine, 1985; Spolsky et al., 1968; Takata & Nábělek, 1990).

Non-native listeners are reported to suffer more due to increasing noise than native listeners when the task involves either word identification (Black & Hast, 1962; Gat & Keith, 1978) or sentence identification (Bergman, 1980; Meador et al., 2000). However, for tasks that are found to either minimise or eliminate the probability of using higher level linguistic information, noise has been found to have an equivalent overall effect both on native as well as non-native listeners (Cutler et al., 2004; MacKay, Flege, Piske, & Schirru, 2001; MacKay, Meador, & Flege, 2001; Rogers et al., 2006). Some errors found during speech perception in noise tasks are due to the influence of the first language (L1) sound system (Lecumberri & Cooke, 2006; MacKay, Flege, et al., 2001) and thus the relative degree of activation of L1 correlates due to its influence (MacKay, Flege, et al., 2001; MacKay, Meador, et al., 2001; Meador et al., 2000). Performance on speech perception tasks in the presence of adverse conditions is found to be highly correlated with both the quality and the quantity of input of the non-native language (Bradlow & Bent, 2002; MacKay, Meador, et al., 2001; Mayo et al., 1997; Rogers et al., 2006).

Several studies have reported that speech perception in the presence of stationary noise is more affected in non-native speakers as compared to their native counterparts due to pure energetic masking (Bradlow & Bent, 2002; Lecumberri & Cooke, 2006; MacKay, Meador, et al., 2001; Rogers et al., 2006). Similarly, to assess the extent of informational masking, researchers have studied speech perception tasks in the presence of maskers composed of speech material (Brungart, 2001; Carhart, Tillman, & Greetis, 1969; Freyman, Balakrishnan, & Helfer, 2004). It has been reported that competing speech as noise increases the overall informational masking for non-native listeners more than for natives (Cooke, Lecumberri, & Barker, 2008; Cooke, Lecumberri, Scharenborg, & Van Dommelen, 2010).

Researchers have reported that several types of factors play an important role in determining the performance of non-native listener. Some of the factors include non-native language exposure (Shi, 2009), non-native language competence (Shi, 2012), and age of acquisition (MacKay, Flege, et al., 2001; MacKay, Meador, et al., 2001; Mayo et al., 1997; Shi, 2009). Also, factors related to the masker, such as type (Cooke et al., 2008; Van Engen & Bradlow, 2007), level of masker (Bradlow & Alexander, 2007; Gat & Keith, 1978; MacKay, Flege, et al., 2001; MacKay, Meador, et al., 2001) and the task factors that define the amount and kind of speech processing knowledge in the non-native language as well as the ability of the non-native speakers to carry out the task (Bradlow & Alexander, 2007; Gat & Keith, 1978; MacKay, Meador, et al., 2001).

2.3 Factors affecting SPIN in non-native language

2.3.1 Age of acquisition of non-native language. Many researchers have found that the age of non-native language acquisition affects perception of speech in the presence of noise (MacKay, Flege, et al., 2001; MacKay, Meador, et al., 2001; Mayo et al., 1997; Meador et al., 2000; Shi, 2009; Weiss & Dempsey, 2008). Mayo et al. (1997) compared performance of SPIN test across three groups of Spanish/English bilinguals, with English as the non-native language. The test consisted of English sentences with controlled predictability with the target word at the end of the sentence. It was presented in the presence of competing babble-type noise. They concluded that the ability of the listeners to recognise speech, deteriorated as they learned language later in life. They also observed that simultaneous English bilinguals (who acquired the language from infancy) could effectively make use of sentential context cues, whereas later bilinguals, who acquired the language post puberty, after 14 years of age could not do so. They also reported that early bilinguals could not function at the level of their monolingual counterparts. Better scores were observed for individuals who acquired the language before the age of 6 years as compared to those who acquired it later in life (around 14 years of age). Mayo et al. also noted that the level of noise at which speech became intelligible was significantly higher for monolinguals and early bilinguals as compared to late bilinguals. These findings indicated that learning a second language at an early age is important for the acquisition of efficient high-level processing of speech, at least in the presence of noise.

Similar results were found by other researchers who found that in the presence of noise, early bilinguals performed better than later second language learners in the perception of different types of speech materials used. Weiss and Dempsey (2008) compared speech perception in the presence of noise for Spanish-English bilinguals having English as the non-native language. They compared the early bilinguals who acquired the non-native language at 4 years with the late bilinguals who acquired it at average age of 15 years. These early and late bilinguals were assessed using the Spanish and English version of Hearing in Noise Test (Nilsson, Soli, & Sullivan, 1994; Soli, Vermiglio, Wen, & Filesari, 2002). The test consisted of a series of sentences that were six to eight syllables in length, presented in the presence of background noise. They concluded that early bilinguals had better scores both in quiet and noise as compared to late bilinguals.

Some researchers have observed that even simultaneous bilinguals who learn the non-native language from infancy manifest differences in perception of speech in the presence of noise as compared to monolinguals. This was found to occur although these differences were neither noticeable in quiet nor in their speech production abilities (Mayo et al., 1997; Rogers et al., 2006).

Crandell and Smaldino (1996) compared speech perception in noise for native English speakers and non-native English speakers having Spanish as their native language. The non-native group acquired English language at the age of 2 years and found near-perfect recognition scores in quiet. However, in the presence of multi-talker babble there was a significant poorer performance of these early language listeners at most of the signal-to-noise ratios. Although the children tested in the study were considered as simultaneous bilinguals, they did show detrimental effects of noise on speech perception. Thus, the authors concluded that even ‘true’ bilingual listeners do not reach the ability of monolinguals of speech understanding in the presence of noise.

Using different maskers (speech-weighted noise, multi-talker babble & music), Shi (2009) assessed speech perception in non-native English speakers. They concluded that subjects who acquired English language after the age of 13 years (average age being 20 years), were susceptible to weaker maskers like music. Non-native speakers who acquired English language before puberty (< 12 years of age) were more susceptible to weaker maskers as compared to simultaneous bilinguals (learned both languages at age of < 3 years) or monolinguals. It was also found that the speech recognition of bilingual listeners in various noise conditions did not correlate with their age of acquisition of the language as well as the length of English language usage. From their findings Shi inferred that on a speech-in-noise task, adults who acquire English later in life performed poorer than monolinguals or those who were simultaneous bilinguals or those who acquired English language early in life. The author ascribed their findings to the critical period theory given by Lenneberg (1967). As per the theory, learning a second language before puberty leads to higher and better linguistic skills in the language when compared to learning the language post-puberty.

Findings contradicting the notion that the performance of non-native language users is poorer than native language users on a speech perception in the presence of noise was reported by Lopez, Martin, and Thibodeau (1997). They used Synthetic Sentence Identification with Ipsilateral Competing Message to assess speech perception in noise at different message-to-competition ratios on English and Spanish speakers. The performance of monolingual speakers of English and Spanish was compared with bilingual speakers of the two languages. They concluded that both monolingual and bilingual speakers performed similar in the presence of competing message and performance was similar at different SNRs (0, -10 and -20).

From the above review it can be inferred that age of acquisition of a second language has an impact on the performance on speech perception in noise tasks. It is generally agreed that the earlier the non-native language is acquired, better will be the speech perception scores in the presence of noise. Also, irrespective of the speech material used there is a clear deterioration of performance seen on speech perception tasks in non-native language in the presence of noise.

2.3.2 Phonetic similarity between native and non-native language. Another factor that has been shown to differentiate speech perception in the presence of noise of native and non-native speakers is the phonetic similarity between the native and non-native languages. Meador et al. (2000) studied the ability of native Italian participants to perceive non-native English. They evaluated groups with early bilinguals and early bilinguals who use the native language seldom. The authors reported that the ability of native Italian participants to perceive English vowels and consonants accounted for a significant variance in the word-recognition scores. These scores were independent of the age of acquisition of the non-native language, amount of native language usage, and duration of exposure to the non-native language. They observed that the native language (Italian) phonetic system affected the representation developed in the non-native language (English) phonemes. Thus, they inferred that the amount of usage of native language increases its phonetic segment representation on the non-native language.

Similar findings were reported by Mayo et al. (1997) suggesting that listeners' linguistic experience in their native language influenced their phonetic repertoire in non-native language. Williams (1979) also reported that listeners who learn non-native language later in life were likely to have difficulty in discriminating non-native language phonemes in the presence of noise. Thus, studies in literature suggest that the phonetic content of a language also influences speech perception in acoustically degraded environments, especially in non-native speakers of a language.

2.3.3 Proficiency of non-native language. The proficiency of a non-native language has been observed to influence perception of speech in the presence of noise. The importance of linguistic experience in perception of speech in the presence of noise has been demonstrated by Gat and Keith (1978). They examined recognition of English words using CID auditory test W-22 in the presence of white noise at different SNRs (+12 dB, +6 dB, & 0 dB) by native and non-native speakers of English. They compared the English monolinguals with those who had on an average 4 years of experience and those with 1 year of experience in the non-native language. All the participants had acquired the non-native language post puberty. The participants with lesser linguistic experience acquired lower speech recognition scores as compared to those with greater experience. From their results they concluded that limited linguistic experience resulted in poor auditory word discrimination tasks in the presence of noise.

Meador et al. (2000) examined the recognition of English words by groups of native speakers of Italian language who differed in the age of acquisition of the non-native language and the amount of continued native language usage. Besides noting that significantly higher scores were obtained by early as compared to late bilinguals, they also noticed that speech perception scores were higher in non-native (English) language for early bilinguals who used native language (Italian) seldom thus, indicating greater exposure to non-native language, as compared to early bilinguals who used non-native language often.

It has also been suggested by Shi (2010) that the performance of bilingual listeners requires an understanding of not only their age of acquisition or exposure to the language but also about their competency in the language and the linguistic background. This was suggested because of greater dependency on context in non-native language speech perception tasks.

Similar findings were reported by Johnson and Newport (1989) who investigated the use of grammatical cues (mainly morphology and syntax) used by native speakers of Chinese and Korean language in English, a non-native language. They compared two groups, one comprising of early non-native language learners, who learnt the non-native language before 15 years of age and late language learners, who learnt the non-native language after 17 years of age. They obtained a clear and strong relationship between age of acquisition of the language and performance on speech perception in noise. They also found a greater variability in performance in participants who learnt the non-native language later in life.

Based on earlier studies, Shi (2010) concluded that many variables related to the linguistic background provide an indication of the second language learning. These included the age of acquisition (Shi, 2009, 2010; Weiss & Dempsey, 2008), the length of language learning or the duration of language learning (Shi, 2009; Takata & Nábělek, 1990), degree of exposure (Mayo et al., 1997), immersion in a non-native language-dominant environment (Meador et al., 2000) and the consistency of non-native language usage (Meador et al., 2000).

Shi (2012) also reported that rather than the conventional variables such as age of acquisition of the non-native language, it is also important to pay attention to variables pertaining to reading, proficiency, length of immersion in the non-native dominant environment and accent severity. These were considered to provide better prediction of the performance as compared to age of acquisition of non-native language on perception tasks in non-native language in the presence of noise.

From the review of literature, it is thus clearly evident that speech perception in the presence of noise is a complex process. Perception in the presence of noise is affected to a greater extent in non-native language users as compared to native language users. Many factors have been reported to contribute to this poorer performance, which are either masker related or stimuli related factors. Also, the age of acquisition of non-native language, similarity between native and non-native language, exposure and proficiency of the non-native language are a few other factors that influence performance on speech perception in noise tasks in a non-native language. These factors require to be considered when studying speech perception in the presence of noise in non-native users of a language.

Chapter 3

METHODS

The study was under taken with the aim to compare the performance of native Kannada speakers with non-native Kannada speakers having Hindi as their native language on a speech in noise test. The Speech perception in noise test in Kannada (SPIN-K), developed by (Vaidyanath & Yathiraj, 2012) was used for this purpose. The study also aimed to obtain a correlation between the SPIN-K scores and language usage as well as proficiency. The study was carried out using a standard comparison design.

3.1 Participants

Two groups of participants, selected using a purposive sampling technique, were studied. Fourty adults who were native speakers of Kannada and 30 adults who were non-native speakers of Kannada, having Hindi as their native language were recruited for the study. The age range of participants in both groups varied between 18 to 40 years. The mean age of the native speakers was 27.34 years (range = 18.6 to 40 years) and that of the non-native speakers was 27.72 years (range = 18.6 to 40 years).

3.1.1 *Inclusion Criteria of the native speakers of Kannada.* All the participants were exposed to Kannada language from early childhood and were able to speak the language fluently. The participants had no history of any speech, language or neurological impairment. It was ensured that all the individuals had hearing sensitivity within normal limits, i.e. air conduction and bone conduction threshold were within 15 dB HL, with air-bone gap not more than 10 dB HL. They had bilateral 'A' type tympanograms with both ipsilateral and contralateral reflexes present. To rule out the presence of an auditory processing disorder, they were required to pass the Screening Checklist for Auditory Processing in Adults (SCAP-A) developed by (Vaidyanath & Yathiraj, 2014).

3.1.2 *Inclusion Criteria of the non-native speakers of Kannada.* The non-native speakers of Kannada were required to meet all the inclusive criteria of the native speakers of Kannada, except that Kannada was acquired during early adolescence. The competence of Kannada language was ascertained using the 'Linguistic Profile Test in Kannada' (Karanth, 1980) and language proficiency was checked using 'Modified Language Proficiency Questionnaire' (Maitreyee & Goswami, 2008-09). The Hindi speakers who had scores ≥ 73.43 in the 'Linguistic Profile Test in Kannada' were included in the study. Also, the native Hindi speakers had to score ≥ 60 on the modified version of Language Proficiency Questionnaire. Additionally, it was ascertained that they were native speakers of Hindi and were exposed to it from early childhood as well as spoke it fluently.

3.2 Equipment

A calibrated dual channel diagnostic audiometer (Maico MA 53) was used to measure pure-tone thresholds and for the presentation of the SPIN-K stimuli. While the air-conduction tests were measured using a TDH-39 headphone, a radio ear B71 bone vibrator was used for estimating bone conduction thresholds. A calibrated immittance audiometer (GSI TympStar) was used to ensure normal middle ear functioning. A lap top (Intel core i5 processor) with CD facility was utilised to play the audio tests that were routed through the audiometer.

3.3 Material

The material used in the study included the Screening Checklist for Auditory Processing in Adults (SCAP-A) developed by (Vaidyanath & Yathiraj, 2014). The version of the checklist to be answered by the adult was used. The 12 questions of the checklist evaluated different aspects of auditory processing such as auditory integration, auditory separation/closure, temporal ordering, memory and attention. The responses were scored on a 2-point rating scale. All the responses that indicate the presence of a problem were rated as 1, and the absence of the problem were rated as 0. The maximum obtainable score with the 2-point rating was 12.

The Linguistic Profile Test in Kannada and the modified version of adapted Language Experience and Proficiency Questionnaire (LEAP-Q) were used to confirm the inclusion criteria of the non-native speakers of Kannada. The syntax section of the Linguistic Profile Test in Kannada developed by Karanth (1980) was used to assess the language competence of the non-native speakers of Kannada. The responses were recorded using Praat software with background noise kept minimum. The maximum possible score for the syntax section was 100. The other tests used to assess bilingual proficiency included Language Experience and Proficiency Questionnaire (LEAP-Q), adapted to the Indian context by (Maitreyee & Goswami, 2008-09). The adapted questionnaire was modified for the purpose of the study by selecting only relevant questions, adding a question and changing the scores (Appendix 1). Thus, the 'Modified Language Proficiency Questionnaire' had eight questions (7 from the adapted version & 1 new question), unlike the 18 questions present in the adapted version by (Maitreyee & Goswami, 2008-09). The modified version of adapted Language Proficiency Questionnaire included questions regarding language understanding, speaking, reading and writing. The scores assigned to the questions were also modified to such that the maximum possible score was 100.

The content validity and the appropriateness of the scoring procedure of the 'Modified Language Proficiency Questionnaire' was reviewed by six speech and hearing professionals. As they reported that the material was appropriate, no further modifications were made. The lowest score obtained by native speakers (score = 75) was chosen to be the cut-off score that differentiated the two groups. On the other hand, the lowest cut-off score for the non-native speakers was set at 60, as this was the lowest score obtained by the non-native participants who met the requirement on 'Linguistic Profile test in Kannada'.

Paired Kannada words developed at the Deparment of Audiology, AIISH were used to calculate SRT which was considered as reference for presenting the speech identification test in noise. The Speech-Perception-in-Noise test in Kannada (SPIN-K) developed by Vaidyanath and Yathiraj (2012) was used to assess speech perception in the presence of noise. The stimuli consisted of phonemically balanced words embedded in ipsilateral 8-speaker babble. The stimuli used in the test were from the phonemically balanced words in Kannada developed by Yathiraj and Vijayalakshmi (2005). The test consisted of four lists with each list contaning 25 words.

3.4 Test environment

The tests to select the participants were carried out in a quiet room, free of distractions. All the audiological tests were carried out in an acoustically treated suite that met the specification of ANSI S3.1-1999-R2013 (American National Standard Institute, 1999).

3.5 Procedure

3.5.1 Procedure for participant selection. To confirm that the native Hindi speakers had adequate knowledge of Kannada, the 'Linguistic Profile Test in Kannada' was administered on them. Participants having a score greater than 73.43 (*SD* = 8.34), which was equivalent to a language age of 10 years and above as per the norms provided by Suchithra and Karanth (1990), were selected as non-native Kannada speakers. The test was also administered on 15 native Kannada speakers. As all of them obtained the maximum possible score of ≥ 87.41, the test was not administered on the remaining native Kannada speakers.

The 'Modified Language Proficiency Questionnaire' containing 8 questions was administered on both the native and non-native speakers of Kannada, to obtain their proficiency of Kannada. The subjects were instructed to answer all the 8 questions tapping their language background and usage of each language in various situations. The questions were scored as per the values given in Appendix 1. The native speakers were selected if they got a score of ≥ 75 while the non-native speakers were selected if they got a score of ≥ 60. Although the participants responded about all the languages that they used, they were scored only for their usage of Kannada.

The audiological assessment included obtaining pure-tone air conduction and bone-conduction thresholds using the modified Hughson-Westlake procedure (Carhart & Jerger, 1959). Air-conduction and bone-conduction thresholds were established at octave frequencies between 250 to 8000 Hz and 250 to 4000 Hz respectively. Middle ear functioning was tested using a calibrated immittance meter. Tympanograms were obtained with a 226 Hz probe tone. The presence of ipsilateral and contralateral reflex thresholds was determined at 500, 1000, 2000 and 4000 Hz. Further, to rule out the presence of an auditory processing deficits, the Screening Checklist for Auditory Processing (SCAP-A) scale was administered on all the participants.

2.5.2 Procedure for administering SPIN-K. The participants who met the required selection criteria were initially tested to establish their speech recognition thresholds in each ear. This served as a reference for administering SPIN-K developed (Vaidyanath & Yathiraj, 2012). The stimuli and noise were presented at 40 dB SL (Ref. SRT) at 0 dB SNR, ipsilaterally. The recorded stimuli were played through a laptop, the output of which were routed to an audiometer and were heard by the participants via headphones. A 1 kHz caliberation tone was used to adjust the VU meter deflection of the audiometer to 0, prior to the presentation of the speech stimulus. Two lists containing 25 words each were presented to each ear. Thus, a total of four lists were presented. Half the participants were tested in their right ear first and half in their left ear first to avoid an ear order effect. The lists within an ear was also randomised to prevent a list order effect. The participants were informed to repeat the words heard by them and their responses were audio recoded and scored later.

3.5.3 ***Scoring***. Each word correctly identified was scored as 1 and an incorrectly identified word was scored as 0. The maximum possible word score was 25, providing a total word score of 100 for the four lists. Likewise, each correctly identified phoneme was given a score of 1 and an incorrect phoneme a score of 0. The maximum phoneme score for List 1, List 2, List 3 and List 4 was 100, 103, 101 and 105 respectively. The phoneme scores were converted into percentage as the total number of phonemes varied acorss the lists. For responses that contained an additonaly phoneme that was not present in the stimulus, a negative score of 1 was given while calculating the phoneme scores.

3.6. Analyses

The data were stastistically analysed using SPSS (Version 20). Shapiro-Wilks test of nomality indicated that the data were not normally distributed. Hence, non-parametric statistics were carried out. Both descriptive and inferential statistics were done.

Chapter 4

RESULTS

The data of the 40 native Kannada speakers and 30 non-native Kannada speakers having Hindi as their native language were analysed using SPSS (Version 20). Comparison of each group across the four lists of SPIN-K as well as comparison of scores (word & phoneme scores) between the two participant groups was determined. Additionally, the correlation between their SPIN-K scores (word & phoneme scores) with their scores on the 'Modified Language Proficiency Questionnaire' was assessed. As Shapiro-Wilks test of normality indicated that the data were not normally distributed the data was analysed using non-parametric statistical tests. The results of the data are presented under the following sub-headings-

4.1. Equivalency of the SPIN-K lists within the two groups (native & non-native) for word and phoneme scores.

4.2. Comparison of SPIN-K scores (word & phoneme scores) across native and non-native groups.

4.3. Correlation between the SPIN-K scores (word & phoneme scores) with the 'Modified Language Proficiency Questionnaire'.

4.1. Equivalency of the SPIN-K lists within the native and non-native participants

The descriptive statistics given in Table 4.1 indicates that the scores across the four lists did not differ much for the native Kannada speakers as well as the non-native speakers. This is evident from the mean, median, standard deviation, minimum and maximum scores for words as well as phonemes provided in the table. This information is provided as raw scores for the words and as percentage scores for the phonemes.

To establish whether a statistical significant difference occurred between the lists in the *native group*, a Friedman test was carried out. No significant difference between the four lists was seen for word scores [χ^2 (40) = 4.885, $p > .05$]. However, the phoneme scores were found to be significantly different across the four lists in the native group [χ^2 (30) = 22.083, $p < .05$]. Thus, Wilcoxon signed ranked test was carried out to check for significance of difference in phoneme scores between pairs of lists. It revealed that there was a significant difference between lists 1 and 3 ($Z = 3.11$, $p < .05$), lists 2 and 3 ($Z = 4.10$, $p < .001$) and lists 3 and 4 ($Z = 3.75$, $p < .001$).

Similarly, the Friedman test revealed that within the *non-native group* there was no significant difference observed in the word scores across the different lists [χ^2 (30) = 7.39, $p > .05$]. On the other hand, the phoneme scores across the lists were found to be significantly different for the non-native group [χ^2 (30) = 19.48, $p < .05$). Results from Wilcoxon signed rank test indicated that there was a significant difference for phoneme scores between the lists 1 and 2 ($Z = 3.14$, $p < .05$), lists 2 and 3 ($Z = 3.34$, $p < .001$), lists 2 and 4 ($Z = 2.60$, $p < .05$) and lists 3 and 4 ($Z = 2.19$, $p < .05$).

Table 4.1

List-wise Mean, Median, Standard deviation (SD), Minimum (Min) and Maximum (Max) SPIN-K word and phoneme scores for the native and non-native speakers

Lists		Native speakers (N = 40)		Non-native speakers (N = 30)	
		Word Scores	**Phoneme Scores**	**Word Scores**	**Phoneme Scores**
List 1	**Mean**	21.47	94.50	19.23	88.93
	Median	21.50	95.00	19.00	88.50
	SD	1.57	3.05	1.75	3.38
	Min & Max	18 & 24	88 & 99	16 & 23	81 & 95
List 2	**Mean**	21.70	95.07	19.93	91.22
	Median	21.50	95.14	20.00	91.74
	SD	1.24	2.41	1.64	3.73
	Min & Max	19 & 24	89.32 & 99.02	17 & 23	82.52 & 98.05
List 3	**Mean**	21.20	92.67	19.03	87.55
	Median	21.50	93.13	19.00	87.74
	SD	1.36	3.02	1.13	3.32
	Min & Max	18 & 24	85.29 & 98.03	17 & 21	80.39 & 94.11
List 4	**Mean**	21.65	94.58	19.47	89.00
	Median	22.00	94.66	19.00	88.46
	SD	1.27	2.31	1.31	3.19
	Min & Max	19 & 24	89.42 & 99.03	17 & 23	83.65 & 96.15

Note. Maximum possible word score = 25; Maximum possible phoneme score = 100%

4.2. Comparison of SPIN-K scores (word & phoneme) across native and non-native group

Table 4.1, showing the list-wise mean, median and viability in scores of the two groups, indicates that the native participants obtained higher scores than the non-native participants. This is evident for all four lists for the word scores as well as the phoneme scores in Figure 4.1 also.

To compare the SPIN-K *word scores* between the two groups, list-wise comparison was done using Mann-Whitney U test, to confirm whether the differences in scores seen between the two groups were statistically significant. There were significant differences observed between the two groups for *list 1* (U = 212.50, Z = 4.65, $p < .001$, r' = 0.55); *list 2* (U = 250.00, Z = 4.27, $p < .001$, r' = 0.51); *list 3* (U = 144.50, Z = 5.49, $p < .001$, r' = 0.66); and *list 4* (U = 149.00, Z = 5.43, $p < .001$, r' = 0.65).

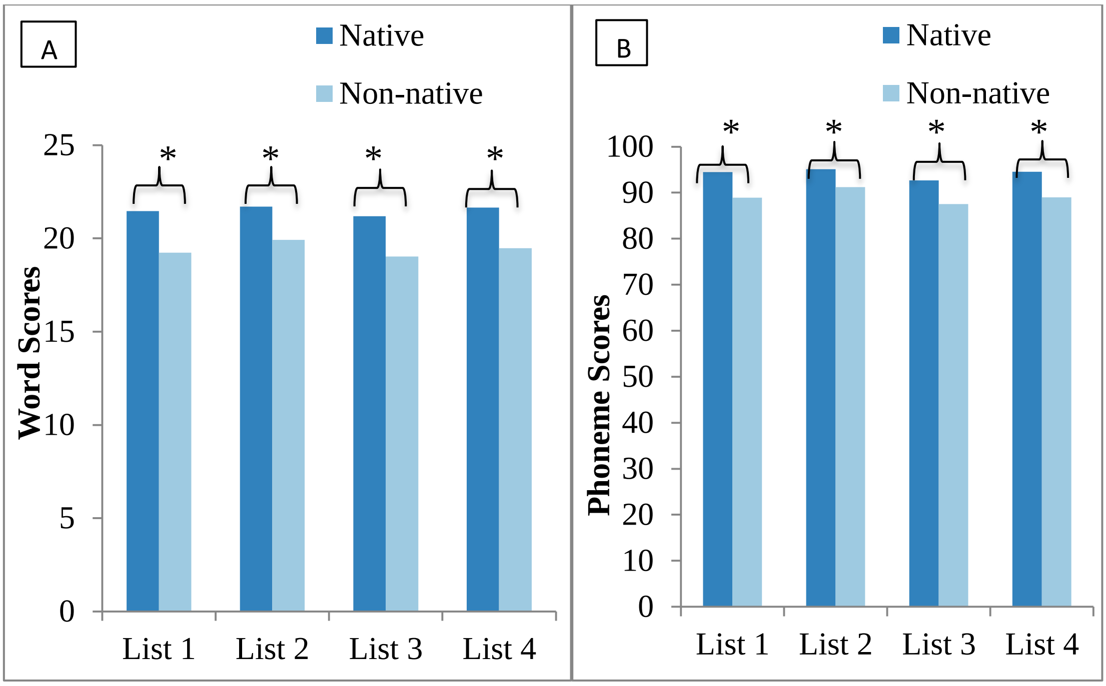

Figure 4.1: List-wise mean SPIN-K word scores (A) and phoneme scores (B) for the native and non-native speakers of Kannada (* = $p < 0.05$)

The *phoneme scores* of the two groups were also compared using Mann-Whitney U test. A significant difference was seen between the native and the non-native group for phoneme scores for all four lists (*List 1*: U = 131.00, Z = 5.59, $p < .001$, r' = 0.67; *List 2*: U = 238.50, Z = 4.31, $p < .001$, r' = 0.52; *List 3*: U = 153.50, Z = 5.31, $p < .001$, r' = 0.63; *List 4*: U = 105.50, Z = 5.89, $p < .001$, r' = 0.70).

4.3 Correlation between the SPIN-K scores (word and phoneme) and language proficiency

As no significant difference was obtained between the word scores / the phoneme scores of the four lists, they were combined, resulting in the maximum total word scores being 100 and total phoneme scores being 100 %. Table 4.2 shows the mean, standard deviation, minimum and maximum of the total word scores, total phoneme scores and the scores of the 'Modified Language Proficiency Questionnaire'. The correlation between SPIN-K total scores (word & phoneme) and the 'Modified Language Proficiency Questionnaire' was established with all the participants grouped together (N = 70). This was calculated separately for the word scores and the phoneme scores using Spearman's test.

Table 4.2

Mean, Median, Standard deviation (SD), Minimum (Min) and Maximum (Max) of the total scores (word and phoneme) and Modified Language Proficiency Questionnaire scores for all the participants (N = 70)

	Total Word Scores	Total Phoneme Scores	Modified Language Proficiency Questionnaire Score
Mean	82.44	92.15	76.70
Median	83.00	92.67	78.00
SD	5.79	3.30	5.73
Min & Max	70.00 & 94.00	85.57 & 97.79	60.00 & 88.00

Note. Maximum possible total word score = 100; Maximum possible total phoneme score = 100%; Maximum possible score for the 'Modified Language Proficiency Questionnaire' = 100.

The SPIN-K *word scores* had a significant strong correlation with the 'Modified Language Proficiency Questionnaire' scores (r = 0.73, p < .001). Likewise, the SPIN-K *phoneme scores* demonstrated a significant moderate correlation with the 'Modified Language Proficiency Questionnaire' (r = 0.62, p < .001).

Thus, from the findings of the study it was seen that there was a significant difference between the SPIN-K scores of the native and non-native Kannada speakers for both word and phoneme scores. Also, the findings revealed that the performance across the four lists did not differ significantly for word scores in both the groups. However, there was a significant difference present for phoneme scores across the lists for both the groups. Further, the SPIN-K word scores as well as the SPIN-K phoneme scores has a significant correlation with the 'Modified Language Proficiency Questionnaire', with the strength of correlation ranging from moderate to strong.

Chapter 5

DISCUSSION

The results of the SPIN-K carried out on the 40 native speakers of Kannada and the 30 non-native speakers of Kannada having Hindi as native language are discussed with reference to the objectives of the study. The equivalency of the SPIN-K lists within the native and non-native participants; comparison of SPIN-K scores (word & phoneme) across the two groups; and the relation between the SPIN-K scores (word & phoneme) and language proficiency are discussed.

5.1 Equivalency of the SPIN-K lists within the native and non-native participants:

The findings of the current study indicated that there was no significant difference in the *word scores* between the lists of SPIN-K in the native as well as the non-native participants. Thus, the lists continue to be equivalent, irrespective of whether the words are presented along with noise to native speakers of Kannada or non-native speakers of Kannada having Hindi as their native language. Similar findings with respect to word scores across SPIN-K lists have been obtained by Vaidyanath and Yathiraj (under review) for young native adults and by Mamatha and Yathiraj (under review) for native Kannada speaking-children. Thus, the masking effect of noise does not affect the equivalence of the lists that are equivalent in quiet. This suggests that the lists can be used interchangeably when the word scores are calculated.

However, in the present study a significant difference was obtained between a few of the lists in both the participant groups when the *phoneme scores* were calculated for SPIN-K. In the native participants, the lists that differed were (lists 1 &

3; lists 2 & 3; and lists 3 & 4) were not exactly the same as what differed in the non-native participants (lists 1 & 2; lists 2 & 3; lists 2 & 4; and lists 3 & 4). This variability across the phoneme scores occurred despite the four lists being phonemically balanced. Although the lists had similar phonemes, the coarticulatory cues would have been different. It is possible that these coarticulatory cues would have been masked differently in the presence of noise, resulting in the phoneme scores being different across the lists. Likewise, Gordon-Salant (1985) also reported that multi-talker babble influenced both consonant and vowel perception due to coarticulation. Gordon-Slant observed that consonants occurring in the context of vowel /a/ were more susceptible to masking effects and influenced speech perception in noise. Consonants occurring in the context of /i/ and /u/ were less influenced by noise as compared to /a/. Based on this the author concluded that vowel coarticulation influenced performance in the presence of noise.

It can be thus seen that the lists were equivalent when word scores were calculated and not when the phoneme scores were calculated. This difference can be attributed to the whole word not being scored when even a single phoneme was perceived wrong. On the other hand, when phoneme scores were calculated, only the specific phonemes that were wrongly perceived were not scored. Observation of the raw data indicated that the phonemes that were wrongly perceived across the lists were not always the same. It was observed that consonantal were more than vowels errors. Among the consonants, stop consonants were more often misperceived in the presence of multi-talker babble. When the responses of all the four lists and all participants were pooled together, it was observed that phonemes that occurred in the context of /a/ vowel were most often perceived wrong (30.54%) followed by /ə/ (20.14%) and then /i/ (14.9%) and /u/ (14.17%). Such a pattern was not observed in the context of any particular consonant. Further, it was noted that these errors varied across the lists in both groups. In the native group, more errors were observed in the context of /a/ in lists 1, 2 & 4, followed by /ə/ in lists 1 & 2, and /i/ and /u/ in lists 3 & 4. Likewise, in the non-native speakers more errors were observed in the context of /a/ occurring in lists 1, 2 & 3, followed by /ə/ in lists 1 & 2, /i/ in lists 3 & 4, and /u/ in lists 1 & 3. Thus, coarticulatory influence of vowels on consonant perception varied between the four lists in both the groups. Hence, it can be inferred that this variation in coarticulation across the four lists would have led to the lists being unequal when the phoneme scores were calculated.

It is recommended that when calculating phoneme score in native Kannada speakers, list 3 should not be used interchangeably with the other lists. On the other hand, the other three lists (lists 1, 2, & 4) can be used interchangeably while calculating phoneme scores. All four lists can be used equivalently when using word scores.

5.2 Comparison of SPIN-K scores (word & phoneme) across native and non-native group

From the results of the present study, it was observed that there was a significant difference between the native and the non-native group for both *word scores*. The findings are in consensus with the findings of studies mentioned in the literature (Buss, Florentine, Scharf, & Canevet, 1986; Florentine, 1985; Gat & Keith, 1978; Shi, 2009). Also, researchers have observed that native speakers do develop highly effective and efficient strategies to deal with the masking effects of noise on speech. Native speakers have been found to have the ability to focus attention on segmental cues that are less susceptible to noise-related distortion unlike non-native speakers (Jiang, Chen, & Alwan, 2006; Parikh & Loizou, 2005). Further, it has been seen that multi-talker babble, the masker used in the present study, causes informational masking of the target stimulus. This informational masking has been found to cause errors due to misallocation of acoustic information such that formant transition bursts or frication information might be wrongly attributed in the non-native language (Simpson & Cooke, 2005).

The non-native participants performed poorer than the native participants probably on account of them being unable to utilise their knowledge of the language to the same extent as that of the native speakers. This is in agreement with the findings obtained by Cooke (2006) who noted that non-native speakers have poorly developed syntactic, semantic and pragmatic processing skills as compared to native speakers. Thus, they would not have been able to make use of higher-level linguistic and contextual information to compensate for losses at the perceptual level due to the presence of noise. Unlike the non-native speakers, the native speakers were probably able to use auditory closure to a greater extent and identify the Kannada speech stimuli in the presence of noise.

Contrary to the current study, Lopez, Martin, and Thibodeau (1997) reported that both native and non-native speakers had equivalent scores on sentence perception in the presence of ipsilateral competing message. This difference in finding may be attributed to difference in stimuli used in the two studies. While words were used in the present study, Lopez et al. (1997) used sentences to assess speech perception in noise. It has been reported by Miller, Heise, and Lichten (1951) and Becker (1979) that isolated words are more difficult to identify than sentences due to contextual cues present. Also Miller et al. (1951) noted that a higher SNR was required for identification of words in isolation rather than in sentences. The lexicon from which words are drawn has also been thought to provide subtle context cues.

Dijkgraaf, Hartsuiker, and Duyck (2017) reported that proficient bilinguals do apply semantic knowledge while performing speech perception tasks in presence of noise and predict the target to same extent in both the native and non-native language. However, in the present study words were used as target stimuli and thus, the non-native speakers lacked semantic or contextual cues which probably led to a significant difference in the performance of the two groups.

In the present study it was also observed that a significant difference was present between the *phoneme scores* for the two groups. As reported in literature, phonetic similarity also plays an important role in speech recognition in the presence of noise (Mayo, Florentine, & Buus, 1997; Meador, Flege, & Mackay, 2000; Williams, 1979). A significant difference is observed between the groups probably on account of the difference in phonemes in the two languages.

It has been observed that masking effects of noise on acoustic cues are more detrimental for non-native speakers of a language. This was presumed to be due to their reduced experience with the full range of cues present for phoneme identification in non-native language (Bradlow & Alexander, 2007). Bradlow and Bent (2002) reasoned that non-native speakers are less sensitive to the phonemic contrasts present in the non-native language due to their limited experience with the different acoustic-phonetic cues present in the language.

The contrast in phonemes of Kannada and Hindi, the native languages of the two groups studied in the present study, is evident from the findings of Chengappa and Devi (2002). They reported that the phonemic contrasts for aspirated and non-aspirated consonants are merged in Hindi and Kannada language. This is also evident from the frequency of occurrence of various sounds in Hindi and Kannada, reported by Ramakrishna et al. (1962). They noted that aspirated sounds occurred more frequently in Hindi than in Kannada. Additionally, in the present study it was also noticed that the phoneme /h/ was more frequently used by the native Hindi speakers, who substituted or added the phoneme when compared to the native Kannada speakers. Ramakrishna et al. (1962) found that the frequency of occurrence of /h/ in Hindi language was 4.25 as compared to Kannada, where it was just 1.35. This substantiates that non-native speakers are likely to substitute speech sounds of Kannada with phonemes that occur more frequently in their native language, Hindi.

It is also speculated that as the native and the non-native languages were considerably different for the non-native speakers, Hindi being an Indo-Aryan language and Kannada being a Dravidian language, the participants may have combined the phonemes of the two languages to create a larger phonemic inventory. Thus, the native participants would have had a smaller inventory to select the speech sounds compared to the non-native participants. This could have resulted in the non-native participants having more errors compared to the native participants.

The findings of the present study regarding the difference between the native and non-native participants on SPIN-K, makes it imperative that normative data obtained on native Kannada speakers cannot be utilised on non-native Kannada speakers who are native speakers of Hindi. By doing so, individuals may wrongly be classified as having an auditory processing problem.

5.3 Correlation between the SPIN-K scores (word and phoneme) and language proficiency

In the present study, a strong correlation was observed between the word scores and the 'Modified Language Proficiency Questionnaire' used to assess language proficiency in Kannada language. Also, a moderate correlation was obtained between SPIN-K phoneme scores and the 'Modified Language Proficiency Questionnaire'.

These findings are in line with other studies that evaluated the effects of language proficiency on speech perception in noise tasks (Bradlow & Alexander, 2007; Shi, 2012; von Hapsburg & Bahng, 2006). It has been reported that the proficiency of an individual in the non-native language is directly related to their ability to utilize contextual cues in the presence of noise (von Hapsburg & Bahng, 2006). Kilman, Zekveld, Hällgren, and Rönnberg (2014) observed that high proficiency improved performance not only by reducing the effects of noise on energetic masking but also informational masking.

The native language (Hindi) of the non-native group being the national language of India, would have been known to most individuals in Karnataka. Hence, these participants would have been able to communicate with the local population, most of whom know Hindi, without having to be proficient in Kannada. Also, the two languages have different basis of origin, with Hindi being an Indo-Aryan language and Kannada being a Dravidian language. Thus, not necessarily having to learn Kannada, and the languages belonging to different language groups, would have resulted in the non-native participants having a lower proficiency of Kannada. The native Kannada speakers who obtained better scores on the 'Modified Kannada

Proficiency Questionnaire' than the non-native speakers, also obtained higher scores on SPIN-K. This would have led to the significant moderate to strong positive correlation between the two test scores.

Thus, from the results of the present study it can be concluded that two factors mainly affect speech perception in the presence of noise in non-native speakers. They are difficulty to extract the linguistic cues due to degradation of the signal and difficulty to process cues due to limited non-native language exposure. It is recommended that it is preferable to evaluate individuals in their native language when testing their speech perception in the presence of noise. Failure to do so might result in misdiagnosis of individuals due to linguistic differences rather than processing deficits.

Chapter 6

SUMMARY AND CONCLUSIONS

Speech perception in quiet has been reported to be similar for both native and non-native speakers of a language. However, researchers have found the two groups to differ in acoustically degraded environments. It has been observed that non-native speakers have poor performance on speech perception in noise compared to their native counterparts (Buss et al., 1986; Shi, 2009; Spolsky et al., 1968; Takata & Nábělek, 1990). In a multilingual country like India, it is thus, important to assess speech perception abilities in the presence of noise in the non-native language too. Earlier studies have reported that speech perception in noise is better for bilingual speakers in their native language as compared to non-native language (Shi, 2010). Many factors have been found to cause this discrepancy in the speech perception abilities in noise in non-native speakers. Some of the factors include age of acquisition of non-native language (MacKay, Flege, et al., 2001; Shi, 2009; Weiss & Dempsey, 2008), linguistic experience (Gat & Keith, 1978), language competence and proficiency (Shi, 2010, 2012).

The primary aim of the study was to compare word and phoneme scores on a speech perception in noise test between native Kannada speakers (N = 40) and non-native Kannada speakers having Hindi as their native language (N = 30). The participants were assessed using Speech-Perception-in-Noise test in Kannada (SPIN-K) developed by (Vaidyanath & Yathiraj, 2012). The study also aimed to study the influence of noise on the list equivalence of SPIN-K in native and non-native Kannada speakers. Further, the effect of language proficiency was checked on speech perception in noise. This was done using the 'Modified Language Proficiency Questionnaire', revised as part of the current study.

The native Kannada speakers had been exposed to the language since childhood as opposed to the non-native speakers who had been exposed to the language from early adolescence. All the participants had no hearing loss or any auditory processing disorder. Also, the participants were checked for their Kannada language proficiency using the 'Modified Language Proficiency Questionnaire' and the language usage using the Linguistic Profile Test in Kannada (Karanth, 1980).

Shapiro-Wilks test of normality revealed that the data were not normally distributed and thus, non-parametric tests were used for analyses. A Friedman's test revealed that in both participant groups, all the four lists of SPIN-K had word scores that were equivalent, but the lists had unequal phoneme scores. A Wilcoxon signed rank test indicated that a few of the lists had phoneme scores that differed from each other. Additionally, the two groups were found to be significantly different on the Mann-Whitney U test. This was seen for the word and phoneme scores. A moderate to strong correlation was obtained between language proficiency and phoneme scores and word scores respectively.

Thus, it can be concluded from the findings of the study that list equivalence continues to be maintained in the presence of noise in both native and non-native speakers when the word scores are calculated. However, this equivalence is affected in both groups when phoneme scores are calculated. Further, there exists a significant difference in the performance of native and non-native speakers of a language. The comprehension of speech in the presence of noise is affected for non-native speakers of a language who have acquired the language during early adolescence.

Implications of the study

1. The study indicates that equivalence of the word-lists are not compromised when presented in the presence of noise. This is maintained when word scores and not when phoneme scores are calculated.

2. The study indicates that the normative values obtained on native Kannada speakers on SPIN-K cannot be used on non-native speakers who have Hindi as their native language.

3. The study also helps to understand the phonemic differences present in the native and non-native language and its influence on speech perception in the presence of noise.

4. The 'Modified Linguistic Proficiency Questionnaire', modified as a part of the current study can be used to assess proficiency of language.

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APPENDIX 1a

1a. MODIFIED LANGUAGE PROFICIENCY QUESTIONNAIRE

Developed by Yathiraj, A., Jain, S. N., Amruthavarshini B. (2018)

Name: Age:

Gender: Male / Female

Instructions: Please read the below given information carefully and choose the most appropriate choice. Respond to all eight points by either filling in blanks or ticking (✓) the most appropriate response. (***Note****:* L1 refers to the first language that you learnt; L2 refers to the second language that you learnt; L3 refers to the third language that you learnt)

****

1. Name all the languages you have learnt since your childhood in the order of acquisition of the language.

Order of Languages acquired	**Language Name**
L1	
L2	
L3	

2. Since when have you been using your L1, L2 and L3 for understanding, speaking, reading and writing? *(**Note**. Please tick (✓) one duration per language for understanding, speaking, reading, & writing)*

Duration in years	**Understanding**			**Speaking**			**Reading**			**Writing**		
	L1	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**
Less than 5 years												
5 to 10 years												
10.1 to 15 years												
Greater than 15 years												

3. How would you mark your level of proficiency for understanding, speaking, reading, and writing? *(**Note**. Please tick (✓) one level proficiency per language for understanding, speaking, reading, & writing)*

Level of Proficiency	**Understanding**			**Speaking**			**Reading**			**Writing**		
	L1	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**
Low proficiency												
Fair proficiency												
Good proficiency												
Native like/perfect proficiency												

4. How would you rate your ability to switch between the languages? *(**Note**. Please tick (✓) one of the ratings)*

Rating Scale	**Response (✓)**
Low Ability	
Fair Ability	
Good Ability	
Perfect Ability	

5. Please tick (✓) which language you use maximum for the below mentioned situations: *(**Note**. Please tick (✓) one language per situation)*

Sl. No.	**Situations**	**L1**	**L2**	**L3**
a	Interaction with family			
b	Education/ work			
c	Listening to instruction tapes at school			
d	Text books			
e	Dictionary			
f	Story books			
g	Newspapers			
h	Internet source			
i	Writing			
j	Interacting with friends			
k	Interacting with neighbours			
l	Watching TV/ YouTube			
m	Listening to the radio (music)			
n	Market places			

6. On a scale of one to four, how often do you use the languages known to you in the following situations? *(Rating key: 1 = never; 2 = Sometimes; 3 = Most of the time; 4 = Always;* ***Note****. Please write the numbers 1, 2, 3, or 4, for each situation per language).*

Sl. No.	Situations	L1	L2	L3
A	Interaction with family			
B	Schooling/ work			
C	Listening to instruction tapes at school			
D	Text books			
E	Dictionary			
F	Story books			
G	Newspapers			
H	Internet source			
I	Writing			
J	Interacting with friends			
K	Interacting with neighbours			
L	Watching television/ YouTube			
M	Listening to the radio (music)			
N	Market places			

7. How frequently do others identify you as a native speaker based on your accent or pronunciation in the language? *(****Note.*** *Please tick (✓) one rating per language)*

Rating Scale	L1	L2	L3
Never			
Sometimes			
Most of the time			
Always			

8. For how many hours do you use the following languages? *(****Note****. Please tick (✓) one duration per language)*

Duration	L1	L2	L3
Greater than 2 hours			
Greater than 3 hours			
Greater than 4 hours			
Greater than 5 hours			

Note: Refer Scoring key for analysis

Appendix 1b

SCORING KEY

MODIFIED LANGUAGE PROFICIENCY QUESTIONNAIRE

Developed by Yathiraj, A., Jain, S. N., Amruthavarshini B. (2018)

Instructions to professional scoring the scale: Please score the responses on a scale of 1 to 4 for each skill / question as directed.

****

1. Name all the languages you have learnt since your childhood in the order of acquisition of the languages.
No score *(Information to be used for descriptive analysis)*

2. Since when have you been using your L1, L2 and L3 for understanding, speaking, reading and writing?

Duration (in years)	**Scores**	**Understanding**			**Speaking**			**Reading**			**Writing**		
		L1	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**
Less than 5 yrs	**1**												
5 to 10 yrs	**2**												
10.1 to 15 yrs	**3**												
Greater 15 yrs	**4**												
Total Scores		**L1 = /16**				**L2 = /16**				**L3 = /16**			

3. How would you mark your level of proficiency for understanding, speaking, reading, and writing?

Level of Proficiency	**Scores**	**Understanding**			**Speaking**			**Reading**			**Writing**		
		L1	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**	**L1**	**L2**	**L3**
Low proficiency	**1**												
Fair proficiency	**2**												
Good proficiency	**3**												
Native like/perfect proficiency	**4**												
Total Scores		**L1 = /16**				**L2 = /16**				**L3 = /16**			

4. How would you rate your ability to switch between the languages?

Rating Scale	Scores	Response		
Low Ability	**1**			
Fair Ability	**2**			
Good Ability	**3**			
Perfect Ability	**4**			
Total Scores		**L1 = /4**	**L2 = /4**	**L3 = /4**

5. Tick (✓) which language you use maximum for the following situations:
No score *(Information to be used for descriptive analysis)*

6. On a scale of one to four, how often do you use the languages known to you in the following situations? ***(Instruction to professional scoring the scale****: Total the ratings given per language).*

Sl. No.	Situations	L1	L2	L3
a	Interaction with family			
b	Schooling/ work			
c	Listening to instruction tapes at school			
d	Text books			
e	Dictionary			
f	Story books			
g	Newspapers			
h	Internet source			
i	Writing			
j	Interacting with friends			
k	Interacting with neighbours			
l	Watching television/ YouTube			
m	Listening to the radio (music)			
n	Market places			
Total Score		**/56**	**/56**	**/56**

7. How frequently others identify you as a native speaker based on your accent or pronunciation in the language?

Rating Scale	Scores	L1	L2	L3
Never	**1**			
Sometimes	**2**			
Most of the time	**3**			
Always	**4**			
Total Score		**/4**	**/4**	**/4**

8. For how many hours do you use the following languages?

Duration	**Scores**	**L1**	**L2**	**L3**
Greater than 2 hours	**1**			
Greater than 3 hours	**2**			
Greater than 4 hours	**3**			
Greater than 5 hours	**4**			
Total Score		**/4**	**/4**	**/4**

L1	**/100**
L2	**/100**
L3	**/100**