COMPARISON OF NASALANCE IN NATIVE AND NON-NATIVE KANNADA SPEAKERS

SRUTHI DAS A

Registration No: P01II22S123030

This dissertation is submitted as part of fulfillment for the

Degree of

Master of Science (Speech-Language Pathology)

University of Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING

MANASAGANGOTHRI, MYSORE-570006

JULY, 2024

CERTIFICATE

This is to certify that this dissertation entitled **"Comparison of Nasalance in Native and Non-Native Kannada Speakers"** is a bonafide work submitted in part fulfillment for the degree of Mastersin Science (Speech-Language Pathology) of the student with Registration Number P01II22S123030. 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 anyother Diploma or Degree.

Mysuru

July 2024

Dr. M. Pushpavathi

Director

All Indian Institute of Speech and Hearing

Manasagangotri, Mysuru 570006

CERTIFICATE

This is to certify that this dissertation entitled **"Comparison of Nasalance in Native and Non-native Kannada Speakers"** has been prepared under my supervision and guidance. It is also certified that this dissertation has not been submitted to any other University for award of any degree or diploma.

Mysuru

July 2024

GUIDE

Ms. Manasa A. S

Assistant Professor In Speech Pathology

Centre of Public Education in Communication Disorders

(C-PECD)

All India Institute of Speech and Hearing

Mysuru

DECLARATION

This is to certify that this dissertation entitled **"Comparison of Nasalance in Native and Non-native Kannada Speakers"** is the result of my own study under the guidance of Ms Manasa A.S, Assistant Professor In Speech Pathology, Centre of Public Education in Communication Disorders (C-PECD), All India Institute of Speech and Hearing, Mysuru and has not been submitted to any other University for award of any degree or diploma.

Mysuru	Registration No:
July,2024.	P01II22S123030

DEDICATED TO MY KUTTY KOMUS

AND

MY FAMILY..!

ACKNOWLEDGEMENT

I thank God for all the opportunities and fortunes bestowed upon me.

I am incredibly grateful to my guide, ***Ms Manasa AS****, for all the encouragement and support I have received over the journey. Thank you for patiently helping me with every query. Thank you for all your effort and support. I would also like to thank* ***Dr. Irfana M,*** *for all the support and guidance provided throughout the journey. Thank you for all the help provided.*

I would also extend my gratitude to ***Prof. M Pushpavati, Director of AIISH,*** *for allowing me to carry out this study.*

I would also thank ***Dr Vasanthalakshmi*** *for helping me with the statistics patiently.*

*I would also like to thank my professors****, Dr. S P Goswamy, Dr. Sreedevi N*** *and* ***Dr. Priya MB, Dr. Swapna****, for enlightening and inspiring me through the lectures. Thank you for inspiring me and motivating me with your work.*

I would now like to extend my gratitude and love to my family. ***Amma****, you are the strongest person I have ever seen and will always be my priority. I thank you for never giving up, for always choosing 'us' before anything, for believing in me whenever I failed to believe in myself, for never letting any boundaries for me, and for always letting me fly.*

Santhu*, You mean the world to me. Thank you for pushing me toward my dreams, for being my safe haven, my shelter, and, as I always say, my superhero. I love you more than words can express. Thank you for being my rock, my inspiration, and my everything. I wouldn't have achieved anything in my life without you.*

***Sreeku**, A brother like you is a true blessing. Thank you for always lifting me up when I'm down, for supporting me in every way possible, and for being the best brother in the world.I love you with all my heart. My **kutty komus**. You are the biggest blessing in my life. Shanu loves you more than anyone, and we will always be there for you in every walk of your life. You will always have Shanu and Sheeku on either side because You are our Appuni. Thank you for all the innocent smiles and unconditional love.*

***Ammama,** Thank you for being one of the strongest women in my life. Thank you for assuring me that I will get through everything without fail. Thank you for the never-ending prayers and blessings. **Mami,** Thank you for always motivating me to move forward and for never giving up on anything. You have motivated me a lot, and I will always be there for you in every way.*

*My best friends, **Hima, Sreedevi, and Swathy,** for always helping me whenever I am in doubt and comforting me whenever I am in trouble. Especially you, **Hima**; I would not have survived this without you.*

***Kiran**, Thank you for always listening to and supporting me in every way possible. You are a huge part of my happiness. Your unconditional love and sweet smiles mean the world to me. Thank you for being the best.*

***Chechikuttans**, Thank you for being that sister I always longed for. Thank you for always being there for me whenever I was lost. You are, and you will always be special to me.*

***Sniktha and Varna**, Thank you for always listening to my 'n' number of doubts and insecurities and for always finding reasons to push me forward. I owe you a lot. Thank you for always being with me during these two years. You guys are special.*

***Shalabha,** Thank you for always being with me whenever I was in doubt and*

reaching out whenever I needed help. You made me smile.

***Reesha Maam**, Thank you for always helping me with plan 'b' whenever my plan 'a' failed. Thank you for always listening to me and supporting me throughout this. This journey would have been a lot more difficult without you. You helped me a lot. **Edna Maam,** Thank you for always boosting me and keeping me in your prayers. **Aarunichechi,** for always helping me with anything and everything.*

***Bindumema and Praveen Mama,** thank you for helping me to get the reference book at the perfect moment. Thank you so much for your timely support.*

***Devu**, Thank you for every last-minute help and for being our super Techie .!*

I would also love to thank all my batchmates, juniors, and seniors who have helped me throughout this journey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Speech production begins with the pressure created by the lungs, leading to the vibration of the vocal folds in the larynx. The vocal tract alters this vibration, and the articulators shape this air stream into meaningful speech. To comprehend the characteristics and operation of speech, it is crucial to investigate the mechanism engaged in speech production. Speech production is a complex process wherein thoughts, ideas, and concepts are converted into linguistic and neural codes. These neural codes generate muscular movements, producing acoustic signals. Thus, speech is an acoustic signal, and its production can be elucidated through source signal and vocal tract resonance. Regulating the passageway connecting the oropharynx and nasopharynx during speech or singing is a crucial process based on which the specific sounds are produced. This regulation results in nas ality or nasal resonance in speech production.

Articulators are the structures that modulate speech sounds, and the soft palate is one of the significant articulators included in this function. The velopharyngeal valving mechanism regulates speech resonance by selectively coupling or decoupling oral and nasal cavities. Thus, sounds can be classified as oral or nasal, depending upon the resonance of the sounds involved. Oral sounds are typically produced with the velopharyngeal port closed, leading to oral resonance. In contrast, nasal sounds are generated when the velopharyngeal port opens, resulting in nasal resonance. This balance is affected in some disordered conditions such as oro-facial structural deficits, cleft lip and palate, and paralysis or paresis of velum.

Nasality is an aspect of voice quality produced by nasal resonators that can be employed in evaluating and addressing resonance disorders. Nasality is prevalent in individuals with both repaired and unrepaired cleft lip and palate, significantly impacting speech intelligibility. It is essential to acknowledge that nasal resonance is present in disordered speech and clinically normal speech, where its degree can vary based on factors such as age, gender, and native language (Preethy et al., 2018). Thus, the measurement of nasality is accurate for assessing resonance disorders and understanding the variations in normal speech quality.

Subjective and objective measurements are used to assess resonance aspects. Subjective assessment is known as the gold standard, which involves recording and analyzing perceptually including words and sentences. Evaluating the severity of nasality through perceptual ratings presents significant challenges, as the accuracy of listener judgments heavily depends on their experience and skilled training in diagnosing cleft lip and palate (CLP) (Girish et al., 2021). Establishing normative or standard data for this subjective task is challenging because of numerous limitations associated with the method. Therefore, subjective methods are often supplemented by objective evaluation, which can be done using direct or indirect methods.

Over the years, various objective methods for assessing nasality have been developed and categorized into direct and indirect methods. Direct objective methods, such as nasoendoscopy and videofluoroscopy procedures, are widely utilized to evaluate physiological velopharyngeal dysfunction and are known for their high reliability. However, nasendoscopy is invasive, and videofluoroscopy exposes patients to radiation. Furthermore, these techniques require a medical setting, limiting their accessibility to Speech-Language Pathologists (SLPs) in their work setup.

SLPs initially used the accelerometer (vibration detector) to measure intraoral and nasal pressure. Later, Fletcher et al. (1978) introduced the term "nasalance." Numerous acoustic and aerodynamic techniques have been developed to quantify nasalance accurately. Among these is The Oral to Nasal Air Pressure Ratio (TONAR). This instrument involves positioning two microphones, one to capture nasal energy and the other to capture oral energy, separated by a wooden plate. However, this method has several limitations, including the positioning of the microphones, the quality of the separating chamber, and the calibration of the equipment. Furthermore, this technique is not a real-time analyzer, and its use for analyzing running speech has not been widely accepted due to these limitations.

The Nasometer, a device designed to measure nasalance (the ratio of nasal acoustic energy to total acoustic energy), has significantly contributed to speech assessment since its introduction. Initial research efforts primarily focused on evaluating its capability to detect abnormal nasality in clinical populations accurately. Pioneering studies by Dalston et al. (1991) have explored the efficiency of the Nasometer regarding test sensitivity and specificity. These studies laid the foundation for understanding the clinical utility of the Nasometer, demonstrating its potential to enhance diagnostic accuracy and intervention outcomes for individuals with speech disorders characterized by atypical nasality.

Early investigations by Fletcher (1978) and subsequent studies by Dalston and Warren (1986) and Hardin et al. (1992) confirmed the device's reliability and validity. These findings have highlighted the effectiveness of Nasometer as a clinical tool for assessing nasality, reinforcing its importance in diagnostics and therapeutic settings.

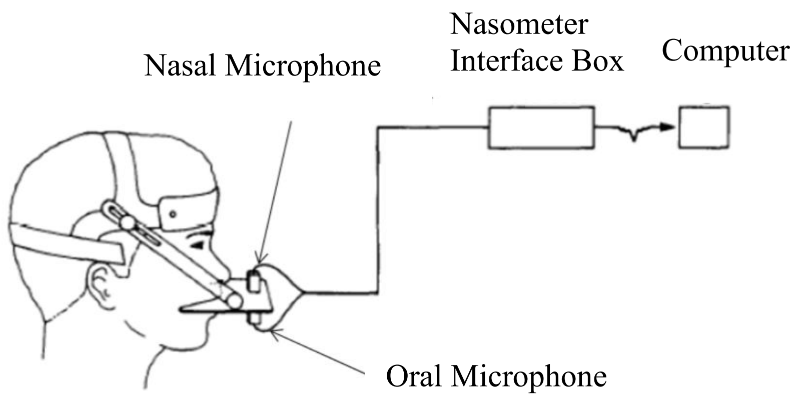
Beyond direct clinical applications, research has also delved into various factors that influence nasalance measures in normal speech, including the impact of native language nasalance on nonnative language and the effect of age and gender on nasality. Understanding these variables is crucial for distinguishing pathological nasality from normal variations, refining the diagnostic criteria, and enhancing the precision of nasalance measurements. Research in this field significantly expanded the knowledge base, providing valuable insights that inform clinical practices and guide further innovations in diagnosing and treating disorders.

Currently, the Nasometer is an extensively used tool for the objective assessment of nasalance in daily clinical settings and for research (Bressmann, 2005). It is a computer-based microphone system that measures nasalance values (Girish et al., 2021). It consists of a headgear equipped with a directional microphone on each side of the sound-separator plate, as given in Figure 1.1. The nasalance value is obtained in percentage (As shown in the equation below). The resulting signal is the ratio of the acoustic signal collected at the nasal microphone to the acoustic signal collected at the oral and nasal microphone (Fletcher, 1978).

$$\text{Nasalance} = \frac{\text{Nasal Signal}}{\text{Oral Signal} + \text{Nasal Signal}} \times 100$$

Figure 1.1

Pictorial representation of Nasometer instrument set up as given by Mayo et al,.2011)



Kummer (2008) stated that the judgment regarding nasalance could be made by comparing individual results with the normative data. High scores, relative to the normative data, indicate hypernasality; low scores, in comparison, suggest hyponasality. Nasalance scores are generally derived from having the client read or repeat a standardized passage, sentences, or syllables (Mayo et al,. 2011).

The measurement of nasal resonance in speech, or nasalance, is influenced by the linguistic characteristics of different languages (Watterson et al.,1996). Leeper, Rochet, and Mackay (1992) demonstrated significant within-subject differences in nasalance scores between bilingual Canadian French-American English speakers, even when phonetic content was carefully matched across the reading materials in both languages. This finding underscores the necessity of establishing language-specific nasalance norms. The normative nasalance developed in a language depends upon the phonetic structure of the language, and it varies across languages; this puts forth the need to establish normative nasalance of individual languages, which can vary for adults and children and across genders.

Numerous studies have been conducted to derive nasalance norms for various languages, particularly among young adults. Notable contributions include norms for Finnish (Haapanen, 1991), Canadian French (Leeper et al., 1992), Spanish dialects (Anderson, 1996; Nichols, 1999), Japanese (Tachimura et al., 2000), Flemish (Van Lierde et.,2001), Cantonese (Whitehill, 2001), Marathi (Nandurkar, 2002), Irish (Sweeney et al., 2004), Kannada (Jayakumar & Pushpavathi, 2005), Hindi (Meshram & pushpavathi ,2012), and Malayalam (Kuppusamy et al., 2013). These studies provide essential reference points for clinicians and researchers, facilitating more accurate assessments of nasality across diverse linguistic contexts.

Many factors, such as vowel length, the context of the stimuli, phonemic characteristics of the language, and the rate of speech, also influence nasalance value. Previous investigations have shown that nasalance values are influenced by vowel height, and increase as the vowel height increases (Reddy et al., 2012; Ha & Cho, 2015; Oliveira et al., 2017), and these values were higher for voiced syllables than unvoiced syllables (Reddy et al., 2012). Some studies have shown no gender difference in nasalance scores (Litzaw & Dalston, 1992; Seaver et al., 1991). In those instances where gender differences were noted, women were more nasal than men (Mishima et al., 2008; Devi & Pushpavathi, 2009). Authors have identified the normative nasalance across many languages and between dialects (Mayo, 2013).

Extensive research has been conducted on nasalance scores in various Indian languages, utilizing oral and nasal sentences as stimuli. Nandurkar (2002) examined nasalance in Marathi, while Jayakumar and pushpavathi (2005) on Kannada, Meshram and pushpavathi (2012) on Hindi, and Kuppusamy et al., 2013 on Malayalam. Furthermore, Arya (2009) and Ravindra (2009) explored nasalance using oral and nasal sentences and paragraphs in Hindi and Malayalam, respectively. Earlier studies indicated that nasalance values vary across languages. (Anderson, 1996; Van Doorn and Purcell, 1998; Van Lierde, 2001; Whitehill, 2001; Van Lierde et al., 2001: Sweeney et al., 2004: Mahesh and Pushpavathi, 2008).

Considering the variation in nasalance values across languages and types of stimuli, it is crucial to establish normative data for each language and stimulus type. These values are influenced by the number of nasal sounds and their frequency of occurrence in the respective languages. Establishing comprehensive normative data ensures accurate assessment and management of resonance disorders within various linguistic contexts.

Nasalance variations are also observed across genders in normal speakers. These differences are attributed to the distinct structural and functional frameworks between males and females, including variations in the size, shape, and surface of subglottal and supraglottal cavities. Previous studies have reported conflicting findings regarding gender differences in nasalance scores. Seaver et al. (1991) and Van Lierde et al. (2001) found that female speakers exhibit significantly higher nasalance scores than male speakers when using a nasal paragraphs. Conversely, Fletcher (1978) reported increased nasalance scores for male speakers compared to females when measured with the nasal paragraphs. These variations underscore the necessity for additional research to comprehend the fundamental causes behind gender differences in nasalance.

Research in the field of nasalance has indicated that in bilingual or trilingual speakers, the native language impacts the nasalance value of the second or third language (Girish et al., 2021). The degree of impact of one language on the other can depend on several factors, including the nasality of the native language, the language proficiency, and the age and gender of the speaker. The studies have indicated a difference in nasalance when Malayalam and Tamil speakers read English passages (Preethy et al., 2018). Another study has found a difference in nasalance when Kannada, Tamil, and Hindi speakers read Zoo passages in English (Philip et al., 2009). However, further research is needed to explore the impact of South Indian languages on one another.

Need for the study

The Eighth Amendment of the Indian constitution recognizes 22 scheduled languages and 100 non-scheduled languages, which includes English (Mallikarjun, 2010). The majority of the population in India are either bilinguals or multilinguals, who frequently use and are exposed to at least two languages. In this scenario, the influence of one language on the other is inevitable in a country like India.

Nasalance is an aspect of speech quality that is produced by nasal resonators, which are used as a parameter for the assessment and management of resonance disorders. The proper assessment and management of resonance disorders are much needed for normal communication and intelligible speech. As discussed above, nasality even in normal speakers, is an aspect that varies from person to person depending on multiple factors including the language spoken, the context of the stimuli, etc.

India is a multicultural and multilinguistic country. So, the people in this country are surrounded by a variety of linguistic cultures and are most often bi/multilingual. Hence, a major population in this country speaks at least one nonnative language daily and how their native language influences the nasality when they are speaking a nonnative language, is a question that arises both in the context of speech of normal as well as disordered populations. An inappropriate nasalance can affect the intelligibility of the speech. As nasalance varies across languages, it is very important to identify these variations and consider them in normal conversations in a non-native language, as it can have much impact on the naturalness of speech.

Most people in South India use Kannada, Tamil, Malayalam, and Telugu, considered as Dravidian languages. Most South Indians are bilinguals/trilinguals who often use more than their native language for daily communication. Tamil is spoken in southern India, Singapore, Malaysia, and Sri Lanka (Stein, 1977) and is one of the oldest languages in the world. Telugu is another Dravidian language spoken by 7.19% of the population in India (Bhaskararao et al., 2017).

Generally, clinicians choose the patient's native language to assess and intervene in resonance disorders. Instances have emerged where individuals exhibit a higher level of proficiency in languages other than their native language. In such circumstances, a comprehensive assessment is necessitated in both the native language and the language in which the individual demonstrates superior proficiency. Also, for intervening multilingual who need to use more than one language with good intelligibility, the individual focus should be given to minor aspects of each language (including nasalance) rather than working on one language only. Studies have stated that nasalance shows a variation when a native and non-native speaker is communicating in a common language (Girish et al., 2021). This scenario shows the pressing priority of understanding this degree of impact and variations between native and non-native speakers and the need to develop a normative for nasalance for non-native speakers. Both of these are important requirements for multilingual intervention. In addition to the clinical implications derived from comparing nasalance values across various languages, there is a theoretical advantage in enhancing our comprehension of how linguistic factors affect nasalance measurements(Mayo, 2013).

Aim and objectives of the study

The present study aims to measure the influence of native language nasalance on non-native language with the following objectives:

1. To compare the nasalance between native and non-native Kannada speakers and among the non-native Kannada speakers for words (Oral words) and sentences (Oral and Nasal sentences).
    - Native Kannada Vs Telugu Speakers
    - Native Kannada Vs Tamil Speakers
    - Native Tamil Vs Telugu Speakers
2. To compare the gender effect on nasalance within native and non-native Kannada speakers.

CHAPTER II

REVIEW OF LITERATURE

Speech production is facilitated by the lung's pulmonary pressure, which produces sound through the vibration of the vocal folds in the larynx. The vocal tract subsequently modifies this sound. Normal speech production relies on the rapid ability to effectively couple and decouple the nasal cavity from the oral cavity (Preethy et al., 2018). The mechanism of coupling and decoupling of the oral and nasal cavities for speech, known as velopharyngeal valving, is regulated by elevation of the velum and constriction of the pharyngeal walls (Reddy et al., 2012).

Individuals with cleft palate and dysarthria often present with velopharyngeal inadequacy/insufficiency. Deviated nasality is a common problem in these individuals, which affects their overall speech intelligibility. Nasality in resonance disorders can be clinically categorized into hypernasality, hyponasality, and nasal air emission. Hypernasality is characterized by excessive nasal resonance during the production of vowels or vowel-like consonants. An inadequate nasal airflow leads to hyponasality during speech. Nasal emission refers to the presence of turbulent noise during the production of high-pressure consonants, often perceived as an audible "puff" of air emitted through the nostrils. The disordered and clinically normal speech exhibits some amount of nasal resonance (Kuppusamy et al., 2013).

Assessment of Nasalance is carried out through subjective and objective methods. Even though the perceptual assessment is considered to be the gold standard assessment. A combination of subjective and objective assessment serves the best to assess nasalance. SLPs and otorhinolaryngologists rely on direct and indirect assessment procedures to assess nasalization (Shprintzen & Bardach, 1995). Direct visualization methods of the velopharyngeal valve include Multiview video fluoroscopy and nasopharyngoscopy, whereas indirect or non-visualization procedures are illustrated by mirror test aerodynamic and acoustic investigations (Van Lierde et al., 2001).

The SLPs prefer indirect assessment methods as they are non-invasive and do not require additional medical support. Additionally, visually observing the velopharyngeal mechanism is challenging, and monitoring the acoustic effects of velopharyngeal action is also problematic. So, the Nasometer is a widely used instrument by speech-language pathologists to assess nasality, which measures the nasalance score by obtaining values from the oral and nasal microphones separately.

Fletcher et al. (1974) introduced the term "nasalance" to describe various metrics assessing the balance between the acoustic energy at the nares (An) and the acoustic energy at the mouth (Ao) during voiced speech. This balance, An/Ao, can be represented as a nasalance ratio (NR) or as a percentage, An/ (Ao + An), referred to as % Nasalance (% N). Both metrics convey the same information on different scales. Recent studies have predominantly reported nasalance measurements in the % nasalance format.

The Nasometer has been utilized to assess velopharyngeal insufficiency and nasal obstruction since its introduction. From its inception, the Nasometer has found interest as a clinical tool for investigators to assess its potential value in evaluating clients at risk for developing velopharyngeal inadequacy. Many studies have indicated that the Nasometer is a practical clinical tool for assessing the nasalance of normal and individuals with resonance disorder. (Seaver et al,.1991).

2.1 Normative Studies of Nasalance in Different foreign languages

Whitehill (2001) stated that the primary clinical importance of providing normative data for any language is its necessity for diagnosing and managing individuals with resonance disorders. Additionally, research investigations and comparisons of nasalance scores across languages enhance theoretical understanding of linguistic and socio-cultural factors that influence the perceptual measurement of resonance judgment.

Anderson (1996) conducted a study to determine the normative nasalance values for Spanish-speaking women using Nasometer 6200. A total of 40 participants aged between 21 and 43 years, were included in the study. Three types of stimuli were considered for the study sentences with nasal consonants, reading passages containing both oral and nasal consonants, and reading passages with oral consonants. Comparisons across stimuli were made. The results revealed significant differences in the mean nasalance scores across the nasal sentences. In the present study, the values of the Spanish group fell within the range mentioned by Seaver (1991) for English-speaking women. However, the results showed possible cross-cultural differences in the perception of nasality and normal resonance.

A study by Tachimora (2000) aimed to identify the nasalance variation for normal adults in the Midwest dialect of Japanese and compare the mean nasalance scores obtained by the two genders. The standard stimulus used was “Kitsutsuki” passages consisting of 4 sentences with no nasal sentences. The stimuli were captured using Nasometer 6200, and each of the sentences was repeated 3 times by each participant. The age range of the participants was between 19 to 35years. The mean nasalance score and overall average nasalance score were calculated for each of the subjects. The average nasalance score was then compared between the two genders.

Whitehill (2001) studied normative data for Cantonese-speaking women. The study included 141 participants aged between 18 and 33 years with normal resonance. The participants were required to read aloud four speech stimuli: oral sentences, nasal sentences, oral passage, and oro-nasal passage. This was recorded using Nasometer 6200. The authors have compared the nasalance between oral and nasal sentences and oral and oro-nasal passages. The results showed that the mean nasalance scores were higher for nasal sentences than oral sentences, and similarly, the nasalance scores were higher for oro-nasal passage than oral passage.

Van Lierda et al. (2001) studies the normative nasalance in the Flemish language. The study included 58 flemish speakers aged between 19 and 27 years. The Nasometer(6200) was used for the recording. The stimuli included oral passages, nasal passages, and oro-nasal passages. The mean nasalance score for the nasal passages was slightly higher than the oral and oro-nasal passages. Significant differences were observed among the nasalance scores of the three types of passages: oral, oral-nasal, and nasal passages.

In the Hungarian language, Hirschberg et al. (2005) developed normative nasalance scores for children and adults. Analyzed the data in comparison with other languages to assess the correlation between the nasalance scores and perceptual ratings of nasality. The participants included 35 children aged 5-7 years and 45 adults aged 20-25 years. The speech stimuli consisted of phonation of isolated vowels, articulation of spirants, cyclical repetition of affricates, pronunciation of various sentences, and evaluation of nasalance score in the continuous speech was also recorded. The mean nasalance score while using oral sentences was recorded as 11-13%, and the mean nasalance scores for nasal sentences were recorded as 56%, while that for mixed sentences representing Hungarian language was 30-40%. The authors concluded that nasalance increases with age but found no significant differences across genders.

Okalidou (2011) derived nasalance norms and determined the gender differences in nasalance scores in Greek adults. The stimuli comprised a corpus of linguistic material, which was divided into three parts: an oral, nasal, and a balanced text; four sets of oral sentences and one set of nasal sentences and the repetitions of each of the 12 syllable types (8 oral and 4 nasal). The study comprised 8 healthy monolingual adults with equal males and females. The recording was made using a Nasometer (Model 6200). The results indicated that the mean nasalance score obtained for the nasal text was significantly higher than the oral and oro nasal text. In the case of sentences and syllables, nasally loaded material had higher nasalance than orally loaded material.

Alfwaress et al. (2021) studied the establishment of normative data for native American English speakers, focusing on young adults and adolescents. They also examined the gender and age-group differences in global nasalance measures using the Simplified Nasometric Assessment Procedures (SNAP) Test-R and the Nasometer II. Normative data for nasalance scores were gathered during Syllable Repetition/Prolonged Sounds, Picture-Cued, and Paragraph subtests. The findings showed statistically significant variations in nasalance scores for syllable repetition, picture-cued, and paragraph subtests, and between males and females for syllable repetition and sound-extended subtests. Standards showed obtainable age- and gender-based variations in nasalance scores, primarily in the Syllable Repetition/Prolonged Sound subtest. Additionally, the type of vowel and place of articulation of the consonants impacted the nasalance scores.

2.2 Normative Studies of Nasalance in Indian Languages

Jayakumar and Pushpavathi (2005) conducted a study to determine normative nasalance in Kannada speakers. The study participants were 100 normal subjects: 50 children aged 5 to 10 years and 50 adults aged 20 to 35 years. Nasometer 6400 was used to record the data. The nasalance score for children in nasal sentences was 51.03%(7.02), and for oral sentences was 9.08% (3.49). For the syllable repetition task, the nasalance value for nasal syllables was 66.44% (6.63), and for oral syllables was 10.66%(4.07). There was no significant difference across the genders in children. Significant differences were evident across the genders in adults.

Kuppusamy et al. (2013) developed normative in Malayalam-speaking adults. The participants included sixty adults, equally divided between men and women. Two sets of meaningful Malayalam words and sentences were the stimuli; in which Set 1 had oral words and sentences, and Set 2 had nasal words and sentences. The recording was made using Nasometer II. In both the oral and nasal stimuli, the average nasalance scores for words were higher than that of sentences for both genders. The findings demonstrated a substantial difference between nasal and oral words and between nasal and oral phrases.

The normative nasalance for Hindi-speaking adults was studied by Meshram and Pushpavathi (2012). The participants included a total of 50 adults, who had an equal number of men and women. The participants were aged between 17-30 years with normal speech, language, and hearing. The stimuli included were vowels /a/, /i/, and /u/; meaningful oral and nasal words, sentences and paragraphs. The nasalance scores were obtained for the subjects across the genders. The results indicated that /i/ has higher nasalance than other vowels across the gender. The results showed increased nasalance for females for oro words, sentences, and paragraphs and nasal words, sentences, and paragraphs.

Kadisonga and Jayakumar (2016) studied normative nasalance in adult Manipuri speakers. The participants included 80 adults with the same number of males and females between 17 and 35 years of age. The stimuli included 2 sets of meaningful sentences – oral and nasal. The Nasometer II (6450) was used for the recording. The results revealed a considerable difference between oral and nasal sentences. That is, the mean nasalance score obtained for nasal sentences is higher, i.e., 59.46% (7.21), than the mean nasalance score obtained for oral sentences, i.e., 22.58% (9.53).

Another study by Pokharel et al. (2020) obtained normative nasalance for Indian Tamil-speaking children. A total of 175 (80 females and 95 males) children were included in the study, aged between 6 to 15 years. The stimuli included 6 standardized sentences, including oral, nasal, and oro-nasal sentences, each two in number.. Males had a significantly higher nasalance score for oral words and oro-nasal sentences.

2.3 Influence of the Native language Nasalance on non-native language.

Mahesh and Pushpavathi (2008) investigated normative nasalance values in Non- native English speakers using the Rainbow passage. The participants included were non-native English speakers from different parts of India who have learned English as their second language. The participants' mothers were Malayalam, Tamil, Kannada, Telugu, or Hindi. The study included a total of 115 participants, including 70 females and 45 males aged 18 to 30 years. The Nasometer II (Model 6400) was used for the recording, and the stimuli used were the rainbow passage. Mean nasalance scores were obtained from 45 normal males and 70 normal females. The results indicated higher nasalance percent and variability in females compared to males. The mean nasalance value was 31.39 for females and 27.93 for males. A comparison of the nasalance values for Rainbow passage across various studies reveals significant differences except for Hutchinson et al. (1978). This difference is due to the difference across subjects, age, and instrumentation.

Philip, Pushpavathi & Sangeetha (2009) The paper investigates the influence of three Indian languages (Kannada, Malayalam, and Hindi) on nasalance values using the standard Zoo passage. The study showed that Kannada speakers had significantly lower nasalance scores compared to Malayalam and Hindi speakers, while there was no significant difference between Malayalam and Hindi. Native Kannada speakers had significantly lower nasalance scores compared to native Malayalam and Hindi speakers when reading the standard English Zoo passage. The nasalance scores of native Malayalam and Hindi speakers were significantly higher than the established norms for English speakers. The differences in nasalance scores can be explained by the phonemic characteristics and inherent features of the native languages, which influence articulation and resonance even when speaking English.

Preethy et al. (2018) compared the influence of Malayalam and Tamil while reading English. The study included 2 groups of participants where: Group A consisted of native Malayalam speakers, and Group B included Native Tamil speakers. Each group had 30 participants(15 males and 15 females). The participants were between 18 and 25 years old. The subjects were asked to read the Zoo passage. The recording was done using Nasometer II (Model 6450). The results revealed a significant difference in nasal resonance between Malayalam and Tamil speakers while reading the English passage.

Chatterjee et al. (2020) measured the nasalance of Khasi speakers while reading English passages. The study comprised 5 native Khasi females as subjects who had been exposed to English since childhood. The stimuli included 3 standardized passages – Zoo passage, rainbow passage, and nasal sentences. Nasometer II model 6400 was used for the recording of stimuli. Standard norms revealed substantial differences in nasalance scores for sentences in the zoo, rainbow, and nasal contexts; these differences are more pronounced for nasal sentences than zoo or rainbow phrases. The significance level was higher for rainbow sentences than zoo sentences regarding nasalance scores.

Liu and Lee (2020) conducted a study to examine the influence of the native language on nasalance scores of the non-native language. The authors examined whether the English nasalance values of Mandarin Chinese speakers are comparable to those of native English speakers. A total of 32 participants were included in the study with an equal number of Mandarin Chinese speakers and native English speakers. The number of males and females was also equal. The stimuli used for the study include prolonged vowels like /i/, /a/ and /u/, 10 English consonant-vowel syllables, 3 sentences having bilabial plosives, lingual-alveolar sibilant, and nasals, and finally 2 vowels in nasal context. The results revealed higher nasalance scores for Chinese learners of English produced than native English speakers on prolonged vowel /i/ and /a/, the syllable “nin,” and non-nasal sentences and passages.

Girish et al. (2021) compared the nasalance scores of vowels, unvoiced syllables, voiced syllables, oral words, and oral and nasal sentences between native Malayalam speakers and native Kannada speakers. The study included 12 native Malayalam and 12 native Kannada speakers with equivalent males and females. The stimuli included vowels, voiced and unvoiced syllables, oral words, and oral and nasal sentences in both Kannada and English. The stimuli were recorded using Nasometer II (Model 6450). The results revealed that for all the stimuli considered for the study, Malayalam speakers had higher nasalance scores than Native Kannada speakers. However, a statistically significant difference was found only on vowels. The higher nasalance values in Malayalam speakers were attributed to the influence of the "inherent nasal quality" and phonemic characteristics of the Malayalam language on the articulation of the second/third language.

Kuriakose et al. (2022) compared the nasalance score between two different dialects of the Konkani language. The study included 32 participants, divided into 2 groups based on the dialects of the Konkani language. The participants were then made to read a list of words and phrases. The nasalance values were measured using the Nasal view. The results indicated that mean scores of nascence were higher in the Karwar dialect of Konkani than in the Goan dialect of Konkani.

2.4 Influence of Gender on Nasalance

Tachimora (2000) conducted a study to identify the nasalance variation for normal adults in the Midwest dialect of Japanese and compare the mean nasalance scores obtained by the two genders using the standard stimulus used “Kitsutsuki” passages consisting of four sentences with no nasal sentences. However, no statistically significant difference was noted across the two genders. The average mean scores of females and males were 9.8% and 8.3% respectively.

Whitehill (2001) studied normative data for Cantonese-speaking women. A total of 141 speakers were included in the study between the age of 18-33 years with normal resonance. The participants were instructed to read aloud 4 speech stimuli: Oral sentences, nasal sentences, oral passage, and oro-nasal passage. They compared the difference in nasalance scores across the stimuli and also the influence of gender on nasalance was noted. For the same purpose, the authors included 12 more men in the total participants and then compared them with the women. The results revealed no significant difference between the genders for nasal sentences and oral and oral-nasal paragraphs. However, a significant difference was observed in the nasal sentences.

Jayakumar and Pushpavathi (2005) conducted a study to determine normative nasalance in Kannada speakers. The study participants were 100 normal subjects, including 50 children aged between 5 and 10 years and 50 adults between 20 and 35 years. Nasometer 6400 was used to record the data. Significant differences were evident across the genders in adults. The nasalance value was 48.27% (8.74) for nasal sentences, and for oral sentences, it was 58.22% (8.40), and for oral sentences, 14.69% (5.86). In females, nasal sentences were 58.22% (8.40), and oral sentences were 14.69%(5.86), which was the obtained nasalance score.

Mahesh and Pushpavathi (2008) investigated the normative nasalance value of nonnatives while reading the rainbow passage. The nasalance of 45 men and 70 women was measured using Nasometer II. The results indicated higher nasalance percent and variability in females compared to males. The mean nasalance value was 31.39 for females and 27.93 for males.

Mishima et al. (2008) determined the gender-related differences and the impact of dialect in nasalance scores for normal Japanese speakers. Number of participants included in the study was 68(31 males and 37 females). The participants were divided, based on the geographic distribution, into 4 regional groups- Chugoku, Kinki, Shikoku, and other regions. A "kitsutsuki" passage consisting of Japanese nonnasal words and vowels along with Japanese vowels /u/,/i/,/e/,/o/, and /a/, was read aloud three times. The mean nasalance was subsequently calculated using Nasometer II (Model 6400). Analysis revealed a statistically significant difference across all vowels.

Kuppusamy et al. (2013) developed normative in Malayalam-speaking adults. The participants included 60 adults (30 males and 30 females). The stimuli included two sets of meaningful Malayalam words and sentences. The recording was made using Nasometer II. The higher mean nasalance scores were obtained for females for the words and sentences across oral and nasal stimuli. The statistical analysis revealed a significant difference across genders for all the stimuli (words and sentences)

D’haeseleer et al. (2015) studied the influence of dialect and gender on nasalance and also determined the normative nasalance for Flemish adults. Participants comprised people from the five Flanders regions, correlating to distinct dialects. 164 adults(71 men and 93 women) volunteered to participate in the study aged 20 to 82. The stimuli used were a connected speech sample with oral, oronasal, and nasal text, and the response was measured using Naometer II (Model 6450). However, no significant difference was obtained between the dialects and gender.

Inostroza-Allende et al. (2022) conducted a study to determine and compare the nasalance between Chilean Spanish-speaking adult men and women. The participants comprised 40 females and 36 males aged between 18 and 35. The stimuli used were oral passage, nasal passage, and oral nasal sentences. The nasalance was determined using a Nasometer (Model 6450). The highest percentage of nasalance was seen for nasal passages, followed by the oral nasal passages, and finally, the oral passages, which presented the lowest value. The results showed no significant differences in nasalance between the genders.

2.5 Other Factors Influencing Nasalance

Lewis et al. (2000) carried out a study to identify the effect of vowels on nasalance. The nasalance scores were compared for nine speech stimuli with controlled vowel content. Out of the nine speech stimuli, four stimuli (/i/, /u/, /æ/, and /a/) were vowels in isolation, and the remaining five were vowels in sentences. Four sentences were specifically designed to emphasize the high front, high back, low front, and low back vowels, while the fifth sentence combines different vowels. The subjects included

19 children with VPD and 19 with normal velopharyngeal function. In both the groups, the nasalance scores for sustained vowels showed that the high front vowel /i/ had significantly higher scores than any other vowel, and also, the high back vowel /u/ had a significantly higher nasalance than the low vowels /æ/ or /a/. However, no significant difference in nasalance was obtained between the low vowels.

Goberman et al. (2001) investigated how variations in speech rate affected the perception of nasalance and airflow. The research also explored the impact of gender and speech elicitation techniques. Nineteen speakers participated in the study. The participants were asked to produce nasal and non-nasal sounds. The oral and nasal airflow was measured using the Rothenberg aerodynamic system. The findings revealed that the nasal airflow and perceived nasalance were higher when the rate of speech was slow.

Van Lierde et al. (2010) conducted a study to identify the effect of intensity and pitch modulation on the nasalance scores. The study included both individuals with cleft and non-cleft. A total of 50 participants were considered in the non-cleft group, and 22 children were considered in the cleft group. The participants were given two passages to read, and the nasalance was measured using Nasometer 6200. The participants were made to read the stimuli under different conditions, including normal intensity and loudness, increased loudness, increased intensity, decreased loudness, and decreased intensity. The results showed that in the non-cleft group, an increase in intensity showed a statistically significant decrease in nasalance. For both cleft and non-cleft groups, lowering the pitch resulted in a significant decrease in nasalance scores.

Whitney et al. (2014) studied the relationship between the rate of speech and nasalance scores. A total of 60 volunteers were enrolled in the study within the age range of 18 to 30 years. The participants were given four speaking tasks: sustaining vowels, syllable repetition, sentence reading, and paragraph reading. The Nasometer and a microphone digital recorder setup were used to analyze the nasalance scores and speech rate, respectively. Statistical analysis revealed that the oral stimuli, at the paragraph (Sibilant Passage) and syllable level, a faster speech rate was associated with lower nasalance. But for the Rainbow Passage and Nasal Paragraph, no relationship between the speaking rate group and nasalance was observed.

Ha and Cho (2015) conducted research to identify the normative nasalance scores of normal Korean children and adults. The author also determined whether the effect of age, vowel contexts and stimuli length influenced the nasalance scores. The participants of the study included 57 children and 17 adults. Mean nasalance scores were calculated for eight sentences without nasal consonants, which were categorized into vowel contexts of /a/ and /i/. The sentences varied in length, containing 4,8,16 and 31 syllables. The participants were made to repeat the stimuli. The average value of two recordings was taken into consideration. The statistical analysis revealed a significant impact of age and vowel contexts on the salience scores and a significant interaction between the age and the vowel context. But, the length of the stimuli had no significant impact on the nasalance. All speakers had higher scores for /i/than /a/. Adults had higher nasalance scores than children in both vowel contexts.

Awan et al. (2015) studied nasalance in speakers from 6 different dialectal regions across North America. A total of 300 participants were included in the study, with an equal number of participants in each dialect and an equal number of males and females in each dialect. Reading samples of zoo passages, rainbow passages, and nasal sentences were collected from each participant. The stimuli were recorded in a nasometer. The results revealed a significant regional difference in nasalance, with speakers from the Texas region exhibiting higher nasalance scores across all passages.

Pua et al. (2018) did a study to develop the nasalance normative scores for bilingual Mandarin-English speakers and compare them with monolingual Mandarin speakers. The study also examined the effect of age, gender, language proficiency, and dialect on the nasalance scores in both Mandarin and English. A total of 45 native Mandarin speakers who were within the age range of 20 to 54 years participated in the study. The stimuli included oral sentences, oronasal sentences, nasal sentences, and vowels /a/,/i/, and /u/. Nasometer II was used for the recording. The normative nasalance scores were obtained, and a repeated measures analysis of variance showed no significant effect of age, gender, dialect, and language proficiency on the nasalance scores. However, there was a significant effect of gender in the nasalance scores of both languages.

Reshma and Jayakumar(2020) conducted a study to find the effect of nasalance on voice quality by correlating acoustic measures and nasalance. The participants were divided into two groups. One is the clinical group included 13 participants and the control group had 7 participants. The ages of the participants were between 12 and 40 years. The nasalance scores were obtained for the oral and nasal sentences (Jayakumar & Pushpavathi, 2005) using Nasometer II (Model 6450). The participants were made to read the stimuli. The sustained phonation and reading samples were used to obtain AVQI scores. The AVQI measures and its constituent parameters were obtained using PRAAT and AVQI script. The results showed better AVQI scores for individuals with nasalized voices than normal voice quality. Also, a few of the AVQI constituent parameters like CPP, Shimmer local, and slope LTAS showed a relation with nasalance.

CHAPTER III

METHOD

3.1 Participants

The present study followed a comparative research design and considered 36 participants. The participants were selected using convenient and purposive sampling methods. Informed consent was taken from all the participants. An SLP evaluated each subject to assess oral structure and function. Speech and language abilities were also informally assessed during a conversational interaction. Furthermore, background information on the subjects' medical history and hearing capabilities was also obtained.

The participants were divided into three groups: Group 1 comprised native Kannada speakers, while Groups 2 and 3 included non-native Kannada speakers, specifically native speakers of Telugu and Tamil, respectively. Each language group had ‘12’ participants with an equal number of males and females. The age range of the participants was from 18 to 30 years.

Table 3.1

Details of the participants included in the study

Native Language	**Age Range**	**Gender**	**Number of Participants**
Kannada Speakers	19-28 years	Female	6
		Male	6
Tamil Speakers	18-28years	Female	6
		Male	6
Telugu Speakers	18-29years	Female	6
		Male	6
Total (N)			36

The inclusion criteria for the participants were:

a) Each participant should be a native Kannada, Telugu, or Tamil speaker.

b) No history of speech and language deficits.

c) Normal hearing, orofacial structure, and function.

d) Native Tamil and Telugu speakers should not have received formal education in Kannada.

The exclusion criteria for the participants:

a) Participants with any signs and symptoms of cold, cough, or upper respiratory tract infection at the recording time.

b) Individuals with cognitive impairment.

c) History of any maxillofacial surgery.

d) Individuals with any dental or oral prostheses.

3.2 Stimuli

The test stimuli consisted of six meaningful oral words (Prasad & Pushpavathi, 2011) and five meaningful oral and nasal sentences (Jayakumar & Pushpavathi, 2005) in Kannada. Oral words and sentences were loaded with oral pressure consonants, whereas nasal sentences predominantly exhibited nasal pressure consonants. The list of oral words, and oral and nasal sentences used in the study is provided in Appendix 1.

3.3 Instrumentation

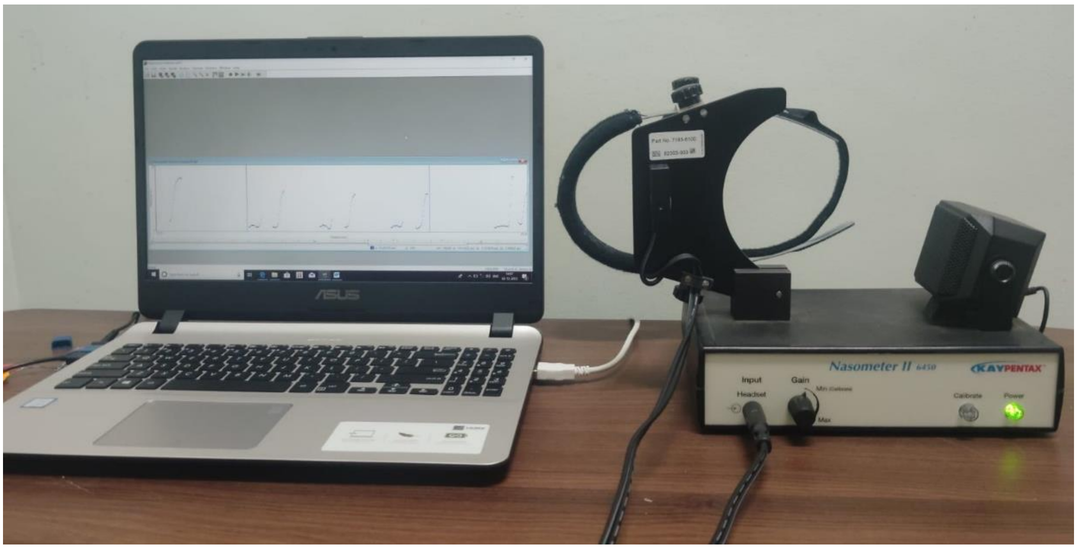
The speech stimuli were recorded using a Nasometer II (Model 6450, Kay Elemetrics) in a quiet environment. Nasometer II utilizes an advanced headset device worn by the patient, effectively separating the oral and nasal cavities with a baffle plate. The device is equipped with microphones mounted on the top and bottom of the plate, enabling the gathering of acoustic energy from the nasal and oral cavities during speech (Figure 3.1,3.2 and 3.3).

The signal from each microphone is filtered individually and customized by electric modules. The Nasometer II software was installed in the operating system and computes a ratio of the acoustic data captured by the two microphones. Specifically, it calculates the nasal acoustic energy relative to the total nasal and oral acoustic energy expressed as a percentage multiplied by 100 (as shown in the equation below). This obtained ratio, termed nasalance, is an acoustic parameter correlating with the perceived nasality. This value is displayed as a percentage, where higher percentages indicate increased nasalance.

$$\textbf{Nasalance} = \frac{\textbf{Nasal Signal}}{\text{Oral Signal} + \text{Nasal Signal}} \text{ X } 100$$

Figure 3.1

Picture of Nasometer II (Model 6450) along with computer system



3.4 Procedure

The Nasometer II was set up in a quiet recording room. The instrument was calibrated every day before the actual measurement. The subjects were assessed and recorded individually. Every participant was comfortably seated on a chair. The instrument's headgear was positioned to be firmly placed on the upper lip and perpendicular to the nasal septum.

The Nasometer headset was correctly positioned following the instructions provided in the manual. The participants were instructed to repeat the speech stimulus after the examiner, using their comfortable pitch and loudness for reliable output. Each participant repeated the stimuli three times, and the average was considered for the analysis. The stimuli included oral words , oral and nasal sentences. The stimuli gap for oral words was three seconds, while for the oral and nasal sentences, it was four seconds. The angle of the baffle plate against the subject's face was cross checked throughout the recording to ensure that it maintained its position.

Figure 3.2

Placement of Nasometer headset during recording- Side view

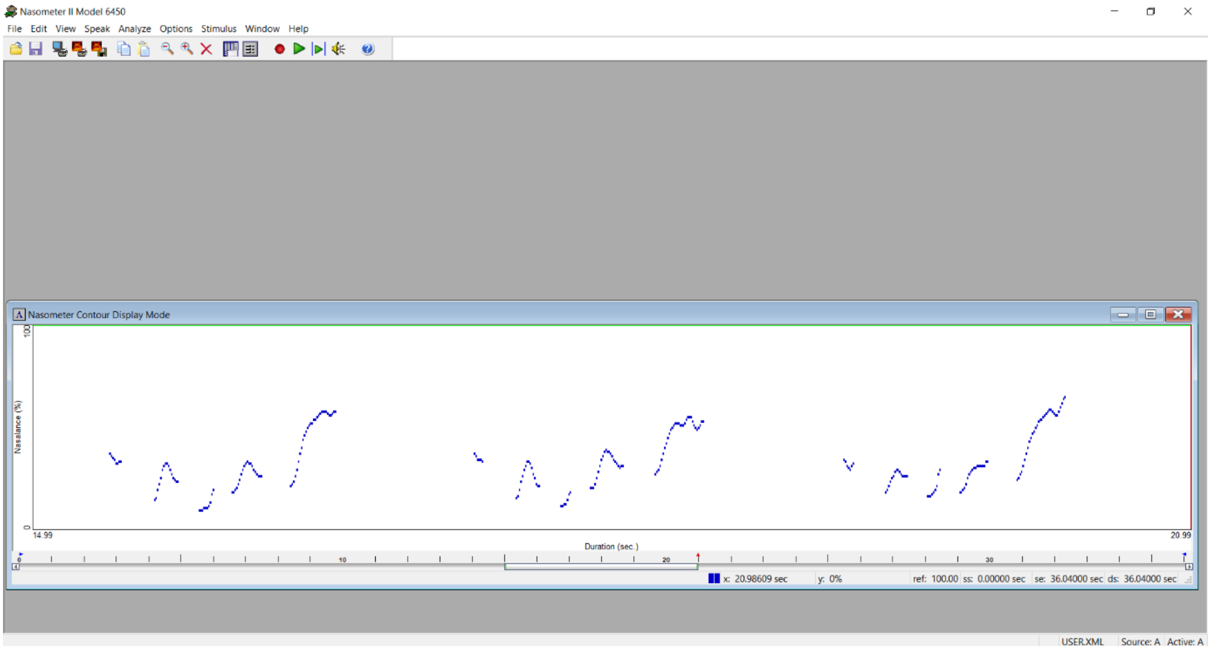
Figure 3.3

Placement of Nasometer headset during recording- Front view

The nasalance trace was monitored continuously throughout the recording to ensure the data was correctly captured. In conditions where the subjects made an error during the recording or in the presence of extraneous factors such as spontaneous coughs, a retrial was taken, and the correct response was included for the analysis. After the recording session, the speech samples were stored in the computer using '.nsp' format for further analysis. Figure 3.4, 3.5 & 3.6 shows the captured waveform for different stimuli for the data analysis.

Figure 3.4

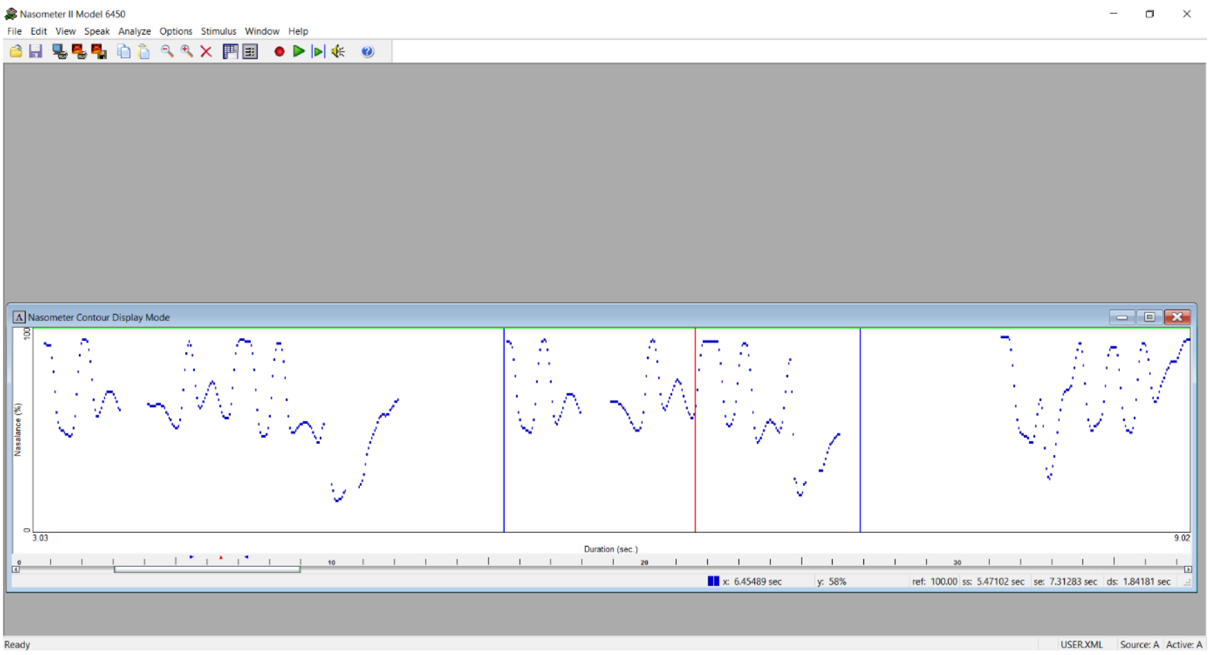
An example of the captured waveform for an oral sentence.



Stimuli : /ka:ge ka:lu kappu/

Figure 3.5

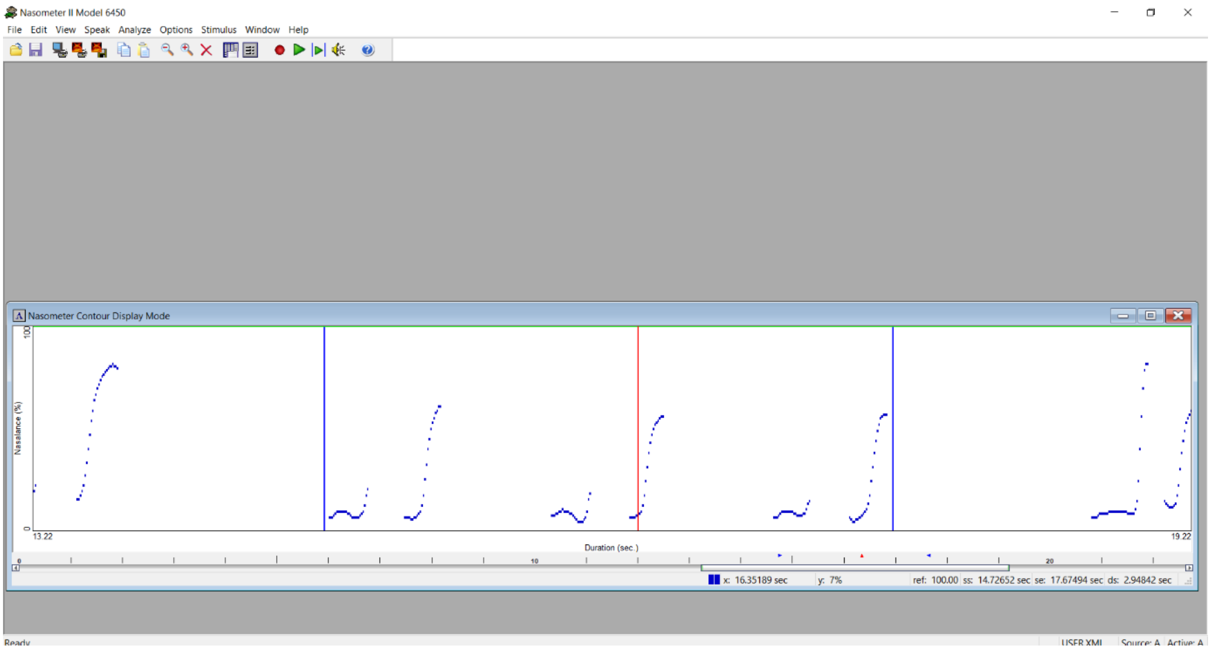
An example of the captured waveform for a Nasal sentence.



**Stimuli: /manu a:nejannu noḍiḍa/*

Figure 3.6

An example of the captured waveform for an Oral word.



Stimuli: /ka:ge/

3.5 Data Analysis

Nasalance scores was obtained for all the sets of stimuli recorded from all the participants. All the data files were screened to ensure no inaccurate data was included for further analysis. Nasalance scores were tabulated accordingly and subjected to statistical analysis as per the objectives of the study. The descriptive statistics, Multivariate Analysis of Variance (MANOVA) and Mann Whitney U test were carried out using *Statistical Package for the Social Sciences (SPSS, Version 26.00)*.

CHAPTER IV

RESULTS

The present study used an objective method to assess nasalance scores across native and non-native Kannada speakers. The primary aim of the study was to compare the nasalance score between native and non-native Kannada speakers for oral words, and oral and nasal sentences in Kannada. A total of 36 participants were divided into 3 groups, with 12 participants in each group, having an equal number of male and female participants. The three groups considered in the study are Group 1, native Kannada speakers, while Group 2 and 3 included non-native Kannada speakers, i.e, Native Telugu and Tamil speakers, respectively. The nasalance was measured using the Nasometer II (Model 6450). The participants were asked to repeat the stimuli and the nasalance score was obtained for each stimulus. The descriptive statistics and parametric tests/non-parametric tests were carried out for each objective following the normality test.

The results discussed under each of the objectives were as follows:

1. To compare the nasalance between native and non-native Kannada speakers and among the non-native Kannada speakers for words (Oral words) and sentences (Oral and Nasal sentences).
    - Native Kannada Vs Telugu Speakers
    - Native Kannada Vs Tamil Speakers
    - Native Tamil Vs Telugu Speakers
2. To compare the gender effect on nasalance within the native and non-native Kannada speakers.

The following statistical analysis was carried out to evaluate objectives using *Statistical Package for the Social Sciences* (SPSS, Version 26.00).

1. The descriptive statistics, including Mean, Standard Deviation, Median, and Intra Quartile Range, were obtained across all 3 groups.
2. The Shapiro-Wilk test was done to check the normality of data.
3. The parametric, Multivariate Analysis of Variance (MANOVA), and Univariate Analysis compared the differences between groups based on the first objective.
4. Post-hoc Tuckey's Honestly Significant Difference (HSD) test was administered for further pairwise comparison across stimuli in the first objective.
5. The non-parametric Mann-Whitney U test was conducted to analyze the second objective statistically.

4.1 To compare the nasalance between native and non-native Kannada speakers and among the non-native Kannada speakers for words (Oral words) and sentences (Oral and Nasal sentences).

The mean nasalance scores were compared between native and non-native Kannada speakers across the stimulus. The non-native language group includes native Telugu and Tamil speakers. The nasalance score is also compared between the two nonnative Kannada groups. With this present objective, the comparison is made between Kannada vs. Telugu, Kannada Vs. Tamil and Telugu Vs. Tamil speakers, respectively.

Table 4.1.

Mean and Standard Deviation of Nasalance of Native and non-native Kannada speakers

	KANNADA (Group 1)		**TELUGU (Group 2)**		**TAMIL (Group 3)**	
N=36	MEAN	SD	MEAN	SD	MEAN	SD
OW	19.25	6.18	25.33	6.16	22.51	3.47
OS	17.15	4.91	21.26	4.32	21.25	5.45
NS	57.40	6.05	63.35	5.16	59.95	3.95

OW=oral words, OS= Oral Sentences, NS=Nasal Sentences, SD=Standard Deviation

Table 4.1 shows the mean and standard deviation for the nasalance of native and non-native Kannada speakers for different stimuli. In the native Kannada group, mean nasalance scores are highest for nasal sentences, followed by oral words, and least for oral sentences. A similar trend was seen in the mean nasalance scores for the other two non-native Kannada groups i.e., Group 2 Native Telugu Speakers and Group 3 Native Tamil speakers.

The normality of the data was then assessed using Shapiro-Wilk's test, and the data followed a normal distribution ($p > 0.05$). Consequently, a parametric test was applied to evaluate the first objective. Multivariate Analysis of Variance (MANOVA) was performed to examine the difference in mean nasalance scores between the three language groups (Groups 1,2 and 3) for all the stimuli, a marginal difference was seen between the groups $F(6, 64) = 1.995$, $p=0.079$.

Univariate analysis was then performed to understand the individual differences between the three groups for mean oral words. The analysis showed a significant difference $F(2,33) = 3.780$, $p< 0.05$. Further, post-hoc Tukey's HSD multiple pairwise comparisons were carried out. The results showed a significant difference between Native Kannada and Telugu speakers in the mean nasalance score for oral words. The results are shown in Table 4.2. However, no significant differences were observed between the native Kannada and Tamil speakers and between Tamil and Telugu speakers for oral words.

Table 4.2

A post hoc Tukey's HSD test results of pairwise comparisons for oral words

Pairwise Comparisons	P value	Significance
Kannada Vs Telugu	$p < 0.05$	Significant difference
Kannada Vs Tamil	$p > 0.05$	No significant difference
Telugu Vs Tamil	$p > 0.05$	No significant difference

The individual differences for the three groups for mean nasal sentences were then analyzed using Univariate analysis F (2,33) = 4.063, $p < 0.05$. The results showed a significant difference. A post-hoc Tukey's HSD test was then performed to conduct pairwise comparisons. According to Tukey's table (Table 4.3), significant differences were seen in the nasalance score of nasal sentences between Native Kannada and Telugu speakers. However, No significant differences in nasalance scores were observed between Kannada and Tamil speakers and between Tamil and Telugu speakers.

Table 4.3

A post hoc Tukey's HSD test results of pairwise comparisons for nasal sentences

Pairwise Comparisons	***p* value**	**Significance**
Kannada Vs Telugu	$p < 0.05$	Significant difference
Kannada Vs Tamil	$p > 0.05$	No significant difference
Telugu Vs Tamil	$p > 0.05$	No significant difference

A univariate analysis was then performed to understand the individual differences between the three groups for mean oral sentences and the results showed no significant difference. $F(2,33) = 2.665$, $p > 0.05$. According to Tukey's HSD analysis (Table 4.4), no significant differences were observed between any groups.

Table 4.4

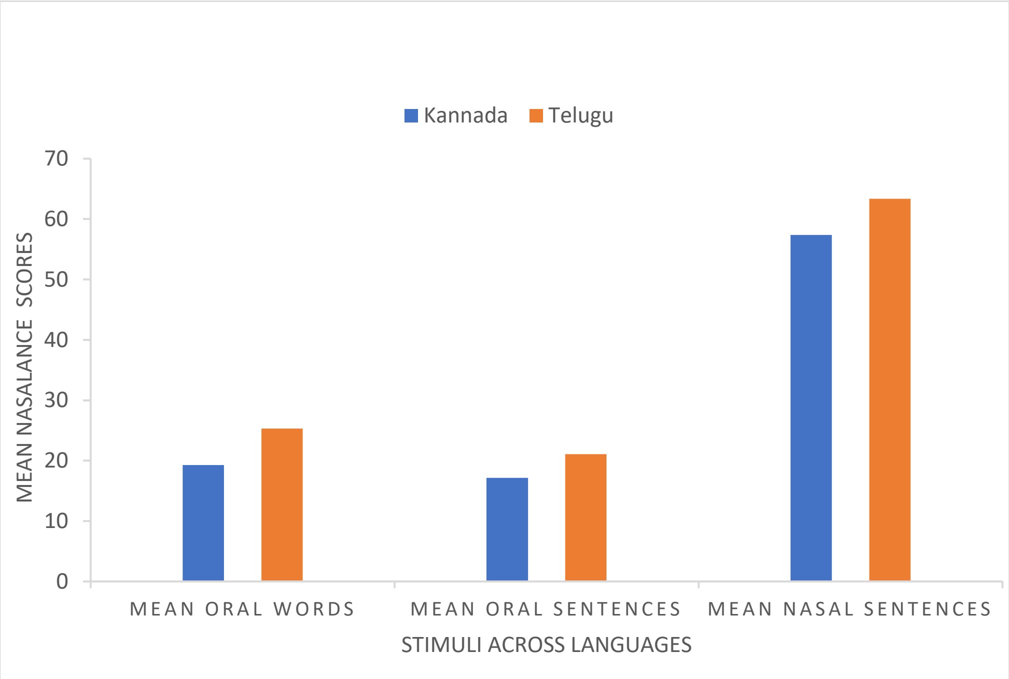
A post hoc Tukey's HSD test results of native and non-native speakers for oral sentences

Pairwise Comparisons	***p* value**	**Significance**
Kannada Vs Telugu	$p > 0.05$	No significant difference
Kannada Vs Tamil	$p > 0.05$	No significant difference
Telugu Vs Tamil	$p > 0.05$	No significant difference

Based on the results obtained from the Tukeys tables (from tables 4.2, 4.3, and 4.4), comparing the nasalance score between native and nonnative speakers for oral words, oral and nasal sentences. It is observed that there is a significant difference between the nasalance scores of native Kannada and Telugu speakers for oral words and nasal sentences but not for oral sentences. However, the mean nasalance scores were higher for native Telugu speakers across all three stimuli as shown in figure 4.1.

Figure 4.1

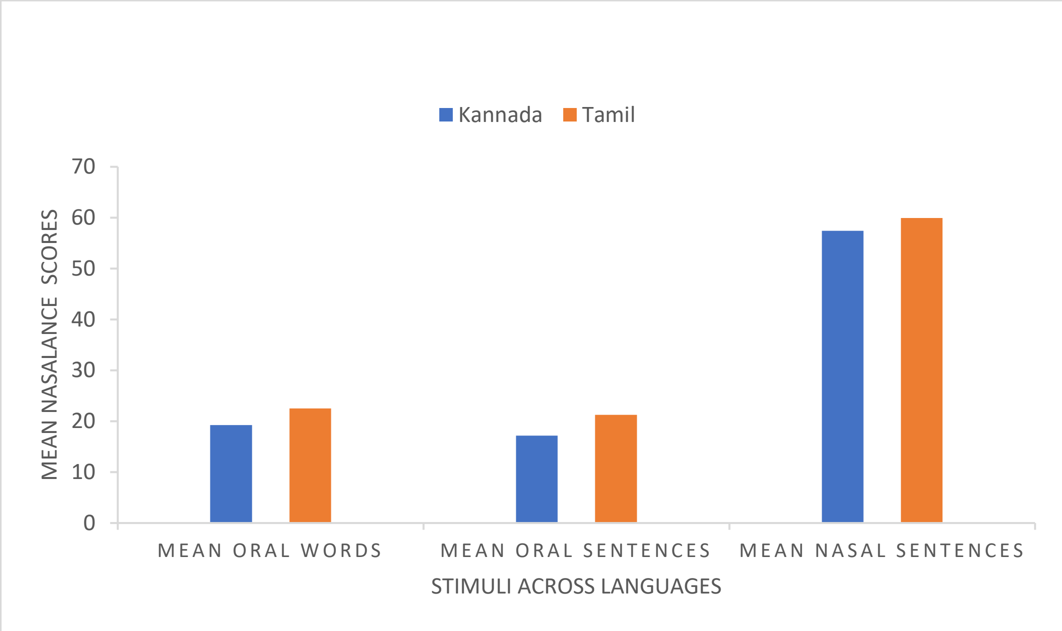
Bar graph representation of mean nasalance scores of oral words, oral and nasal sentences in Kannada and Telugu speakers.



The comparison of the mean nasalance scores between native Kannada and Tamil speakers shows that the mean nasalance scores are higher for Tamil speakers than Kannada speakers as depicted in figure 4.2. However, no significant difference in the mean nasalance scores was obtained for oral words and oral and nasal sentences.

Figure 4.2

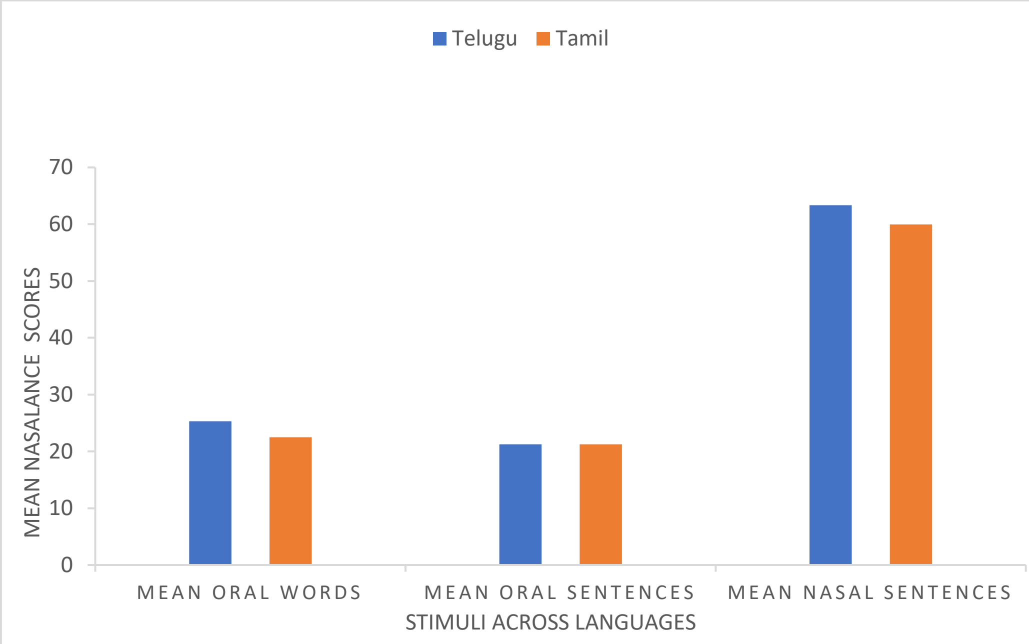
Bar graph representation of mean nasalance scores of oral words, oral and nasal sentences in Kannada and Tamil speakers.



On comparison of the nasalance between the two non-native Kannada speakers (Native Tamil Vs. Native Telugu speakers), it revealed that there is no significant difference between the non-native Kannada speakers for all three stimuli. However, the mean nasalance scores of Native Telugu speakers are higher than that of Native Tamil speakers as shown in Figure 4.3.

Figure 4.3

Bar graph representation of mean nasalance scores of oral words, oral and nasal sentences in Telugu and Tamil speakers.



4.2 To compare the gender effect on nasalance within native and non-native Kannada speakers.

The effect of gender on nasalance was assessed in each language group. A non-parametric Mann-Whitney U test was carried out for the same, considering the sample size of individual groups. The descriptives of each gender in native and non-native language groups are mentioned below (Table 4.5).

Table 4.5

Mean, median, SD, and IQR of Kannada males and females.

	Females				**Males**			
	Mean	Median	SD	IQR	Mean	Median	SD	IQR
Oral words	21.53	20.67	6.56	13.38	16.97	15.18	5.35	10.58
Oral Sentences	19.50	20.5	3.92	7.00	14.80	12.20	4.93	9.40
Nasal Sentences	57.83	58.6	5.29	8.95	56.97	55.50	7.22	12.25

SD=Standard Deviation; IQR=Intra Quartile Range

Table 4.6

Mann-Whitney U test results for comparing nasalance scores across genders in Native Kannada Speakers.

	/Z/ value	**p-value**
Mean Oral Word	0.96	0.34
Mean Oral Sentences	1.76	0.07
Mean Nasal Sentences	0.24	0.81

Table 4.5 shows the descriptive for male and female Kannada speakers. Results indicated that the mean nasalance is higher for females than males across all three stimuli, i.e., oral words and oral and nasal sentences. Mann-Whitney U test was carried out to find the significant difference across the genders. Table 4.6 shows no significant difference in nasalance ($p > 0.05$) for oral words and oral and nasal sentences in

Kannada speakers.

Table 4.7

Mean, median, SD, and IQR of Telugu males and females.

	Females				Males			
	Mean	Median	SD	IQR	Mean	Median	SD	IQR
Oral words	28.47	27.58	7.21	10.33	22.19	21.83	2.79	5.21
Oral Sentences	21.83	21.9	2.23	3.90	21.30	21.8	5.99	10.65
Nasal Sentences	65.23	66.10	5.67	10.90	61.47	62.10	4.25	6.55

Table 4.8

Mann-Whitney U test results for comparing nasalance scores across genders in Native Telugu Speakers.

	/Z/ value	p-value
Mean Oral Word	1.76	0.07
Mean Oral Sentences	.24	0.2
Mean Nasal Sentences	1.28	0.81

Table 4.7 shows the descriptive for male and female Telugu speakers. Results indicated mean nasalance value is higher for females than males across all three stimuli, i.e., oral words, oral sentences, and nasal sentences. Mann-Whitney U test was conducted to find the significant difference across the genders. Table 4.8 shows no significant difference in nasalance (p > 0.05) for words and sentences in Telugu

speakers for Kannada stimulus.

Table 4.9

Mean, median, SD, and IQR of Tamil males and females.

	Females				**Males**			
	Mean	Median	SD	IQR	Mean	Median	SD	IQR
Oral words	23.19	21.58	4.34	8.42	21.83	21.75	2.56	5.13
Oral Sentences	23.50	21.80	6.14	11.15	19.00	19.10	3.92	7.25
Nasal Sentences	61.37	63.30	4.85	8.40	58.53	58.50	2.42	4.55

Table 4.10

Mann-Whitney U test results for comparing nasalance scores across genders in Native Tamil Speakers.

	/Z/ value	***p*-value**
Mean Oral Word	0.402	0.69
Mean Oral Sentences	1.20	0.23
Mean Nasal Sentences	1.44	0.15

Table 4.10 represents the descriptive analysis of male and female Tamil speakers. Results found that the mean nasalance score is higher for females than for males across all three stimuli, i.e., oral words and oral and nasal sentences. Mann-Whitney U test was carried out to find the significant difference across the genders. Table 4.11 shows no significant difference in nasalance ($p > 0.05$) for oral words and nasal sentences in

Tamil speakers while repeating Kannada stimuli.

Thus, in the present objective, all three-language groups were compared for the effect of gender on nasalance. In all the groups, the mean nasalance scores were higher for females than males. However, it was found that there was no statistically significant difference between the two genders for nasalance.

CHAPTER V

DISCUSSION

The present study compared the nasalance between native and non-native Kannada speakers. A total of 36 participants were considered for the study and were categorized into three groups: Group 1 comprised native Kannada speakers, while Groups 2 and 3 included non-native Kannada speakers, specifically native speakers of Telugu and Tamil, respectively. Each group had an equal number of males and females. The participants were asked to repeat oral words, oral sentences, and nasal sentences in Kannada. The stimuli were recorded using Nasometer II (Model 6450).

The first objective of the study was to compare the nasalance between native and non-native Kannada speakers. A comparison of the mean nasalance scores of all three language groups across the three stimuli showed a marginal difference in Multivariate analysis of Variance (MANOVA). Further, univariate analysis and Post-hoc Tuckey's HSD test results revealed a significant difference only between native Kannada and Telugu speakers for oral words and nasal sentences ($p< 0.05$). However, there were differences in the mean nasalance scores between the native and non-native language groups.

The findings of the study supplement the concept of the influence of native language on the nasalance of non-native languages. The difference in the nasalance scores of native and non-native languages has been studied earlier, and it is identified that the native language influences the nasalance scores of the non-native language. For instance, Malayalam speakers exhibit higher nasalance values than Kannada speakers across various stimuli, indicating an influence of native language on nasalance values in second or third languages (Girish et al., 2021; Preethy et al., 2018). The differences in the mean nasalance scores can be attributed to the phonemic characteristics inherent to the languages (Girish et al., 2021). The number of nasal consonants present in the language and the frequency of these consonants can be a few of the reasons for the mentioned differences (Philip et al,2009)

Firstly, on comparing Telugu and Kannada languages, the Telugu language has three nasal consonants,/m/,/n/, and/ṇ/; among these, the nasal sound /n/ has four allophones, including /n̪/,/n/,/ñ/, /ŋ/. So, the six nasal continuants in Telugu includes bilabial /m/, dental /n̪/, alveolar /n/, retroflex /ṇ/, palatal /ñ/ and velar / ŋ / (Sastry,1972; Lakshmi.2011). In contrast, Kannada has five nasals consonants : bilabial /m/, dental /n/, retroflex /ɳ/, palatal / ɲ /, and velar /ŋ/ (Deepthi & Pushpavathi, 2017). Out of these 5 nasal consonants, only 3 are commonly used (Girish et al., 2021). So, there are more nasal occurrences in Telugu than in Kannada. This can be one of the contributing factors for the increased nasalance scores in Telugu speakers. However, the frequency of these nasal sounds occurring in the language can differ.

The frequency of occurrence of nasals in Kannada is 7.58% (Ramakrishna et al., 1962), and one of the more recent studies shows it to be 10.95% (Sreedevi et al., 2012). In Telugu, the frequency of nasals is 10.15% (Ramakrishna et al., 1962). Further recent investigations on the frequency of nasal consonants in Telugu are needed to confirm the impact of the frequency of occurrence of nasals on the nasalance score of the respective language.

The nasalance scores are also influenced by other linguistic factors, such as the type of the vowel (Lewis et al., 2000). High front vowel /i/ is identified to have more nasalance than any other vowels (Stevens & House, 1961; Ha & Cho, 2015; Meshram & Pushpavathi, 2012; Lewis et al., 2000; Awan et al., 2011). This pattern is observed in both individuals with velopharyngeal dysfunction and those without communication disorders (Lewis et al., 2000). Higher nasalance scores of high vowels may be attributed to the acoustic properties of these vowels, which typically exhibit lower oral intensity and higher nasal intensity than low vowels. As a result, high vowels generate a more significant proportion of nasal acoustic energy, leading to elevated nasalance (Stevens & House, 1961). These differences may be attributed to increased oral impedance and reduced radiated oral sound pressure for high vowels (Awan et al., 2011). The physiological explanation for higher nasalance is that the strong effect of the horizontal position of the tongue during the production of nasal sounds and the production of high vowels requires maintaining the velum in a high position to achieve tight velopharyngeal closure (Kendrick, 2004). Dialect, accents, or languages that use high vowels or high tongue positions might have increased nasalance scores than other languages (Philip et al.,2009)

On comparing the frequency of occurrence of the high front vowel (/i/) in Kannada and Telugu, it is seen that the frequency of occurrence of the high vowel (/i/) in Telugu is 7.23% (Ramakrishna et al., 1962). In Kannada, it is 7.08% (Sreedevi et al., 2012). Even though /i/ is one of the most frequently occurring vowels in Kannada there is a difference in the frequency of its usage between the two languages; though marginal, these differences can be one of the contributing reasons for the differences in the nasalance scores.

The current study shows a significant difference in the mean score of nasalance for oral words and nasal sentences between native Kannada speakers and Non-native Kannada speakers, i.e., Telugu speakers (Group 2). Even though the mean nasalance scores were higher for Telugu speakers in oral sentences, there was no statistically significant difference; this can be due to the diversity in stimulus used.

Secondly, comparing the nasalance scores between native Kannada and Group

3 Non-native Kannada speakers i.e., Tamil speakers showed no statistically significant difference between the two groups across the three stimuli. However, the mean nasalance scores were higher for native Tamil speakers than for Kannada speakers. The differences in the mean nasalance scores of the two groups can be attributed to the phonemic characteristics inherent to the languages. The Tamil language also features nasalized vowels (Balasubramanian, 1980). So, the increased nasalance in Tamil speakers can be attributed to the extensive use of nasal consonants and the presence of nasalized vowels, which is less prevalent in Kannada.

As discussed earlier, the number of nasal sounds and the frequency of their occurrence in each language may play a significant role in these variations (Philip et al,.2019). Tamil is one of the oldest languages of the Dravidian family, with six nasal consonants. Tamil distinguishes six nasal consonants as bilabial /m/, dental /n̪/, alveolar /n/, retroflex /ɳ/, palatal /ɲ/, and velar /ŋ/ (Murthy et al., 2010). Kannada has five nasal consonants, of which only four are commonly used: bilabial /m/, dental /n/, retroflex /ɳ/, palatal /ɲ/, and velar /ŋ/ (Deepthi & Pushpavathi, 2017), out of which only 3 are commonly used (Girish et al.,2021). So, the number of nasal consonants is higher in Tamil than in Kannada, which might have been one of the reasons for the increased nasalance scores of native Tamil speakers compared to native Kannada speakers.

The frequency of nasal consonants in each of the languages also varies. The frequency of usage of different sounds has been studied (Ramakrishna et al., 1962), and considering this, the frequency of nasal consonants in Kannada is around 7.58%, and that of Tamil is 14.42%. The frequency of phonemes in Kannada was later studied (Sreedevi et al.,2012), and the frequency of nasal consonants was identified as 10.95%. In comparison, the frequency is seen more in the Native Tamil language. Hence, the increased frequency of occurrence of the nasal sounds in Tamil might have acted as one of the factors for the increased nasalance scores.

Thirdly, comparing mean nasalance scores between two non-native Kannada speakers, i.e., Native Tamil and Native Telugu, the results revealed that based on post hoc Tukey's pairwise comparison there was no significant difference in mean nasalance scores between native Telugu and native Tamil speakers across any of the stimulus. However, the native Telugu speakers had higher mean nasalance scores across stimuli.

Researchers have opined that nasalance scores are affected by the speaker's rate of speech (Whitney, 2014; Gauster et al., 2010). Some studies found slower speech rates associated with increased nasality and nasal airflow (Goberman et al., 2001). Dwyer et al. (2009) reported that increasing speaking rates in hearing-impaired individuals led to decreased perceived nasality. Brancewicz and Reich (1989) found only small, albeit statistically significant, effects of speech rate on perceived nasality, with poor correlation to objective measures.

The rate of speech in the Telugu language is 133 WPM (Words Per Minute) and 8 SS (Syllables per Second). In comparison, the rate of speech parameters for the Tamil language includes 136 WPM (Words Per Minute) and 65 SS (Syllables per Second) (Savithri & Jayaram, 2004). On average, the rate of speech of Native Tamil speakers stands higher than that of Telugu speakers. Some of the studies have stated that nasalance is seen to increase with a decreased rate of speech (Brancewicz & Reich, 1989; Whiney, 2014). More recently, Goberman, Selby, and Gilbert (2001) have observed that producing speech at a slower pace in individuals with normal hearing can make the velum contact with the posterior pharyngeal wall inadequate. This insufficient contact allows air to flow through the nasal cavity, resulting in increased nasalization during slowed speech, as Brancewicz & Reich (1989) noted. So, the increased nasalance scores obtained for the native Telugu speakers compared to native Tamil speakers can be attributed to the decreased rate of speech of the Native Telugu speakers compared to the Native Tamil speakers.

The differences in the nasalance scores across the language groups can also be due to the geographical distances separating them (Seaver et al., 1991; Awan et al., 2015). Studies in North America found that speakers from the Texas South dialect region exhibited higher nasalance scores compared to other regions, with dialect accounting for 7-9% of nasalance variation (Awan et al., 2015; Bae et al., 2020).

However, the present study could not obtain a statistically significant difference between the mean nasalance scores between Native Kannada and Native Tamil speakers and between Native Tamil and Telugu groups. This can be because of the limited sample size considered for the study.

The second objective was to identify the effect of gender on nasalance. The comparison was done within all the language groups (Both Native and Non-native Kannada speakers). Based on the Mann-Whitney U test, there was no significant difference ($p > 0.05$) in the mean nasalance scores for any of the groups.

The findings of the current study are in agreement with several other studies that compared the mean nasalance scores across genders, which showed no statistically significant differences (Sweeney et al., 2004; Van Doorn & Purcell, 1998; Tachimura et al., 2000; Whitehill, 2001; Okalidou et al., 2011; D''haeseleer et al., 2015; Inostroza-Allende et al., 2022). On the contrary, there are some gender-based studies where the nasalance scores of women were higher than those of men (Van Lierde et al., 2001; Jayakumar,2005 ; Mahesh & Pushpavathi,2008; Mishima et al.,2008; Kuppusamy et al.,2013). Previous research has also indicated gender-related differences in various aspects of velopharyngeal function during speech production (Hoit et al., 1994; Seaver et al., 1991; Thompson & Hixon, 1979; Zajac et al., 1996).

Gender-related differences in the nasalance scores can be attributed to the anatomical and physiological variations in velopharyngeal closure between the genders (Seaver et al., 1991). The resonance of voice is affected by the shape, size, and surface of supraglottal resonating structures and cavities (Mahesh & Pushpavathi, 2008). Two subject variables that could be associated with increased nasal flow rate in female speakers are increased respiratory effort and a larger nasal cross-sectional area. Since females typically have a longer nasal cross-sectional area than males, such differences could be observed (Liu, 1990). This might also be because of the interaction between formant frequencies, fundamental frequency, and acoustic filter of the Nasometer. (Alfwaress et al., 2021).

Along similar lines, the present study also showed that the mean nasalance of females was higher than that of males in all three language groups across all three stimuli. However, the result did not yield a statistical significance. This can be due to individual variability and the limited sample size that was considered for the study.

Nevertheless, the collective results of earlier research have only produced inconclusive findings. (Fletcher, 1978; Hutchinson et al., 1978; Seaver et al., 1991; Litzaw & Dalston, 1992; Kavanagh et al., 1994; Vallino-Napoli & Montgomery, 1997; Whitehill, 2001). Future research should examine nasalance variations during speech onsets and offsets, which could be related to respiratory effort, speaking style, or both.

.

CHAPTER VI

SUMMARY AND CONCLUSION

Nasalance is an aspect of speech quality produced by nasal resonators that can be employed in evaluating and addressing resonance disorders. Nasality is a common characteristic in individuals with both repaired and unrepaired CLP, significantly affecting speech intelligibility. The assessment of nasality can be done subjectively and objectively. However, the perceptual assessment of nasality is combined with instrumental evaluation to best identify nasalance scores. Several instruments, including an accelerometer, nasometer, nasal view and oro nasal system, have been used to assess nasality. Nasometry is presently considered the gold standard for measuring nasalance because of its consistent and reliable results.

The normative for nasalance has been developed in many Indian languages, including Kannada, Malayalam, Hindi, and Manipuri (Kuppusamy et al., 2013; Meshram & Pushpavathi, 2012; Jayakumar & Pushpavathi, 2005; Kadisonga & Jayakumar, 2016). Previous literature has shown that the nasalance values depend upon several factors, including the phonetic composition of the speech stimuli used in assessment, native language, regional dialect, age, and gender. Considering these factors that influence the nasalance, it is crucial to know the impact of the nasalance of the native language on the non-native language.

The present study aimed to measure the influence of native language nasalance on non-native language with the following objectives:

1. To compare the nasalance between native and non-native Kannada speakers and among the non-native Kannada speakers for words (Oral words) and sentences (Oral and Nasal sentences).

- Native Kannada Vs Telugu Speakers
- Native Kannada Vs Tamil Speakers
- Native Tamil Vs Telugu Speakers

2. To compare the gender effect on nasalance within native and non-native Kannada speakers.

The present study consisted of a total of 36 participants who were divided into 3 groups based on their native language. Group 1 is native Kannada speakers, and groups 2 and 3 are non-native Kannada speakers (native Telugu and Tamil speakers). Each of the groups had an equal number of male and female participants. An SLP evaluated each subject to assess oral structure and function. Speech and language abilities were informally assessed based on the conversational task. The stimuli included 6 oral words, 5 oral sentences, and 5 nasal sentences. The participants were made to repeat the stimuli after the clinician. Nasometer II (Model 6450) was used for the recording. The recordings were analyzed and the nasalance scores were obtained for each of the stimuli.

The descriptive and inferential statistics were carried out for each of the objectives. The normality of the data was assessed using Shapiro-Wilk's test. The data followed a normal distribution and so a parametric test was conducted. Multivariate Analysis of Variance (MANOVA) was used to compare the nasality between native and non-native Kannada speakers. A non-parametric test, i.e., Mann Whitney U test, was conducted to compare the effect of gender on nasality, considering the reduced sample size.

The findings of the present study are as follows:

- The comparison of the nasalance scores between the native and non-native Kannada speakers was highlighted in the study.

- The influence of the native language on the non-native language was seen in the overall mean nasalance scores.
- The initial comparison showed that the native Telugu speakers had more mean nasalance scores than native Kannada speakers across all three stimuli (oral words, oral and nasal sentences). However, the statistically significant differences were noted only for oral words and nasal sentences.
- The native Tamil speakers had higher mean nasalance scores across all the stimuli than native Kannada speakers. However, the differences were not statistically significant.
- On comparison of nasalance scores between two non-native Kannada speakers revealed that the mean nasalance scores were higher for native Telugu speakers than native Tamil speakers, but the result was not statistically significant.
- Finally, on comparing the influence of gender on nasalance scores, a significant gender effect was not seen within the native and non-native Kannada groups. However, the mean nasalance scores were higher for Females than Males.

In the Indian context, most of the population is bilingual/multilingual. This study has identified an impact of the native language on the non-native language. Therefore, in the case of multilingualism, the stimuli used to assess nasalance must include both the native language and the non-native language. This holistic approach provides a comprehensive understanding of nasalance on overall speech intelligibility. The findings can guide the development of targeted assessment protocols and intervention plans and enhance speech intelligibility in children and adults with repaired cleft lip and palate.

IMPLICATIONS OF THE STUDY

Implications from the present study are as follows:

- Establishing baseline nasalance values for bilingual/multilingual individuals in native and non-native languages can help diagnose resonance disorders more accurately when the assessment is done in the non-native language. This can be particularly useful in differentiating between a pathological condition and normal variations due to bilingualism.
- By addressing the nasalance issues in both languages, clinicians can adopt a more holistic approach, which can significantly improve the overall speech intelligibility of bilingual individuals. This is particularly important for children with repaired cleft lip and palate (CLP) or other resonance disorders, as improving intelligibility in both languages can enhance their communication abilities and social integration.
- Incorporating the information on the native language during assessment protocols will lead to more accurate diagnosis and effective intervention strategies. For instance, clinicians can use tailor-made stimuli including the specific phonetic and phonological features of a client's native language in the evaluation process to better assess the nasalance scores.

LIMITATIONS

- The sample size of the participants could be expanded
- In conducting comparative analyses, it is essential to account for dialect and language proficiency variations.
- Furthermore, the existing literature lacks sufficient studies conducted in Tamil and Telugu languages, thereby limiting comprehensive insights into the current research findings

FUTURE DIRECTIONS

- The study is an initial step, and there is a need to develop normative data for different linguistic and dialectal populations in India.
- The normative nasalance for non-native speakers can be established.
- The study can be replicated on a larger sample size, including men and women across different age groups.
- Findings need to be compared with clinical data.
- It is essential to consider perceptual evaluation along with objective method.
- In advanced research nasalance studies can assist forensic linguists in speaker identification and profiling, as nasal sounds may serve as distinctive features in a speaker's voice.

REFERENCES

Alfwaress, F., Kummer, A. W., & Weinrich, B. (2021). Nasalance scores for normal speakers of American English obtained by the Nasometer II using the MacKay-Kummer SNAP-R test. *The Cleft Palate-craniofacial Journal*, *59*(6), 765–773. https://doi.org/10.1177/10556656211025406

Anderson, R. T. (1996). Nasometric Values for Normal Spanish-Speaking Females: a preliminary report. *The Cleft Palate-craniofacial Journal*, *33*(4), 333–336. https://doi.org/10.1597/1545-1569_1996_033_0333_nvfnss_2.3.co_2

Arya, P., & Pushpavathi, M. (2009) Normative value in Hindi language. Unpublished dissertation. *All India Institute of Speech and Hearing, University of Mysore.*

Awan, S. N., Bressmann, T., Poburka, B., Roy, N., Sharp, H., & Watts, C. (2015). Dialectical Effects on nasalance: a multicenter, Cross-Continental study. *Journal of Speech, Language, and Hearing Research*, *58*(1), 69–77. https://doi.org/10.1044/2014_jslhr-s-14-0077

Bae, Y., Lee, S. a. S., Velik, K., Liu, Y., Beck, C., & Fox, R. A. (2020). Differences in nasalance and nasality perception between Texas South and Midland dialects. T*he Journal of the Acoustical Society of America*, *147*(1), 568–578. https://doi.org/10.1121/10.0000543

Bakshi, A., & Sunil Kumar Kopparapu. (2018). Spoken Indian language identification: A review of features and databases. *Sādhanā,* *43*(53). https://doi.org/10.1007/s12046-018-0841-y

Balasubramanian, T. (1980). Nasalisation of vowels in colloquial Tamil. *Journal of Phonetics*, *8*(3), 361–373. https://doi.org/10.1016/s0095-4470(19)31486-x

Bhaskararao, P., Speech & Vision Laboratory, LTRC, IIIT, Hyderabad, India, Ray, A., Department of Linguistics, University of Calcutta, & Speech & Vision Laboratory, LTRC, IIIT, Hyderabad, India. (2017). Illustrations of the IPA. *Journal of the International Phonetic Association*, 232–233. https://doi.org/10.1017/S0025100316000207

Brancewicz, T. M., & Reich, A. R. (1989). Speech rate reduction and "Nasality" in normal speakers. *Journal of Speech, Language, and Hearing Research*, *32*(4), 837–848. https://doi.org/10.1044/jshr.3204.837

Bressmann, T. (2005). Comparison of nasalance scores obtained with the nasometer, the nasal view, and the Oro Nasal System. *Cleft Palate Craniofacial Journal, 42*(4), 423-433.

Chatterjee, I., Bhatt, S. S., Kumari, K., Raj, D., & Saxena, V. (2020). Influence of Khasi language on nasal and oral passages in English: a nasometric study. *Bengal Journal of Otolaryngology and Head Neck Surgery*, *28*(1), 17–22. https://doi.org/10.47210/bjohns.2020.v28i1.22

Dalston, R. M., & Warren, D. W. (1986). Comparison of TONAR II, pressure flow, and listener judgments of hypernasality in the assessment of velopharyngeal function. *Cleft Palate Craniofacial Journal*, *23*(2), 108-115.

Dalston, R., Warren, D. W., & Dalston, E. (1991). Use of nasometry as a diagnostic tool for identifying patients with velopharyngeal impairment. *Cleft Palate-Craniofacial Journal*, *28*(2), 184–188.

D''haeseleer, E., Bettens, K., De Mets, S., De Moor, V., & Van Lierde, K. (2015). Normative data and dialectical effects on nasalance in Flemish adults. *Folia Phoniatrica Et Logopaedica*, *67*(1), 42–48. https://doi.org/10.1159/000374110

Deepthi, K.J.,& Pushpavathi, M.(2017) An Overview of Vowel and Consonant Production by Four Kannada Speaking Preschool Children with Repaired Cleft Lip and Palate. *Global Journal of Otolaryngology*, *9*(3). https://doi.org/10.19080/gjo.2017.09.555765

Devi, T. R., & Pushpavathi, M. (2009). Normative nasalance value in Malayalam language. *Student Research at AIISH, Mysore, 7,* 67-82.

Dwyer, C. H., Robb, M. P., O'Beirne, G. A., & Gilbert, H. R. (2009). The influence of speaking rate on nasality in the speech of Hearing-Impaired Individuals. *Journal of Speech, Language, and Hearing Research*, *52*(5), 1321–1333. https://doi.org/10.1044/1092-4388(2009/08-0035

Fletcher, S. G., Sooudi, I., & Frost, S. D. (1974). Quantitative and graphic analysis of prosthetic treatment for "nasalance" in speech. T*he Journal of Prosthetic Dentistry/the Journal of Prosthetic Dentistry*, *32*(3), 284–291. https://doi.org/10.1016/0022-3913(74)90032-8

Fletcher, S. G. (1978). *Diagnosing speech disorder from the cleft palate*. Grune & Stratton.

Gauster, A., Yunusova, Y., & Zajac, D. (2010). The effect of speaking rate on velopharyngeal function in healthy speakers. *Clinical Linguistics and Phonetics,* 24(7), 576-588.

Girish, K., Pushpavathi, M., & Satish, H. (2021). Influence of native language on Nasalance values in Kannada and Malayalam speakers. *Journal of Cleft Lip Palate and Craniofacial Anomalies*, *8*(2), 111. https://doi.org/10.4103/jclpca.jclpca_33_20

Goberman, A. M., Selby, J. C., & Gilbert, H. R. (2001). The effects of changes in speaking rate on nasal airflow and the perception of nasality. *Folia Phoniatrica et Logopaedica, 53*(4), 222–230. https://doi.org/10.1159/000052257

Ha, S., & Cho, S. (2015). Nasalance scores for normal Korean-speaking adults and children: Effects of age, vowel context, and stimulus length. *International Journal of Pediatric Otorhinolaryngology, 79*(8), 1235–1239. https://doi.org/10.1016/j.ijporl.2015.05.019

Haapanen, M. L. (1991). Nasalance score in normal Finnish speech. *Folia Phoniatrica*, *43, 197-203.*

Hardin, M. A., Van Demark, D. R., Morris, H. L., & Payne, M. M. (1992). Correspondence between nasalance score and listener judgments of hypernasality. *Cleft Palate Craniofacial Journal, 29*(4), 349-351.

Hirschberg, J., Bók, S., Juhász, M., Trenovszki, Z., Votisky, P., & Hirschberg, A. (2006). Adaptation of nasometry to the Hungarian language and experiences with its clinical application. *International Journal of Pediatric Otorhinolaryngology*,*70*(5),785–798. https://doi.org/10.1016/j.ijporl.2005.09.017

Hoit, J. D., Watson, P. J., Hixon, K. E., McMahon, P., & Johnson, C. L. (1994). Age and Velopharyngeal Function During Speech Production. *Journal of Speech, Language, and Hearing Research*, *37*(2), 295–302. https://doi.org/10.1044/jshr.3702.295

Hutchinson, J. M., Robinson, K. L., & Nerbonne, M. A. (1978). Patterns of nasalance in a sample of gerontologic subjects. *Journal of Communication Disorders, 11*(6), 469–481. https://doi.org/10.1016/0021-9924(78)90015-2

Inostroza-Allende, F., Palomares-Aguilera, M., Jara, M. G., Gaponov, C. Q., Villarroel, C. G., & Pegoraro-Krook, M. I. (2022). Normative nasalance scores in Chilean adults. *CoDAS*, *34*(6). https://doi.org/10.1590/2317-1782/20212021152

Jayakumar, T., & Pushpavathi, M. (2005) Normative value for Nasometer in Kannada. Master's Thesis. *All India Institute of Speech and Hearing, University of Mysore.*

Kadisonga, P., & Jayakumar, T. (2016) Norms for nasalance scores of adult Manipuri speakers. Master's Thesis. *All India Institute of Speech and Hearing, University of Mysore.*

Kavanagh, M., Fee, E., Kalinowski, J., Doyle, P., & Leeper, H.(1994). Nasometric values for three dialectal groups within the Atlantic provinces of Canada. *Journal of Speech-language pathology and Audiology, 18,* 7–13

Kendrick KR. Louisiana State University Nasalance Protocol Standardization. [Master's Thesis]. Louisiana: Louisiana State University and Agricultural and Mechanical College; 2004

Kummer, A. W. (2008). *Cleft palate and craniofacial anomalies: Effects on speech and resonance* (2nd ed.). Delmar Cengage Learning.

Kuppusamy, G., Ramaswamy, G & Mariswamy, P.(2013). Normative nasalance values across stimuli and gender in Malayalam-speaking individuals. *Otolaryngology Online Journal*, 3(4).

Kuriakose, T., Varghese, S. A., & KN, M. (2022). Comparison of Nasalance between Goan Konkani and Karwar Konkani Speakers. *International Journal of Speech and Audiology*, 5–7. https://www.rehabilitationjournals.com

Leeper, H. A., Rochet, A. P., & MacKay, I. R. A. (1992). Characteristics of nasalance in Canadian speakers of English and French. *International Conferences on Spoken Language Processing* (Abstract), Banff, Alberta, October, 49-52.

Lewis, K. E., Watterson, T., & Quint, T. (2000). The effect of vowels on Nasalance scores. T*he Cleft Palate-craniofacial Journal*, *37*(6), 584–589. https://doi.org/10.1597/1545-1569(2000)037

Litzaw, L. L., & Dalston, R. M. (1992). The effect of gender upon nasalance scores among normal adult speakers. *Journal of Communication Disorders*, *25*(1), 55–64. https://doi.org/10.1016/0021-9924(92)90014-n

Liu, Y., & Lee, S. a. S. (2020). English Nasalance Values of Chinese learners of English. *Folia Phoniatrica Et Logopaedica*, *73*(5), 422–431. https://doi.org/10.1159/000510940

Mallikarjun, M. (2010). Patterns of Indian multilingualism. *Language India*, *10,* 1-18.

Mahesh, S., & M., P. (2008). Nasalance Value for Rainbow Passage: Normative Data for Non-Native Speakers. In *JAIISH: Vol. Vol. 27*.

Mayo, C.M. and Mayo, R. (2011). Normative nasalance values across languages. *ECHO,* 6(1), 22-32.

McKerns, D., & Bzoch, K. R. (1970). Variations in velopharyngeal valving: The factor of sex. *Cleft Palate Journal, 7*(4), 652-662.

Mishima, K., Sugii, A., Yamada, T., Imura, H., & Sugahara, T. (2008). Dialectal and gender differences in nasalance scores in a Japanese population. *Journal of Cranio-Maxillo-Facial Surgery*, *36*(1), 8–10.

Murthy, J., Sendhilnathan, S., & Hussain, S. A. (2010). Speech Outcome following Late Primary Palate Repair. T*he Cleft Palate-craniofacial Journal*, *47*(2), 156–161. https://doi.org/10.1597/08-230_1

Nandurkar, A. (2002). Nasalance measures in Marathi consonant-vowel-consonant syllables with pressure consonants produced by children with and without cleft lip and palate. *Cleft Palate-Craniofacial Journal, 39*(1), 59-65.

Nichols, A.C. (1999). Nasalance statistics for two Mexican population. *Cleft Palate Craniofacial Journal*, *36, 57-63.*

Meshram, N. R., & Pushpavathi. (2012) Normative Nasalance in Hindi language. Master's Thesis. *All India Institute of Speech and Hearing, University of Mysore.*

Okalidou, A., Karathanasi, A., & Grigoraki, E. (2011). Nasalance norms in Greek adults. *Clinical Linguistics & Phonetics*, *25*(8), 671–688. https://doi.org/10.3109/02699206.2010.549993

Oliveira, D. N., Sampaio Teixeira, A. C., Alvarenga, B. G., Fukushiro, A. P., Yamashita, R. P., & Trindade, I. E. (2017). Nasalance scores of Brazilian Portuguese speakers at 5 years of age. *Codas, 29*(e20160197). https://doi.org/10.1590/2317-1782/20172016197

Pokharel, A., Naina, P., Sebastain, S., Syed, K. A., John, M., & Varghese, A. M. (2020). Normative nasalance scores in Tamil-speaking Indian children. *Logopedics, Phoniatrics, Vocology, 47*(1), 43–48. https://doi.org/10.1080/14015439.2020.1849391

Pua, E., Holt, Y., Kollara, L., Rangarathnam, B., Fang, X., & Perry, J. L. (2018). Evaluating nasalance values among bilingual Mandarin–English speakers. *The Cleft Palate-craniofacial Journal, 56*(4), 462–470. https://doi.org/10.1177/1055665618791942

Prasad, S. D., & Kanduri, Y. (2016). Telugu handwritten character recognition using adaptive and static zoning methods. *IEEE*. https://doi.org/10.1109/techsym.2016.7872700

Preethy, S. R., Johnson, P., & Veeramani, P. (2018). Comparison of nasalance scores in non-native English speakers. *Asia Pacific Journal of Research*, *1*(88), May 2018.

Philip, L., Pushpavathi, M., & Mahesh, S. (2009). Influence of native language influence on Nasalance measurement. *Journal of All India Institute of Speech and Hearing (JAIISH)*, 28.

Ramakrishna, B. S., Nair, K. K., Chiplunkar, V. N., Atal, B. S., Ramachandra, V., & Subramanian, R. (1962). Some statistics of Indian languages. In *Some aspects of the relative efficiencies of Indian languages* (pp. 12–17). Catholic Press.

Ravindra, D.T., & Pushpavathi, M. (2009) Normative value in Malayalam language. Student research at *All India Institute of Speech and Hearing, University of Mysore.*

Reddy, M. S., Sheela, S., & Pebbili, G. K. (2012). Comparison of nasalance values obtained from nasality visualization system and Nasometer II. *JAIISH, 31*, 1.

Reshma, O., & Jayakumar, T. (2020) Relationship between nasalance and Acoustic Voice Quality Index (AVQI). Master's Thesis. *All India Institute of Speech and Hearing, University of Mysore.*

Sastry, J. V. (1972). *Telugu phonetic reader*. Central Institute of Indian Languages.

Savithri, S. R. (2004). Rate of Speech/Reading in Dravidian languages. *AIISH Research Fund Project*.

Seaver, E. J., Dalston, R. M., Leeper, H. A., and Adams, L. E. (1991). "A study of nasometric values for normal nasal resonance," J. Speech Lang. Hear. Res. 34, 715–722.

Shprintzen, R. J., & Bardach, J. (1995). *Cleft Palate Speech Management: A Multidisciplinary approach*. https://ci.nii.ac.jp/ncid/BA2767290X

Sreedevi, N., Nair, S.K., & Vikas, M. D. (2012). Frequency of occurrence of phonemes in Kannada: A preliminary study. *Journal of All India Institute of Speech and Hearing (JAIISH)*, 31.

Stein, B. (1977). Circulation and the historical geography of Tamil country. T*he Journal of Asian Studies*, *37*(1), 7–26. https://doi.org/10.2307/2053325

Stevens, K. N., & House, A. S. (1961). An Acoustical Theory of Vowel Production and Some of its Implications. *Journal of Speech and Hearing Research*, *4*(4), 303–320. https://doi.org/10.1044/jshr.0404.303

Sweeney, T., Sell, D., & O'Regan, M. (2004). Nasalance scores for Normal-Speaking Irish children. T*he Cleft Palate-craniofacial Journal*, *41*(2), 168–174. https://doi.org/10.1597/02-094

Tachimura, T., Mori, C., Hirata, S., & Wada, T. (2000). Nasalance score variation in normal adult Japanese speakers of Mid-West Japanese dialect. T*he Cleft Palate-craniofacial Journal*, *37*(5), 463–467. https://doi.org/10.1597/1545-1569(2000)037

Thompson, A. E., & Hixon, T. J. (1979). Nasal airflow during normal speech production. *Cleft Palate Journal*, *16*(4), 412-420.

Van Doorn, J., & Purcell, A. (1998). Nasalance levels in the speech of normal Australian children. T*he Cleft Palate-craniofacial Journal*, *35*(4), 287–292. https://doi.org/10.1597/1545-1569_1998_035_0287_nlitso_2.3.co_2

Vallino-Napoli, L. D., & Montgomery, A. A. (1997). Examination of the Standard Deviation of Mean Nasalance Scores in Subjects with Cleft Palate: Implications for Clinical Use. *The Cleft Palate-craniofacial Journal*, *34*(6), 512–519. https://doi.org/10.1597/1545-1569_1997_034_0512_eotsdo_2.3.co_2

Van Lierde, K. M., Wuyts, F. L., De Bodt, M., & Van Cauwenberge, P. (2001). Nasometric values for normal nasal resonance in the speech of young Flemish adults. T*he Cleft Palate-craniofacial Journal*, *38*(2), 112–118. https://doi.org/10.1597/1545-1569(2001)038

Van Lierde, K. M., Van Borsel, J., Cardinael, A., Reeckmans, S., & Bonte, K. (2010). The impact of vocal intensity and pitch modulation on nasalance scores: a pilot study. *Folia Phoniatrica Et Logopaedica*, *63*(1), 21–26. https://doi.org/10.1159/000319733

Watterson, T., Hinton, J., & McFarlane, S. (1996). Novel stimuli for obtaining nasalance measures from young children. *The Cleft Palate-Craniofacial Journal*,*33*(1),67–73.https://doi.org/10.1597/1545 1569_1996_033_0067_nsfonm_2.3.co_2

Whitehill, T. L. (2001). Nasalance measures in Cantonese-speaking women. *The Cleft Palate-craniofacial Journal*, *38*(2), 119–125. https://doi.org/10.1597/1545-1569(2001)038

Whitney, Rachel, "The Relationship between Speaking Rate and Nasalance in Typical Adult Speakers" (2014). Master's Theses. 484.

Zajac, D. J., Lutz, R., & Mayo, R. (1996). Microphone sensitivity as a source of variation in Nasalance scores. *Journal of Speech, Language, and Hearing Research*, *39*(6), 1228–1231. https://doi.org/10.1044/jshr.3906.1228

APPENDIX-1

Oral Words

1. /ka:ge/
2. /t̪aʈʈe/
3. /kappe/
4. /ɖabbi/
5. /ʃarʈu/
6. /su:ʤi

Oral Sentences

1. /ka:ge ka:lu kappu/
2. /gi:t̪a be:ga ho:gu/
3. /appa paʈa t̪a/
4. /ba:lu t̪abala ba:risu/
5. /beɖa ka:ɖige oɖid̪a/

Nasal Sentences

1. /manu a:nejannu noɖid̪a/
2. /navi:na manejind̪a band̪anu/
3. /na:nu a:nejannu noɖid̪e/
4. /manga maneja me:lid̪e/
5. /ma:ma: mandʝad̪ind̪a band̪anu/