PERCEPTUAL ANALYSIS OF SPEECH IN INDIVIDUALS WITH REPAIRED CLEFT LIP AND PALATE: AN INSIGHT INTO FEW VARIABLES

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(Speech-Language Pathology)

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May 2019

CERTIFICATE

This is to certify that the dissertation entitled **"*Perceptual analysis of speech in individuals with repaired cleft lip and palate: An insight into few variables*"** is a bonafide work submitted in part fulfillment for degree of Master of Science (Speech Language Pathology) of the student Registration Number: 17SLP023. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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CERTIFICATE

This is to certify that the dissertation entitled **"*Perceptual analysis of speech in individuals with repaired cleft lip and palate: An insight into few variables*"** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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Declaration

This is to certify that the dissertation entitled **"*Perceptual analysis of speech in individuals with repaired cleft lip and palate: An insight into few variables*"** is the result of my own study under the guidance Professor M. Pushpavathi, Director, Department of Speech-Language Pathology, All India Institute of Speech and Hearing, Mysuru, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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CHAPTER I

INTRODUCTION

Cleft lip and palate (CLP) is the most common congenital birth defect forming malformation of the face and oral cavity that happens during pregnancy (Kummer, 2008). CLP exhibits various deviations and deficiencies, which results in impairment of the child's communication skills and inturn impair the child's ability to express verbally. In India, almost 40,000 children are born every year with CLP (Shrivatsav, 2013). Team of health professionals usually treats the individual with CLP. The speech-language pathologist is ultimately responsible for evaluating the speech and resonance characteristics of these children.

Speech analysis is crucial for individuals with CLP as it provides direction for the time and type of management. Speech analysis in individuals with CLP is done mainly using subjective, objective or using both subjective and objective methods. Objective procedures include acoustic measures, aerodynamic measures, and imaging techniques. However, the subjective method is considered as the gold standard. Perceptual speech evaluation is the foundation of the speech assessment. Based on the listener's perception ultimate decision is drawn about presence of nasalaity or other associated speech problems (Moll, 1964). Perceptual assessment should always be the initial method of all speech assessment procedures as there is no better instrument to assess speech than the human ear (Falzone, Jones & Kernell, 2006). This includes the use of low technology such as audio or video recordings and basic materials along with high-level skills of speech-language pathologists to evaluate and rate the severity of speech characteristics in individuals with cleft palate.

Perceptual evaluation of hypernasality is important assessment tool that the Speech Language Pathologist (SLP) will employ in clinical practice for assessing the resonance characteristics of the speech of individuals with cleft palate (Falzone, Jones & Kernell 2001). According to Kent (1996), auditory perceptual agreements are usually the ultimate arbitrator in clinical decision-making and sometimes offer the standards against those instrumental measures are compared.

Kent (1996) pointed numerous variables such as articulatory patterns, rate of speech, fluency, and phonological repertoire of speaker can influence the listener's perceptual agreement this limits the validation of perceptual evaluation. Fletcher et al. (1989 highlighted in their study about the interaction effect of phonetic context of the speech sample which influences the perceptual agreement of resonance measures.

The main variables influencing the perceptual agreement are the experience of judges, type of speech stimuli such as phonation, words, sentences, spontaneous speech, and the phonetic context of the respective language and length of utterances. Mode of presentation of the sample is also one of the variables as the stimuli can be presented either through audio mode or Audio-Visual (AV) mode. In the Audiovisual mode of presentation, facial appearances play a part in determining the severity of speech disorder. Apart from all these, the type of recording of the stimuli also plays a vital role. The environment of recording could be professional recording carried out with appropriate protocol in a sound-treated room or live recording in natural settings.

Apart from case history and oral mechanism examination perceptual evaluation of speech is a decisive factor to quantify in the diagnosis of velopharyngeal dysfunction (Kummer, Briggs & Lee, 2003). Through the perceptual evaluation of resonance measures diagnosis for the presence of hypernasality, nasal air emission, nasal turbulence, and compensatory articulation can be made. Many studies have highlighted the association between the perceived degree of nasality and size of the velopharyngeal gap and results have concluded that there are number of factors interacting like articulation, oral and pharyngeal dynamics variations, size of the nasal cavity, vocal pitch and loudness, respiratory effort , ratio of oral and nasal acoustic impedances (Baken & Orlikoff, 2000), the extent of time the valve is open (Dalston & Seaver, 1990; Warren, Dalston, & Mayo, 1993), and the speaker's articulatory compensations for the velopharyngeal opening (Watterson & Emanuel, 1981; Folkins, 1985).

Data collection plays a crucial role in perceptual speech assessment. The main goal is to obtain a speech sample considering the sound inventory of the language. It is essential to obtain samples of different context. (Peterson-Falzone et al., 2006) and for planning effective intervention intended for children with cleft palate. Over 50 years the variation of nasality differs based on other aspects of speech variables. Also, few studies have shown that many judges rated nasality as more severe on high vowels compared to low vowels in individuals with CLP. (Hess, 1959; Spriestersbach & Powers, 1959), and judgments of severity of nasality differs based on phonetic context and articulation expertise (McWilliams, 1954; Van Hattum, 1959). It is generally agreed that articulation incompetence is related to greater severity of nasality judgments.

Reliability of listener's ratings varied but was generally established satisfactory association between the variables (Moller & Starr, 1984). There is a current agreement that compilation of multiple listener severity ratings can be considered as single-listener judgments for severity ratings if the reliability is established. Several protocols have been developed to assess speech disorder in children with CLP. Many perceptual assessment protocols have been developed for evaluation of an individual with Velopharyngeal dysfunction, and among them, Henningson's protocol, (2008) is the most widely accepted one.

Need for the study

There are limited numbers of Indian studies related to the listener's perception of speech in individuals with CLP in different modalities of stimulus presentation. There is a need to evaluate the perceptual agreement of inconsistencies among trained and untrained listeners. Also, there is a dearth of studies that compare and contrast the variability of severity with variation in speech stimuli used for analysis. These aspects necessitate the need for the present study in assessing the listener's judgment of speech in individuals with cleft palate across different conditions, stimulus, and experience of the judges. Thus the current study was aimed to investigate the effect of mode of stimulus presentation and length of stimuli in perceptual judgment among trained and untrained listeners in the speech of individuals with cleft palate.

Objectives of the study

1. To study the variability in perceptual evaluation ratings across different mode of stimulus presentations.
2. To compare the perceptual evaluation ratings of trained and untrained judges to determine the influence of the experience and training on evaluating the speech of repaired CLP.
3. To investigate the difference in perceptual analysis of speech across the type of stimuli.

CHAPTER II

REVIEW OF LITERATURE

Cleft lip and palate is a congenital defect which has several associated problems such as dental anomalies, feeding issues, hearing impairment, psychosocial issues, and delayed speech and language milestones. The severity of the problem is varied across individuals due to a different type of clefts and its nature. Cleft lip and palate is also associated with syndrome conditions where additional associated problems can be identified such as motor deficits, poor intellectual abilities.

The incidence of CLP in India is found to be approximately one in 500 live births (Ankola, Nagesh, Hegde & Karibasappa, 2005). In India, a survey was carried out by the Tata Institute of Social Sciences; Mumbai (Raju, 2000). The outcomes reported that 35,000 children are born with cleft lip and palate every year. Another survey done by Nagarajan, Murthy, and Raman (2005) reported that cleft lip and palate are approximately one in 781 live births. The prevalence rate differs across reports (Ankola et al., 2005; Raju, 2000; Murthy & Raman, 2005).

The common speech associated problems seen are resonance and articulation disorder. Resonance related problems are present due to anatomical and physiological defects such as the presence of unoperated cleft, fistula, velopharyngeal dysfunction. Based on the type of cleft the severity of speech problems can vary between individuals. Due to the inappropriate velopharyngeal function, there will be abnormal closure of velopharyngeal port during speech production, due to which air escapes and these results in imbalance in resonance sub systems leading to resonance disorders.

The most common speech problems seen in individuals with a repaired cleft lip and palate are hypernasality, audible nasal emission, weak consonant production, compensatory articulatory patterns, reduced speech intelligibility. If the cleft lip and palate is associated with hearing impairment leads to poor feedback mechanism causing significant speech errors. Overall speech acceptability of individual reduces due to the presence of facial grimaces, scarring of the operated cleft of the lip and facial appearance. Hence, the detailed assessment of speech and language issues plays a crucial role in planning the intervention strategies of an individual.

Speech assessment in individuals with repaired cleft lip and palate is mainly done using subjective, objective or both subjective and objective methods. Objective procedures include acoustic measures, aerodynamic measures, and imaging techniques. However, the subjective method is considered as a gold standard method (Kuehn & Moller, 2000). Hence, the perceptual speech analysis is the benchmark of the speech assessment. The conclusion concerning the severity of the speech problem is depended on the listener's subjective analysis (Moll, 1964). Perceptual assessment should always be the initial step for all speech assessment procedures as there is no better instrument to analyze speech than the human ear (Falzone, Jones & Kernell 2006). These perceptual procedures can include the use of low technology instrumentation or recording apparatus such as audio and audio-visual presentations. Choosing the appropriate recording system is a crucial role by a speech-language pathologist and to analyze the severity of speech characteristics in the speech of cleft lip and palate.

The subjective assessment procedures began during early 1930-40s. In early stages, the perceptual evaluation was limited to an assessment of articulation skills,

which mainly concentrated on the frequency of articulatory errors, description of articulation errors and type of error patterns. The speech errors were studied in detail using traditional SODA analysis procedures like identifications and specifications of Substitution, Omission, Distortion, and Addition.

Perceptual analysis of speech has its limitations as well. The main variables influencing the perceptual agreement are the experience of judges in analyzing and perceiving speech of individuals with cleft palate. Apart from this type of speech stimuli obtained from an individual such as words, sentences, spontaneous speech, rate of speech, length of utterance produced, the phonetic context of the respective language also plays an important role. Along with this mode of presentation of the speech sample to the listener plays an important role like audio (A) and audio-visual (AV) modalities. In the Audiovisual mode of presentation facial appearances also plays a significant function in formulating the severity of speech disorder. The type of recording is another variable.

Resonance and speech intelligibility are crucial measures to decide the severity of the speech. Thus carrying out a perceptual judgment of resonance and speech intelligibility is important to measure the speech outcomes and to determine appropriate treatment plans. There are several studies carried out to explain the effect of different variables of speech perception. Each of the variable related studies is explained in the following sections.

2.1 Influence of the mode of stimulus presentation on the auditory perceptual analysis of speech in individuals with CLP

Gnanavel and Pushpavathi (2013) carried out a perceptual study to compare the severity of nasality with velopharyngeal port opening using cineradiography imaging techniques. Ten native speakers of Kannada with an unoperated submucous cleft palate of age range 7 to 18 years were considered. The data collection of speech sample comprised of phonation of /a/,/i/,/u /, ten words loaded with high-pressure consonants, five standardized oral sentences were recorded using Olympus digital recorder 550M. They mainly measured Speech intelligibility, Voice and size of the velopharyngeal port. All the samples of the audio mode were randomized, and judges were blindfolded before presenting the stimulus. A gap of one week was maintained between the rating of velopharyngeal videos and audio videos to rule out the bias due to familiarization. The Henningsson, Kuehn, Sell, Sweeney, Trost- Cardamone, and Whitehill (2008) speech assessment rating scale (0-4) was incorporated for rating the perceptual speech parameters such as hypernasality, nasal air emission, speech intelligibility, and voice. Reliability analysis was carried out and showed higher internal consistency and good inter-judge reliability for all the speech parameters. The outcomes of this study revealed that there was no correlation between speech intelligibility, voice measures, and size of the velopharyngeal port. The results implied that it is important to consider both physiological and perceptual assessment procedures to correlate the severity of speech disorder while diagnosing and treating the individuals with cleft palate. Hence, they studied the correlation connecting the size of the velopharyngeal port and perception of speech features. To conclude this study mainly highlighted about the physiological correlates with perceptual analysis using video-fluoroscopic images.

Padilha, Dutka, Marino, Lauris, Silva, and Pegoraro-Krook (2015) compared the perceptual judgments for live ratings and recorded speech respectively. The study designed to know the influential factor of the background of recording in the perception of speech disorder. They mainly measured the nasality component of the individual with a cleft palate. The study included children with a repaired cleft of lip and palate of age range 5 to 12 years. The speech recording involved samples of high and low-pressure consonants in spontaneous speech. Later the speech samples were given to speech-language pathologist to rate the severity of hypernasality using an ordinal scale. The percentage conversion was carried for all the severity ratings obtained from speech-language pathologists. In live condition, the statistical analysis revealed 23% of the participants showed mild to moderate in 8% of the children and the absence of hypernasality in 69% of the children with RCLP. In recorded condition, 50% of the participants exhibited hypernasality in high-pressure consonants, 62% in low-pressure consonants. Hence, the study concluded that there was a significant difference in the perception of the severity of nasality in live and recorded condition.

To conclude, although there are very limited studies related to the mode of presentation. Few of the studies attempted to highlight the importance of mode of recording. Each study differs with respect to the parameters measured and the procedures carried out. However, these studies fetch the importance of different types of recording and background environment.

2.2 Influence of the experience of judges on auditory perceptual analysis of speech in individuals with CLP

Bradford, Brooks, and Shelton (1964) studied the perception of hypernasality in individuals with CLP. The participants of the study are 17 children 6 to 14 years. The data collection incorporated samples of spontaneous speech, /a-i/ test (Jonson, Darley & Spriestersbach, 1963). The main highlight of the study was to compare the perception of hypernasality across two groups of judges. They considered four experienced judges, are those having experience in the field of cleft lip palate for more than 3 years. 2 inexperienced judges were considered are those post-graduate speech-language pathologists who had no experience in dealing with children with CLP. These judges were guided to rate the severity of nasality using 7-point rating scale perceptually. Where zero indicated no hypernasality and six indicated extreme hypernasality. The reliability measures indicated poor reliability of 0.14 and 0.25 for both experience and inexperienced judges respectively.

To conclude, variables like voice quality, articulation influence the judgment task. Due to the lack of the contrast in voice quality pitch and loudness measures, there was a poor agreement between the two groups of judges. Presence of different articulatory patterns leads to poor reliability across judges.

Sinko and Hadrik (1982) studied the relationships between ratings of facial acceptability and speech of individuals with CLP. The study incorporated data collection of 20 participants with cleft lip and palate. Conversation samples were collected both in audio and audio-visual mode separately. The collected samples were given to two groups of judges. The 7-point adjective rating scale was used to rate the

severity in both the modalities. Thirty trained and untrained observers were instructed and explained to rate the samples using a rating scale. Reliability analysis was carried out and results revealed ratings were more reliable for speech and facial acceptability. The results found that speech was rated more negatively in speakers with cleft palate by untrained judges. Hence, there was a significant difference between the judges no interaction between speech and speech acceptability was observed.

Mayo, Dalston, and Warren (1993) studied the perceptual judgments of experienced speech-language pathologists. The main parameter included in the study was resonance measures. The participants were 293 non-syndromic children with a repaired cleft of lip and palate of age range 4 to 5 years. Standard assessment protocols were used to assess their articulation, resonance, and language. Data collection included conversation sample of 30 minutes. These phonologic samples were given to clinicians to rate the severity using an interval scale. The severity of hypernasality and hyponasality was measured. Hypernasality was base on 6 points equally appearing interval scale. The systematic statistical analysis of speech samples revealed1.4% of the children rated with the absence of hypernasality. Hence, the study concluded that it is a tedious task for clinicians to analyze the phonological samples of younger children and this requires adequate experience. Also, resonance assessment in younger children will be withdrawn by acoustic parameters of voice and vocal tract resonances.

Karry, Thomas, and Sarah (2002) studied the influence of listener experience, and academic training on ratings of nasality and results revealed that agreement of nasality was highest for Speech-Language Pathologists compared to another group of

listeners. The study incorporated 20 individuals with CLP. Conversation sample of each individual was recorded. These samples were given to the 2 groups of listeners. 12 Trained and three untrained listeners. Twelve trained listeners had received four levels of academic training in the field of cleft lip and palate, and three untrained listeners are graduate students studying in the field of speech-language pathology. The results revealed there low to moderate correlation between the nasalance scores and nasality judgments.

To conclude, the experience of listener played an important role, speech-language pathologists with adequate training and expertise in the field of CLP showed a higher correlation in instrumental measures compared to native speakers. A strong correlation was observed between the perceptual ratings of nasality and nasalance scores among expert speech-language pathologists. A moderate correlation was observed for untrained speech-language pathologists and untrained listeners. (Brunnegard et al., 2012). Hence, it is an important component to consider the professional skill of clinician in assessment and treatment.

2.3 Influence of the type of stimulus presentation on the auditory perceptual analysis of speech in individuals with CLP

Whitehill and Chau (2004) investigated word intelligibility across the type of cleft, age, and gender in Cantonese speaking population with CLP. They considered 15 children with repaired cleft lip and palate in the age range of 5 to 44 years. 60 Chinese words loaded with pressure consonants were selected, and it was made to repeat. Eight Cantonese speaking individuals were selected as listeners and the

responses recorded were given to the listeners for identification. There was no significant effect of the type of cleft, age, and gender on speech intelligibility.

Kang, Park, Paek, Kwon, Lee, and Choi (2009) assessed the correlation between speech intelligibility and speaking factors like language, articulation, nasalance score and reading ability in 11 children with cleft palate and age and a gender-matched equal number of typically developing children. The data collection of speech samples in repetition and conversation task was considered. Multiple regression analysis was incorporated to find a significant correction between the variables. The results confirmed the difference in speech intelligibility and speaker factors between children. They concluded that there was no statistically significant correlation between nasalance score and speech intelligibility.

A study by Klinto et al. (2011) studied the effect of speech in a different context on speech judgment in five-year-old children with and without cleft palate. Single-word naming, sentences repetition, story narration, spontaneous speech were used as speech samples for assessment. Judges were asked to rate for a percentage of correct consonants, correct place, and manner, active cleft speech characteristics. Results revealed active cleft speech characteristics, percentage correct consonants, places, manner, and phonological simplification processes were found to be correct in word naming than all other speech stimuli in children with CLP. They concluded that word naming was found to be the most reliable speech material compared to other materials that can be considered with good Intra and inter-judge reliability.

In the Indian context, Gnanavel and Pushpavathi (2012) evaluated the impact type of cleft and stimuli on speech intelligibility between sentences and words in cleft lip and palate population. They considered a total of 20 participants having different types of cleft with an equal number of participants in each category in the age range of 10 to 25 years. They were made to repeat the words and sentences loaded with pressure consonants in the Kannada language. Responses were recorded and presented to 4 SLPs for perceptual assessment of speech intelligibility on a 5 point rating scale given by Ray (2002). The study revealed that there was no stimuli effect on speech intelligibility. There was high inter-judge reliability between the 4 SLPs which was statistically significant. Hence they concluded from their study that speech intelligibility could be enhanced with the help of speech therapy soon after the surgical management.

Main factors influencing the speech of CLP are articulation, variations in oral, pharyngeal, and nasal cavity size, vocal pitch and intensity, respiratory effort, and the ratio of oral and nasal acoustic impedances contributed the degree of nasality. (Baken & Orlikoff, 2000).

However, there are drawbacks and disagreement in rating speech intelligibility using traditional rating scales (Whitehill, 2002). Speech understandability and speech acceptability were proposed as global speech parameters in assessing cleft lip and palate population, which are important to explain speech intelligibility. ‘Speech understandability is the degree to which the speaker's message can be comprehended by the listener' and ‘Speech acceptability is the degree to which speaker's message is acceptable in the speaker's language or dialect' (Henningsson et al., 2008; Whitehill,

2002). For example, an individual with CLP may use glottal stops and the speech can be comprehended by the listener but still, the speech is not acceptable for that respective language. Sell et al., (1994) and Witzel (1991) reported that, one should be cautious while reporting on intelligibility because it is hard to rate consistently. It can be affected by many factors such as articulatory errors related to hearing, developmental errors, and experience of the listener.

Few investigations have been conducted on the effect of stimuli over speech intelligibility, especially in children. However, there is a lack of studies in both Indian as well as western context on the perceptual assessment of resonance, understandability, and acceptability in children with RCLP using a standardized assessment protocol. Hence, there is a need to investigate the same across stimuli in children with RCLP.

A study by Whitehill et al., (2002) has emphasized a need for global measures of speech performance with a detailed quantitative methodology. Lohmander and Olsson (2004) have recommended that resonance, nasal airflow, and consonant production should be considered for the evaluation of speech outcome studies. There have been several scales developed and used for the perceptual assessment of speech parameters in children with CLP. Temple Street scale was developed by Sweeney (2000). It was developed to assess the errors related to resonance and nasal airflow. However Temple Street scale does not include the assessment of the consonants errors, but it provides information about the hypernasality, hyponasality, and nasal airflow errors and this has been tested for validity and reliability. Use of common terminologies and their description are rarely included in the cleft palate measures

(Kent et al., 1999 and Whitehill, 2002). Multiple systematic procedures and protocols are used to evaluate speech production errors and nature of the disorders in CLP population, each individual must be vigilantly observed because several factors can contribute to the error patterns and individuals with CLP form a heterogeneous group. Irrespective of language spoken lot of parameters are used to study the speech outcomes of individuals with CLP to achieve internal consistency globally.

To conclude, perceptual analysis of speech remains the gold standard for evaluating speech, as well as the most commonly used method. Hence, Henningsson, Kuehn, Sell, Sweeney, Trost-Cardamone and Whitehill (2008) developed a framework of universal parameters for detailed documentation of speech outcomes in persons with cleft palate with a standardized 4 point rating scale for assessing the severity of hypernasality and speech intelligibility. Thus carrying out a perceptual judgment of resonance and intelligibility is important to measure the speech outcomes and to determine appropriate treatment plans. Many perceptual assessment protocols have been developed for evaluation of an individual with Velopharyngeal dysfunction, and among them, Henningson's protocol, (2008) is the most widely accepted one.

To summarize, the above review highlighted the requirement for documenting the analysis of speech of individuals with cleft palate using the perceptual method. There are very few studies reported on perceptual speech analysis of individuals with cleft lip and palate. However, there are no Indian studies, which provide insight into the detailed perceptual analyses of speech in children with CLP across variables. The effect of variables on speech perception has to be studied. Hence the current study was initiated to explore the influence of different variables on the perception of speech.

CHAPTER III

METHOD

3.1 Participants

Ten children in the age range of 7 to 12 years with repaired cleft lip and palate were considered as participants for the study. The database of clients maintained in Unit of Structural and Oro-Facial Anomalies (USOFA) unit at the Department of Clinical Service (DCS), AIISH was reviewed for prospective participants. Case files were accessed from registration counter and were separately analyzed in detail for their demographic details like information about assessment details, the date of the evaluation, participant's age at the time of evaluation and surgery details were collected. It was ensured that the language abilities of all the children were age adequate. The age, gender, and type of cleft details of the participants are mentioned in the table 1.

Inclusion criteria for the participants

1. All participants were native speakers of Kannada.
2. Children in the age range of 7 to 12 years.
3. Children with repaired CLP were considered.
4. All participants had average intelligence as per IQ assessment report was done by Clinical Psychologist.
5. Language abilities of all participants were age adequate
6. Children with hearing sensitivity in normal limits with no middle ear pathologies.

Exclusion criteria for the participants

1. Children with RCLP in the absence of any syndrome/Neurological impairment
2. Children with RCLP should not have hearing loss/ frequent history of ear infection or any other associated disorder.
3. Children with below average intelligence /cognitive impairment were excluded based on IQ assessment reported by Clinical Psychologist.

Table 1

Demographic and clinical details of the participants.

Sl.No	Age (Years)	Gender	Type of Cleft
01	10	M	Bilateral cleft of the palate
02	07	M	Bilateral cleft of lip and palate
03	11	M	Bilateral cleft of lip and palate
04	10	M	Bilateral cleft of lip and palate
05	11	M	Bilateral cleft of lip and palate
06	08	F	Bilateral cleft of lip and palate
07	07	F	Bilateral cleft of lip and palate
08	10	F	Bilateral cleft of lip and palate
09	07	F	Bilateral cleft of lip and palate
10	11	11	Bilateral cleft of the palate
	N=10		(M=5 , F=5)

M=Male, F=Female, N=Total number of participants.

3.2 Ethical considerations

The written consent was obtained from parents of individuals with cleft lip and palate. They were explained about the study and recording procedure involved along with the approximate duration required for a complete recording.

3.3 Procedure

Data collection

The data collection procedure included two phases. In the first phase, each participant's speech sample was recorded in two modalities. Three different types of stimulus words, sentences, and spontaneous speech were considered. Ten meaningful bi-syllabic words loaded with high-pressure consonants and five oral sentences were selected as stimuli. Each participant was asked to repeat 10 words loaded with high-pressure consonants, five oral sentences are taken from standardized list (Jayakumar & Pushpavathi 2005), Narration/ Spontaneous speech was also recorded simultaneously in audio and audio-visual modalities.

The stimuli were audio recorded using a digital voice recorder (Olympus WS-550M) with the help of a native male Kannada speaker in a quiet room. The inter-stimulus interval of three seconds and five seconds were maintained across words and sentences respectively. This pre-recorded stimulus was fed through headphones and participants were instructed to repeat them. A trail was provided to all the participants to ensure that they have understood the instructions.

Recording

First Phase: Speech sample recording was done simultaneously in two sets of condition Audio (A) and Audi-Visual (AV). Children were seated comfortably in a quiet room and the data was collected individually. Children were asked to listen to the speech sample provided through the headphone (HD 457) and repeat the words, sentences clearly in their comfortable pitch and loudness. Repeated words were audio recorded using Digital voice recorder Olympus WS-550M kept 10 cm away from the participant's mouth. During this simultaneously audio-video recording was carried out using Sony digital video camera recorder (DCR-SR88E) was kept at 30 cm from the speaker with a primary focus on the face. These audio and audio-video recorded samples were extracted and randomized systematically which later served as the basis for perceptual analysis. Randomization of all the samples across the conditions was carried out to overcome the bias and familiarization of the speaker to the listener. The judges were blindfolded and presented the stimulus as shown in table 2. This systematic randomization was carried out for all (30*2=60 samples).

Table 2

Randomization of the speech samples for presentation to the judges.

STAGE 01- Audio mode			
TRIALS	**Listener 1**	**Listener2**	**Listener3**
Sample 1	Sample A –S	Sample C –SS	Sample B-W
Sample 2	Sample C –W	Sample A –W	Sample B –S
Sample 3	Sample B –SS	Sample C –S	Sample A –SS
STAGE 02- Audio Visual mode			
TRIALS	**Listener 1**	**Listener2**	**Listener3**
Sample 1	Sample A- S	Sample C –SS	Sample B-W
Sample 2	Sample C –W	Sample A-W	Sample B-S
Sample 3	Sample B –SS	Sample C –S	Sample A-SS

W=Words, S=Sentences, SS=Spontaneous speech

***Second phase*:** In this phase group of five trained and five untrained judges with normal hearing sensitivity were considered. Speech-Language pathologists experienced in the clinical / research area of Cleft palate and had ear training for at least three years was considered as trained judges their age ranged from 28 to 40 years. The postgraduate students studying in M.Sc (SLP) was considered as untrained judges, their age ranged from 22 to 25 years. Both the group of judges was able to speak and comprehend the Kannada language. An example scoring sheet provided to the judges is given under table 3.

Table 3

Example of scoring sheet provided to the judges.

Mode Audio	Hypernasality		Nasal Emission		Speech Understandability	Speech Acceptability
	W	S	W	S	SS	
Sample 1						
Sample 2						

W=Words, S=Sentences, SS= Spontaneous Speech

3.4 Perceptual analysis

The perceptual analysis was carried out by providing randomized speech samples to the judges. The judges were asked to listen to the speech sample and rate accurately. An appropriate format was provided to each of them to rate each sample based on the guidelines given by Henningson et al. (2008). Henningson's Protocol provided for hypernasality, audible nasal air emission, speech understandability, speech acceptability was used. A standardized four-point rating scale was used for perceptual evaluation of resonance, understandability, and acceptability (Henningsson et al., 2008), where zero indicates "within normal limits," one indicates "mildly affected," two indicates "moderately affected," and three indicates "severely affected." The speech samples obtained in the audio mode and in the visual mode was

randomized across all samples as shown in table 2, and this was presented using headphones. Initially, only audio samples were given for analysis followed by audio-visual samples. Each judge was asked to analyze all the three types of the stimulus of 10 participants recorded in two modalities. The analysis was done based on the criteria given in Table 4.

Table 4

Universal parameters for reporting speech outcomes in individuals with cleft palate (Henningson et al., 2008).

Hypernasality- Single Words 0= Within normal limits 1= Mild 2= Moderate 3= Severe X= Missing data	**Hypernasality-** Sentences 0= Within normal limits 1= Mild 2= Moderate 3= Severe X= Missing data
Nasal Emission – Single Words 0= Within normal limits/ None 1= present X= Missing data	**Nasal Emission** -Sentences 0= Within normal limits/None 1= Present X= missing data
Speech understandability-Conversational Speech 0= **Within normal limits** 1= **Mild** 2= **Moderate** 3= **Severe** X= Missing data	**Speech acceptability-**Whole speech sample 0= **Within normal limits** 1= **Mild** 2= **Moderate** 3= **Severe** X= Missing data

3.5 Statistical analysis: Obtained qualitative data were subjected to statistical analysis using IBM Statistical Package Social Sciences software (version 20), and the following measures were performed. Raw scores/ ratings of all judges were compiled by considering most frequently rated score for each variable. Reliability check was carried out by calculating Cronbach's alpha value (>0.70) showed data to be more reliable within the groups. Percentage and Mean ranks were calculated for all the parameters accordingly. Comparison of percentage values was carried out to know the pattern of variation across variables. Non –Parametric test Wilcoxon's signed ranks test was used to compare the level of significance between different modalities (A) and (AV), between judges (Trained and Untrained) and across stimulus (Words, sentences, and spontaneous speech).

CHAPTER-IV

RESULTS AND DISCUSSION

The present study aimed to investigate the influence of different variables on the perception of speech of individuals with RCLP. The study included data recorded for all the 10 participants simultaneously in audio and audiovisual modes. These recordings obtained were randomized systematically across all types of stimulus. These randomized samples were played through headphones to five trained and untrained judges. The judges were instructed to rate the variables hypernasality, nasal emission, speech understandability, and speech acceptability accordingly using the universal speech outcome rating scale given by Henningsson et al. (2008).

All the raw data (severity ratings) obtained from the five trained and five untrained judges for each parameter were compiled by considering the most frequently rated score. The statistical analysis was done by converting the severity ratings for all parameters into percentage scores. Nonparametric test, i.e., Wilcoxon's signed rank test was used to find the level of significance across the modalities, judges, and parameters. The statistical analysis of variables related to the perceptual analysis of speech of individuals with cleft lip and palate is explained in the following sections.

4.1 To study the variability in perceptual evaluation ratings across different mode of stimulus presentations.

Perceptual ratings based on the audio and audio-visual mode of stimulus presentation for various speech parameters were shown in table 5. The ratings converted to percentage scores were compared across parameters such as

hypernasality, nasal emission, and speech understandability, speech acceptability for different stimuli words, sentences, and spontaneous speech.

The results indicated that across the parameters (hypernasality, speech understandability, and acceptability) ratings based on audio mode were high for a normal and mild degree of severity. Whereas, ratings based on audio-visual mode indicated higher ratings for the moderate and severe degree of severity. On evaluating nasal emissions, majority ratings based on audio–visual mode were indicating presence of nasal emissions within normal limits (75% for words, 65% for sentences), whereas audio mode of evaluation predominantly indicated the presence of nasal emissions higher than normal limits (55% for words, 75% for sentences). The differences in the results based on audio and audio-visual modalities for all the parameters across the stimuli were significantly different ($p<0.05$) except for nasal emission measures for words ($p>0.05$).

The possible reason for majority rating hypernasality, speech understandability, and acceptability into the moderate and severe degree of severity in audiovisual mode than audio mode could be due to additional information gained from the visual mode while listening to the samples. In audio-visual mode along with auditory perception facial acceptability, presence of a scar, deviation in nasal septum plays a major role and could influence the overall perception of speech.

The reverse pattern was observed in nasal emission indicating higher ratings were for the presence of nasal emissions in audio mode. This could be attributed to the selective attention of listener towards the speaker in audio mode than audiovisual

recording as nasal emissions are difficult to perceive. Another influencing factor could be the placement of the microphone. In audio-visual mode, the microphone of the video cam is placed at a distance of 30 cm to capture the full face of the participant while recording, whereas in audio mode the microphone is placed at 10 cm from the speaker. So this could have an impact on the audibility of the nasal emissions. The findings of the study carried out by Padilha et al. (2015) supports the results of the current study as they had highlighted a significant difference in the perception of resonance measures in live and audio-recorded samples. The live recorded samples were rated with increased severity in the nasality than the audio recorded samples. The authors attributed these differences to the background influence on the audio recorded samples while recording.

Table 05

Results of percentage comparison of severity ratings using Wilcoxon's signed ranks test in A v/s AV modalities.

Parameter	**Rating**	**Audio**	**Audio-visual**	|z|	*p*
Hypernasality –W	Within normal limits	40%	5%	3.46	0.001
	Mild	50%	40%		
	Moderate	10%	30%		
	Severe	0	25%		
Nasal emission-W	Within normal limits	45%	75%	1.89	0.059
	Present	55%	25%		
Hypernasality-S	Within normal limits	15%	5%	3.23	0.001
	Mild	60%	25%		
	Moderate	15%	35%		
	Severe	10%	35%		
Nasal emission-S	Within normal limits	25%	65%	2.53	0.011
	Present	75%	35%		
Speech understand ability-SS	Within normal limits	20%	5%	3.09	0.002
	Mild	60%	30%		
	Moderate	15%	45%		
	Severe	5%	20%		
Speech accceptibility-SS	Within normal limits	20%	5%	3.314	0.001
	Mild	50%	20%		
	Moderate	20%	40%		
	Severe	10%	35%		

Note. W=words, S=sentences, SS=Spontaneous speech, A=Audio, AV=Audio-visual

4.2 To compare the perceptual evaluation ratings of trained and untrained judges to determine the influence of experience and training on evaluating the speech of RCLP.

Perceptual ratings based on trained and untrained judges were shown in table 6. The ratings converted to percentage scores were compared across parameters such as hypernasality, nasal emission, and speech understandability, speech acceptability for different stimuli words, sentences, and spontaneous speech.

The results indicated that across the parameters (hypernasality, speech understandability, and acceptability) ratings based on trained judges were high for a normal and mild degree of severity. Whereas, ratings based on untrained judges indicated higher ratings for the moderate and severe degree of severity. On evaluating nasal emissions, majority ratings based on trained judges were indicating the presence of nasal emission higher than normal limits (55% for words, 75% for sentences), whereas untrained judges predominantly indicated the presence of nasal emissions within normal limits (50% for words, 45% for sentences). The differences in the results based on trained and untrained judges for all the parameters across the stimuli were significantly different ($p<0.05$) except for nasal emission measures for words and sentences ($p>0.05$).

On observing the results, it is evident that there are differences in the judgments of the trained and untrained judges. Most of the untrained judges rated speech in more towards severe end ranging from moderate to severe. Wherein, trained judges rated between normal to a mild degree of severity. Identifying the mild abnormalities in the speech parameters (hypernasality, speech understandability, and acceptability) required sensitivity to subtle changes, keen observation, and adequate

ear training to perceive the error patterns accurately. As reported by Sell et al., (1994) and Witzel (1991) listener should be attentive in analyzing the speech due to the presence of inconsistencies.

The presence of nasal emissions was identified by the trained judges as it is essential to have the expertise to notice nasal emissions in the speech samples. Overall, the differences in the ratings of the judges can be attributed to the perceptual variations. Stevens (1974) highlighted the dilemma in the listeners while subdividing the rating scale into small intervals. Thus equal appearing intervals are need not be equal for the entire scale.

Table 6

Results of percentage comparison of severity ratings using Wilcoxon's signed ranks test in trained v/s untrained judges.

Parameter	**Rating**	**Trained**	**Untrained**	|z|	*p*
Hypernasality –W	Within normal limits	40%	5%	3.47	0.001
	Mild	50%	35%		
	Moderate	10%	35%		
	Severe	0%	25%		
Nasal emission-W	Within normal limits	45%	50%	0.33	0.739
	Present	55%	50%		
Hypernasality-S	Within normal limits	15%	5%	2.67	0.008
	Mild	60%	45%		
	Moderate	15%	25%		
	Severe	10%	25%		
Nasal emission-S	Within normal limits	25%	45%	1.63	0.102
	Present	75%	55%		
Speech understandability-SS	Within normal limits	20%	0%	3.58	0.000
	Mild	60%	15%		
	Moderate	15%	55%		
	Severe	5%	30%		
Speech accceptibility-SS	Within normal limits	20%	5%	3.21	0.001
	Mild	50%	25%		
	Moderate	20%	40%		
	Severe	10%	30%		

Note. W=words, S=sentences, SS=Spontaneous speech

4.3 To investigate the difference in perceptual analysis of speech across the type of stimuli

Table 7 exhibits the variables (hypernasality and nasal emission) considered for evaluating in words and sentences. There was no consistent trend observed in the ratings across the stimuli. Pairwise comparison was carried out between words and sentences across speech parameters. The result indicated no significant difference between the perception of the severity of words and sentences (*p>0.05).* The results can be attributed to the similarity in the structure of the stimulus as both the words and sentences were dominated by the oral pressure consonants. Similar results were also reported by Gnanavel and Pushpavathi (2012) who revealed that there was no stimuli effect on speech intelligibility. A study by Whitehill and Chau (2004) also indicated no significant difference in speech intelligibility across stimulus.

Table 7

The comparison of severity ratings between words and sentences

Parameter	**Rating**	**Words**	**Sentences**	z	*p*
Hypernasality	Within normal limits	22.5%	10%	1.88	0.059
	Mild	42.5%	52.5%		
	Moderate	22.5%	20%		
	Severe	12.5%	17.5%		
Nasal emission	Within normal limits	47.5%	35%	1.38	0.166
	Present	52.5%	65%		

4.4 Reliability measures

Interjudge reliability was calculated between the judges for all different modalities across parameters. Cronbach's alpha (α), the coefficient of reliability was calculated separately for each subsection and represented in table 8.

Table 8

Interjudge reliability across different conditions.

Stimulus	Trained		Untrained	
	Audio	**Audio-Visual**	**Audio**	**Audio-Visual**
Hypernasality-W	0.90	0.86	0.91	0.90
Nasal EmissionW	0.86	0.80	0.51*	0.69*
Hypernasality- S	0.89	0.90	0.71	0.91
Nasal-Emission-S	0.81	0.82	0.59*	0.66*
Speech Understandability	0.82	0.93	0.74	0.77
Speech-Acceptability	0.89	0.93	0.8	0.9

Cronbach's alpha value >0.70= good reliability, W=Words, S=Sentences.

The results revealed that Cronbach's alpha value ranged from 0.51 to 0.93 indicating moderate to excellent reliability. The trained judges exhibited good inter-judge reliability in both the modalities across all four variables. But in the untrained condition, it showed poor inter-judge reliability with respect to nasal emission in both the modalities. This could be due to the subtlety involved in judging nasal emissions. The variations in the reliability measures could be due to the difficulties involved in perceiving the deviancy from normalcy with the same severity by various judges, as speech is a complex task. Similar results are reported by Brunnegard et.al., (2012) that trained speech-language pathologists showed more reliable data compared to untrained speech language pathologists because of multiple variables. Whereas Watterson et al., (2007) reported the inter-judge reliability of two expert listeners to be poor to moderate. The variations in the results could be attributed to the methodological differences, with respect to the stimuli, listener's experience and expertise, participant's language background.

CHAPTER V

SUMMARY AND CONCLUSIONS

Around 40,000 children are born every year with cleft lip and palate in India. A team of health professionals including the Nutritionists, Plastic surgeons, Maxillofacial Surgeons, Dentists, Psychologists, and Speech-language pathologists usually treats the children with CLP. The Speech-language pathologist (SLP) is ultimately responsible for evaluating the speech characteristics and selecting appropriate intervention strategies for enhancing their speech characteristics. Evaluation by an SLP involves use of subjective and objective measures for analyzing the articulatory and resonance characteristics of speech in these individuals. These objective measures such as the Nasalance being expensive in terms of time and investment, may not be feasible across the settings and hence the subjective assessment procedures play a key role in assessing individuals with cleft lip and palate.

Despite the perceptual analysis being considered gold standard and most feasible testing procedure, it is assumed to be influenced by several stimulus-related and rater related factors and also on the mode in which the samples are presented for analysis. Considering the dearth of studies addressing these potential issues, the present study was taken up to investigate the effect of mode of stimulus presentation and type of stimuli on the perceptual judgment of the speech of individuals with cleft palate by trained and untrained listeners. The specific objectives of the study were, to study the variability in perceptual evaluation ratings across different mode of stimulus presentations, to compare the perceptual evaluation ratings of trained and untrained judges to determine the influence of the experience and training on evaluating the

speech of RCLP and to investigate the difference in perceptual analysis of speech across the type of stimuli.

Ten children in the age range of 7 to 12 years with repaired cleft lip and palate were considered as participants for the study. Their speech sample involving words, sentences, and spontaneous speech were recorded simultaneously in Audio and Audi-Visual conditions. These samples were randomized and presented to five Speech-language pathologists with a minimum of three years of experience in handling children with CLP (trained judges). The samples were also presented to five postgraduate students of Speech-language pathology (untrained judges). The Henningson's protocol, a standard four-point rating scale to rate the parameters hypernasality, audible nasal air emission, speech understandability, speech acceptability was provided to the judges for rating the samples. The obtained qualitative data was subjected to the appropriate statistical analysis.

In terms of the effect of mode of presentation on perceptual severity of the parameters, the Wilcoxon's signed rank test revealed a significant difference between the audio and audio-visual mode of presentations. This difference could be due to the perception of additional information in terms of facial acceptability, presence of a scar, deviation in the nasal septum in the audio-visual mode versus the selective attention by the listeners for the 'audio' mode. With respect to the experience of the judges, most of the untrained judges rated speech towards severe end ranging from moderate to severe, and the trained judges rated it between normal to a mild degree of severity. The significant difference in the severity of rated parameters in association with the judge's experience indicates that the experience of the judges plays a considerable role in the perceptual analysis and hence needs to be considered while

interpreting these results. Further, with reference to the type of stimulus used for analysis, the word and sentence stimuli did not indicate the statistically significant difference, indicating that either of them can be used for the perceptual testing in individuals with CLP. This could be due to the similarity in the structure of the stimulus between the words and sentences used in the present study. Both the words and sentences used in the present study they were dominated by the oral pressure consonants.

In terms of reliability inter-rater reliability, the trained judges had shown excellent inter-judge agreement compared to the untrained judges who revealed to have an agreement of moderate-good level. However, the difference between these two groups of judges was statistically significant only for the parameter nasality.

To conclude, the present study highlighted the importance of considering different variables that could influence the auditory perceptual assessment of speech in individuals with repaired CLP. While the audio mode of presentation could elicit speech specific information, the audio-visual mode elicits the overall perception of the individual. Hence, these two modes of presentation could be complementary for perceptual analysis in cleft speech evaluation. The speech perception of a listener was found to vary with respect to the mode of stimulus presentation and the experience of the judges. Therefore, these factors could be potential extraneous variables which must be controlled in the future studies involving auditory perceptual analysis of speech in individuals with CLP. However, the word/ sentence stimuli revealed similar findings indicating that either of these stimuli could be used for perceptual ratings.

The present study facilitates understanding the importance of perceptual analysis of speech in the evaluation of speech in individuals with CLP. The present study also shed light on the influence of some of the potential factors that could influence the perceptual analysis of cleft speech. Based on the finding that the trained judges had shown excellent inter-rater agreement, the present study emphasizes the importance of auditory perceptual training for future SLPs in evaluating the speech of individuals with cleft palate.

Although the present study sheds light on some potential factors to be considered during the perceptual evaluation, the results have to be interpreted with caution considering the limited number of participants used in the study. Future studies in these lines are warranted with a larger sample size to facilitate better generalization of the results. The untrained judges considered in the present study are pursuing their post graduation in the SLP and are exposed to various speech-language disorders for at least four years, which could have influenced their ratings to some extent. Therefore, future studies could also consider the perception of cleft speech by naive listeners, as an individual ultimately faces them in day to day social situations.

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