COMPUTERIZED ASSESSMENT OF PHONOLOGICAL PROCESSES IN MALAYALAM

(CAPP-M)

Project funded by A.I.I.S.H Research Fund (ARF)

(2010-2011)

Sanction Number: SH/CDN/ARF/3.90/2010-2011

Total Grants: ₹ 4,81, 000

Total Duration of the Project: 13.9.2010 – 31.9.2011

Principal Investigator
Dr. N. Sreedevi
Reader in Speech Sciences

Research Officer
Ms Merin John

Department of Speech Language Sciences
All India Institute of Speech and Hearing
Manasagangothri, Mysore – 570 006

ACKNOWLEDGEMENTS

Our sincere gratitude to our Director, Prof. S R Savithri, All India Institute of Speech and Hearing, Mysore, for funding and providing the infrastructure to carry out the project. We also acknowledge our late Director, Dr. Vijayalakshmi Basavaraj for sanctioning the project and for all her support and encouragement.

We extend our gratitude to Prof. Y V Geetha, Head, Department of Speech Language Sciences for lending us the departmental facilities to carry out the project work. We sincerely thank Dr. K.S Prema, HOD, Department of Special Education, for allowing us to administer the test to preschool children. We thank Mrs. M S Vasanthalakshmi, Lecturer in Biostatistics, AIISH, Mysore, for helping us with statistics. Our thanks are due to the Head and staff of the AIISH Library for their help in completing the project. We also thank Ms Sindusha Chandran, Research Officer for her timely help

We also thank the parents and teachers of the children for their co- operation extended during the data collection. Last but not the least we thank all the children for their enthusiastic participation in the study.

Dr. N. Sreedevi
Principal Investigator

Ms Merin John
Research Officer

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF GRAPHS

INTRODUCTION

Phonological process analysis has had considerable influence on the analysis of children's phonological systems and, to a lesser extent, on the methods that have been used to treat disordered phonological systems since the 1980s. Phonological process analysis made a clear entry, leaving behind the methods like SODA analysis of 1950’s and it proves to be a robust way of assessing the child’s phonological system.

By investigating the phonological processes, one comes near to unraveling the development of the phonological system of a child, being able to discover the intricacies of a child’s development of speech. Moreover, such information is of substantial use in cases of children with communication disorders as it shows where the child lies in the process of phonological development and how deviant the child’s productions are when compared to a typically developing child.

When dealing with children with communication disorders, assessment is a significant step for Speech Language Pathologists. A thorough assessment leads to accurate diagnosis, identification of etiology and complicating conditions, and provides a foundation for intervention. Haphazard assessment leads to wasted time and energy, and eventually to poor diagnostic decisions and inefficient planning. Assessment of the phonological processes also emerged as a popular technique to meet the demand for a more comprehensive means of assessing children who exhibit multiple speech sound production errors.

Phonological process analysis, despite its clinical significance, a task by itself is laborious and time consuming. Researchers therefore began investigating the applicability of computers to this task. Hence, began the era of computerized phonological assessment procedures. In English, several such computer based analysis have been developed. The computerized Articulation and Phonology Evaluation System (CAPES) (Masterson and Bernhardt, 2002) is a good example of such a system that was developed to elicit and analyze phonological productions. Some other computerized phonological analysis programs are Computer Analysis of Phonological Processes (CAPP) version 1.0 (Hudson, 1985), Computer Profiling (CP) (Long & Fey, 1988), Logical International Phonetic Programs Version 1.03 (LIPP) (Oller & Delgado, 1990), and Programs to Examine Phonetic and Phonologic Evaluation Records Version 4.0 (PEPPER) (Shriberg,1986).

Attempts to computerize the phonological analysis were made in India too. Ramadevi (2006) developed a computerized assessment tool for profiling the phonological production of children with hearing impairment. However, only the presentation of the stimuli was computerized, with the other tasks left solely to the hands of the clinician. Merin (2010) developed another computerized assessment tool 'Computer based Assessment of Phonological Processes in Malayalam (CAPP-M*).* This is a user friendly software program developed to automatically assess the phonological processes in Malayalam speaking children, in the age range 3-3.6 years. This study attempts to develop similar software for a younger group of children (2.0-3.0) and also incorporating the existing software in Malayalam. This will reduce the laborious and repetitive manual work involved in traditional phonological analysis.

Need for the study

The intent of the present study is to provide normative data on phonological processes observed in normal 2.0-3.0 year old native Malayalam speaking children. Several earlier researchers have concentrated on higher age range; hence information in this age range is limited. Obtained data fill a void in the existing literature by providing a frame of reference for those assessing phonological development in this age group.

Computerized assessment of phonological processes helps the tester in achieving the goal in a short time. Though there are many such computerized tests published in English, an attempt to develop computer software for phonological analysis are in the initial stages in India. Hence this study is an important milestone in the field of computer based assessment of phonological processes in Malayalam Language.

Aim of the study

To develop an indigenous computer based software to assess the phonological processes in native speakers of Malayalam language speaking children.

Objectives

1. To obtain the most common phonological processes in native Malayalam speaking children in the age range of 2.0-3.0 years.

2. Based on the normative data collected, to develop a computer based software in collaboration with software engineers to assess

    - ✓ The common phonological processes in each child's utterance

    - ✓ To rank the ordering of phonological processes

3. To append the existing software in Malayalam named "Computer based Assessment of Phonological Processes in Malayalam" (CAPP-M), a software developed for assessing phonological processes in 3.0- 3.6 years old children to the newly developed assessment

tool. Hence the resultant final software will assess phonological processes from 2.0-3.6 years in Malayalam speaking children.

4. To administer the developed software on children with communication impairment for sensitivity evaluation.

Implications of the study

- The main attraction of the study is the development of an assessment software, minimizing the effort of the examiner in assessing phonological processes in an Indian context.

- It provides a quick computer based assessment of phonological processes, as the phonological process analysis done manually is a tedious and time consuming task.

- The study can be extended in various dimensions with regard to age range and different dialects of Malayalam and also in other Indian languages.

- This computer based tool aids in early intervention and remediation which can be used as an index of phonological disability. It serves as a basis for planning phonological remediation.

- This is a highly user friendly assessment software with absolutely no training required on the part of the clinician to operate the tool
- It is easy and quick to administer

Limitations of the study

- This study assesses the phonological processes within a limited age range from 2.0 years to 3.6 years, whereas the suppression of the phonological processes continues to a higher age range.
- The tool identifies any other production patterns other than the patterns given in the tool as idiosyncratic processes, leaving no option to describe the kind of processes.
- It contains closed set of patterns and there is no option to describe any other patterns.
- While testing the sensitivity of CAPP-M, children with communication disorders are considered in the broad category of Hearing impairment and Mental retardation. Children are not classified according to different levels or degrees of impairment.

REVIEW OF LITERATURE

According to natural phonology theory (Stampe, 1979), phonological processes describe phonetically motivated and natural patterns of speech production. Supporting evidence for natural theory comes from examples of evolutionary language change and from descriptions of sound change in children's developing phonological systems. Stampe (1979) argued that the sound patterns of language are governed by the limitations of the human speech perception and production mechanisms and are thus both innate and natural. During development, phonological processes help to put the least strain on a human's speech ability.

A phonological process will, for example, merge the potential contrast between /t/ and /k/, resulting in production of [t], the unmarked member of the pair. A child whose language requires a contrast between /t/ and /k/ will learn from experience to suppress this process (velar fronting) and produce the contrast between /t/ and /k/. A phonological process may apply to a class of sounds or sound sequences (Stampe, 1979); for example, the process of stopping results in the production of stops where fricatives occur in the adult language. The reverse would not occur naturally because fricatives have the more difficult property. Phonological processes can co-occur, giving rise to more unique pronunciations. On the other hand, phonological processes that do not have a clear physiological basis are not natural and are considered deviant processes.

Phonological processes have been an interesting topic since the proposal of Natural Theory (Stampe, 1979) by many authors. There are many definitions that one will find while reviewing the literature. Table 1 shows definition of phonological processes given by different authors.

SL NO.	AUTHORS	DEFINITION OF PHONOLOGICAL PROCESSES
1.	Stampe (1969)	Phonological processes merges a potential phonological opposition into that member of the opposition which least tries the restrictions of the human speech capacity.
2.	Stampe (1979)	A phonological process is a mental operation that applies in speech to substitute for a class of sounds or sound sequences presenting a common difficulty to the speech capacity of the individual, an alternative class identical but lacking the difficult property.
3.	Lowe (1996)	A systematic sound change that affects classes of sounds or sound sequences and results in a simplification of productions.

Table 1: Various definitions of phonological processes

Systematicity in Phonological Patterns

Phonological process is a descriptive rule or statement which accounts for errors of substitution, omission or addition. In search of systematicity and patterns in misarticulated speech, Ingram (1976) suggested two assumptions. One assumption is that phonological processes are correspondence rules. That is 1:1 correspondence is observed between child's error production and the adult target. This is because, the child knows the adult form but simplifies it. The second assumption is that phonological processes are simplification rules. The child applies phonological processes to simplify adult targets that are difficult to produce. These two assumptions explain not only describing the error production but also attempt to provide an explanation for why the errors occur. Ingram also explains the reason for the child's attempt to simplify and produce all the segments of the adult target as immature motor, cognitive, perceptual, or linguistic capabilities.

Oller (1975) explains "the sorts of substitutions, deletions and additions which occur in child language are merely random errors on the child's part, but are rather result of a set of systematic tendencies”. Phonological substitutions show great regularity in the language of children.

Phonological processes in English

Different authors have identified different phonological processes (approximately 40), though only a handful occur with any frequency. Table 2a and 2b give the classification of phonological process as given by various authors and Table 2c shows the profile of phonological development (Grunwell, 1987).

Weiner (1979)	Shriberg & Kwiatkowski (1980)	Hodson (1980)
Syllable structure process Deletion of Final consonant Cluster reduction Initial stop+ liquid Initial Fricative + Liquid Initial /s/ clusters Final /s/ clusters Final Liquid + stop Final nasal + stop Weal syllable Deletion Glottal Replacement Harmony Process Labial assimilation Alveolar assimilation Velar assimilation Prevocalic voicing Final consonant devoicing Syllable harmony Feature contrast processes Stopping Gliding fricatives Affrication Fronting De-nasalization Glide of liquids Vocalizations	1. Final consonant deletion 2. Velar fronting: ▪ Initial ▪ Final 3. Stopping: ▪ Initial ▪ Final 4. Palatal Fronting: ▪ Initial ▪ Final 5. Liquid Simplification: ▪ Initial ▪ Final 6. Assimilation: ▪ Progressive ▪ Regressive 7. Cluster Reduction: ▪ Initial ▪ Final 8. Unstressed Syllable Deletion	Basic Phonological Processes Syllable Reduction Cluster Reduction Prevocalic Obstruent Singleton Omission Post Vocalic Obstruent Singleton Omission Stridency Deletion Velar Deviation Miscellaneous Phonological Processes Postvocalic devoicing Glottal Replacement Backing Fronting Affrication De-affrication Palatalization De-palatalization Coalescence Epenthesis Metathesis Sonorant Deviations Liquid /l/ Liquid /r/ Nasals Glides Vowels Assimilations Nasals Velar Labial Alveolar Articulatory shifts Substitution of /f, v, s, z/ for / θ, ð/ Frontal lisp Dentalization of /t, d, n, l/ Lateralization Other patterns

Table 2a: Classification of phonological processes by various authors

Ingram (1981)	Grunwell (1985)	Dean et al. (1990)
Deletion of Final Consonant 1. Nasals 2. Voiced stops 3. Voiceless stops 4. Voiced fricatives 5. Voiceless fricatives Reduction of Consonant Cluster 6. Liquid 7. Nasals 8. /s/ Clusters Syllable deletion and reduplication 9. Reduction of disyllables 10. Unstressed syllable deletion 11. Reduplication Fronting 12. Of palatal 13. Of velars Stopping 14. of initial voiceless fricatives 15. Of initial voiced fricatives 16. Of initial affricates Simplification of Liquids and Nasals 17. Liquid gliding 18. Vocalization 19. Denasalization Other substitution processes 20. Deaffrication 21. Deletion of initial consonants 22. Apocalizattion 23. Labialization Assimilation Processes 24. Velar assimilation 25. Labial assimilation 26. Prevocalic voicing Devoicing of final consonant	Structure simplifications Weak syllable deletion ▪ Pretonic ▪ Postonic Final Consonant Deletion ▪ Nasals ▪ Plosives ▪ Fricatives ▪ Affricatives ▪ Clusters-1 -2+ Vocalization /l/ other C Reduplication ▪ Complete ▪ Partial Consonant Harmony ▪ Velar ▪ Alveolar ▪ Labial ▪ Manner Other S.L Cluster Reduction ▪ Plosives+ approximants ▪ Fricatives + approximants ▪ /s/ + plosive ▪ /s/ + nasal ▪ /s/ + approximants ▪ /s/ + plosive + approximants Systematic Simplifications Fronting ▪ Velars ▪ Palato- Alveolars Stopping ▪ /f/ /v/ ▪ / θ/ /ð/ ▪ /s/ /z/ ▪ /t/ /ʤ/ ▪ /l/ /r/ Gliding: ▪ /r/, /l/ ▪ Fricatives Context Sensitive Voicing WI and WF Voicing Voicing WW Devoicing WF Glottal replacement WI WW WF Glottal Insertion	Systemic processes Velar fronting Palato-alveolar fronting Stopping of Fricatives Stopping of Affricates Word final devoicing Context sensitive devoicing Liquid Gliding Fricatives Simplification (th, f: dh. v) Backing of alveolar stops (unusual or atypical processes) Structure processes Final consonant deletion Initial consonant deletion (unusual / atypical processes) Initial Cluster Reduction/ deletion

Table 2b: Classification of phonological processes by various authors

Stage I (0;9-1;6)	Labial Lingual Nasal Plosive Fricative Approximant	Final word tend to show ➢ Individual variation in consonants used; ➢ Phonetic variability in pronunciations; ➢ All simplifying processes is applicable.	
Stage II (1;6-2;0)	m n p b t d w	Reduplication Consonant harmony FINAL CONSONANT DELETION CLUSTER REDUCTION	FRONTING of velars STOPPING GLIDING/r/→[w] CONTEXT SENSITIVE VOICING
Stage III (2;0-2;6)	m n ŋ p b t d k g w h	Final Consonant Deletion CLUSTER REDUCTION	STOPPING FRONTING GLIDING /r/—› [w] CONTEXT SENSITIVE VOICING
Stage IV (2;6-3;0)	m n ŋ p b t d k g f s j h w (I)	Final Consonant Deletion CLUSTER REDUCTION	STOPPING /v ð z tʃ dʒ/ FRONTING /ʃ/—› [s] GLIDING /r/ —› [w]
Stage V (3;0-3;6)		Clusters appear: Obs + approx used; /s/ clusters may occur	STOPPING /v ð/ (/z/) /θ/ —› [f] FRONTING of / tʃ dʒ ʃ/ GLIDING /r/—› [w]
Stage VI (3;6-4;0) (4;0-4;6)	ŋ m t d tʃ dʒ k g p b s z ʃ h f v l(r) j w	Clusters established: Obs+approx:approx.'immature' /s/ clusters: /s/→FRICATIVE Obs+ approx. acceptable /s/ clusters: /s/→type FRICATIVE	(/θ/—› [ŋ]) (/ð/—› [d] or [v]) PALATALIZATION of / tʃ dʒ ʃ/ GLIDING /r/ —› [w]
Stage VII (4;6<)	m n ŋ p b t d tʃ dʒ k g f v θ ð s z ʃ ʒ h w l r j	/ θ / → [ŋ] / ð / → [d] or [v] /r/ → [w] or []	

Table 2c: Profile for Phonological Development (Grunwell, 1987)

Grunwell (1987) produced a "profile of phonological development" from age 0.9 to 4.6 years based on information derived from numerous reports of children's word forms. This presents a broader picture about the phonological acquisition as shown in Table 2 (c).

Regardless of the language being learned, the research on the normal use and suppression of phonological process indicates that most children use the common processes early in their development of the sound system. Following paragraphs report the studies done by various researchers related to phonological processes.

Based on the study by Dyson and Paden (1983), five processes in 40 normally developing 2 year olds over a 7 month period were identified. They noted that gliding was most frequently used, followed by cluster reduction, fronting, stopping, and final consonant deletion.

Haelsig and Madison (1986) studied 2:10 to 5:2 years children and developed developmental data on the phonological processes of fifty English speaking normal children. The Phonological Processes Analysis (PPA, Weiner, 1979) was administered to all subjects. The process of cluster reduction, weak syllable deletion, glottal replacement, labial assimilation and gliding of liquids were used by 3 and 3:6 year old children. Weak syllable deletion and cluster reduction were prominent in the speech of 4.6 and 5 year old children. These processes indicated a delayed or disordered phonological system. This study found that greatest reduction in use of the phonological processes occurred between 3 and 4 years of age. Deletion of final consonants, stopping, fronting and gliding of liquids were processes whose frequency was reduced by 50% in the 4 year old children.

The rate at which the processes are suppressed varies between children but the greatest rate of process suppression occurs between 2 ½ and 4 years of age. Roberts, Burchinal and Footo

(1990) note that the most commonly occurring processes (children between 2 ½- and 4- years - old), are deletion of final consonants, cluster reduction, fronting, stopping, and liquid gliding.

Goldstein and Washington (2001) conducted a collaborative study to investigate phonological patterns in 12 typically developing 4- year old bilingual (Spanish- English) children. The results indicate that there were no significant differences between the two languages on percentage of consonant correct; percentage of consonant correct for voicing, place of articulation, and manner of articulation; or percentage of occurrence for phonological processes. Most commonly occurring phonological processes included stopping and final consonant deletion in English and liquid simplification and cluster reduction in Spanish.

James (2001) examined the occurrence of 30 phonological processes in 50 Australian children across the age range of 2.0-7.11 years. Children's most spontaneous naming of 199- mono, di-, and polysyllabic words which repeatedly sampled all consonants and vowels in all different position was used. The results show that the greatest reduction in phonological process was between 3-4 years of age. Phonological processes that persist beyond 4 years of age were velar fronting, depalatalization, vocalization, cluster reduction, final consonant deletion, gliding, vowel changes, epenthesis, velar assimilation, glottal replacement and fricative simplification (θ and ð).

Phonological processes in other languages

With the rapidly increasing number of clinical referrals for children whose first language is not English, it is important to consider the cross-linguistic application of phonological processes. If phonological processes are innate and universal, they must be attested across languages. A study of Italian children (Bortolini & Leonard, 1991) found commonalities across languages in the developmental patterns of both typically developing and disordered phonological systems. Exceptions were attributed to differences in the sound classes that occur. The trilled Italian /r/, for example, was commonly replaced with [1], rather than glides, as commonly occurs for the English rhotic consonant. Yavas and Lamprecht (1988) observed cluster reduction and liquid gliding in Portuguese-speaking children, but stopping of fricatives, glottal replacement and obstruent devoicing did not occur. So and Dodd (1994) found common processes used by both Cantonese- and English-speaking children, but observed a low frequency of gliding as well as processes in Cantonese that are not typical in English (e.g., initial consonant deletion, backing of alveolars, and substitution of [h] for aspirated plosives and /s/). Although these investigators found phonological process analysis to be a useful means of describing speech patterns cross-linguistically, there were major differences in the frequency of usage of processes across languages. This suggests that the articulatory account of children's productions is not a complete explanation of the patterns (Ingram, 1997).

Topbas (1997) studied the phonological acquisition in Turkish children and reported that from a cross linguistic perspective, the phonological patterns exhibited coincide broadly with universal tendencies, although some language specific pattern were also evident. In Turkish /l/ was substituted by /r/, i.e. liquid realization of another liquid where as in English, /r/ is usually replaced by /w/ or /j/ a gliding process.

Dyson and Amayreh (1998) examined the normal acquisition of Arabic consonants between the ages of 2.0 and 6.4 years. The results suggest that the ages of customary production, acquisition and mastery of Arabic consonants were similar to those for English but with notable exceptions. The ages of acquisition of Arabic consonants fell into three development periods: early, intermediate, and late. During the early period in this study, the children acquired at least

10 standard consonants or half of the 28 consonants of Arabic when the acceptable forms were counted. The intermediate period (4.0 to 6.4 years) roughly matches the stage in which the child completes the phonetic inventory (4.0 to 7.0), including difficult consonants (Ingram, 1989). In the present study most of the fricatives, the affricate, and the liquid /r/ were acquired during 2-3 years of age. The late period proposed for those children might be compared to Ingram's stages of morphophonemic development and spelling. Those consonants not acquired by the oldest children in the study would be expected to be acquired after 6.4 years old. Conclusion was made that, medial consonant productions were significantly more accurate than initial and final consonants.

The phonological acquisition of 129 monolingual Putonghua- speaking children, aged 1.6 to 4.6 years is described by Dodd and Hua (2000). Putonghua (Modern Standard Chinese) syllables have four possible elements: tone, syllable-initial consonant, vowel, and syllabic-final consonants. The children's errors suggested that Putonghua- speaking children mastered these elements in the following order: tones were acquired first; then syllable final consonants and vowels; and syllable-initial consonants were acquired last. Simple vowels emerged early in development. However, triphthongs and diphthongs were prone to systematic errors. The acquisition of 'weak stress' and 'rhotacized feature' was incomplete in the oldest children assessed.

Other factors, such as functional load or frequency of occurrence, are also important (Pye, Ingram, & List, 1987; Vihman & Velleman, 2000). Pye and colleagues argue that sounds will be acquired early if they occur in a greater number of important words in the child's early expressive vocabulary. The fricative /v/, for example, occurs in the early vocabulary of Italian children, whereas it is a later-occurring fricative in English. Findings of cross-linguistic studies suggest that more information is needed to make appropriate clinical decisions than is provided by process analysis alone.

Phonological processes in Indian languages

In situations where the child's native language is not English or when a child speaks a language, it would not be appropriate to apply the sound development norms for an English phonological system. It is important to become familiar with the phonological (sound) and linguistic system of the child's primary or dominant language.

The literature on phonological processes is mostly from the Western studies and is inadequate in Indian languages. Therefore, we know relatively little about the phonological development in Indian languages. However, in the recent past a number of such studies have been attempted in several Indian languages focusing on the normal phonological process usage and these have been briefly reviewed in Table 3.

AUTHOR	LANGUAGE	AGE GROUP	COMMON PROCESSES OBSERVED
Sunil (1998)	Kannada	3-4 years	Fronting, cluster reduction, initial consonant deletion, and affrication
Jayashree (1999)	Kannada	4-5 years	Fronting, cluster reduction, and stopping
Ramadevi (2002)	Kannada	5-6 years	Stridency deletion, de-aspiration, and retroflex deletion
Sreedevi , Jayaram & Shilpashree (2005)	Kannada	2-3 years	Retroflex fronting, trill deletion, depalatalization, de-affrication, stopping, cluster reduction etc.
Sameer (1998)	Malayalam	3-4 years	Cluster reduction, final consonant deletion, epenthesis, affrication, apicalization, de-affrication etc.
Bharathy (2001)	Tamil	3-4 years	Epenthesis, cluster reduction, gliding, nasal assimilation, voicing, de-affrication, stopping and fronting
Ranjan (1999)	Hindi	4-5 years	Cluster reduction, partial reduplication and aspiration
Santhosh (2001)	Hindi	3-4 years	Cluster reduction, partial reduplication and aspiration
Rahul (2006)	Hindi	2-3 years	Retroflex fronting, affrication, de-aspiration, de-nasalization, /h/deletion, monothongization, stopping
Merin & Sreedevi (2010)	Malayalam	3-3.6 years	Cluster reduction, epenthesis, stopping, fronting, palatalization, affrication
Vasanta (1990)	Telugu	4^{th} and 6^{th} Graders	Systematic processes: fronting, stopping, voicing errors, liquid gliding, backing Structural processes: Consonant deletions, cluster reductions, assimilations, reduplications, syllable reductions.

Table 3: The phonological processes in Indian languages

Ranjan (2009) studied the developmental data on phonological process in 3-5 years old English speaking Indian children. Results indicate that in 3-4 year old children, the most commonly occurring phonological processes were cluster reduction, final consonant deletion, strident deletion and assimilation. The least occurring processes were diphthong reduction, vocalization, initial consonant deletion, backing of vowel, de-affrication, and gliding. Fronting and backing of vowel was found only in two children and stops replacing glide, affrication, and vowel harmony was found in only one child. The most commonly occurring phonological processes in 4-5 year old English speaking Indian children were cluster reduction, final consonant deletion, and strident deletion. The least occurring process was diphthong reduction, vowelization, initial consonant deletion, backing of vowel, de-affrication and assimilation. Fronting and gliding was present in only two children. Apicalization and diminutization were present in only one child.

Venkatesh, Ramsankar, Nagaraja and Srinivasan (2010) investigated the phonological processes in groups of predominantly Tamil speaking children and bilingual Tamil-Telugu speaking children in the age range of 4.6 to 6 years. A total of 60 children including 15 Tamil and 15 Tamil Telugu speaking children in the age range of 4-5 and 5-5.6 years participated in the study. Results provided preliminary evidence for differences in the development of phonological skills in the two groups. The phonological processes of initial consonant deletion, final consonant deletion, syllable deletion, cluster reduction, affrication, gliding of liquids, fronting, deaffrication, vowel assimilation, nasal assimilation were observed to be operating in the speech of monolingual children in the age range of 4-5 years. The processes were found to decrease with age and observed less frequently as age increases. In contrast to monolingual group there was an increase in frequency of processes in bilingual Tamil-Telugu speaking children. While most of the errors resolved by the age of 5 years in the monolingual group, most of the errors persisted in higher bilingual group studied.

The different speech sounds are acquired at different ages in typically developing chidren. Various studies have been investigated and suggested that the speech sounds are acquired by typically developing children and are specific to different Indian languages and gender. Divya (2010) suggested that in 2-3 years old Malayalam speaking children acquire bilabials, labiodentals, dentals and velars were acquired earier compared to alveolar, palatal, and glottal sounds. Unaspirated sounds were acquired earlier compared to aspirated sounds. While Usha (2010) reported that in 2-3 years old Telugu speaking children acquired unaspirated sounds earlier than aspirated sounds. Gender is another possible contributor to differences in the capacity to acquire speech sounds in early childhood. Huttenlocher, Haight, Bryk, Seltzer, and Lyons reported faster maturation in language capacities in girls than boys.

Phonological processes in disordered population

Mackay and Hodson (1982) collected speech samples of 20 mentally retarded children between the ages of 6 year, 4 months and 15 year and were analyzed for the purpose of identification of systematic patterns. Liquid deviations and cluster reductions were the most prevalent phonological processes evidenced in their misarticulations. Postvocalic obstruent omissions, deviations of other sonorants (glides and nasals), velar deviations, stridency deletion, stopping, and /θ, ð/ deviations were demonstrated less frequently. In addition, the children demonstrated pre- and postvocalic devoicing.

Wolk and Edward (1993) provided a detailed phonological investigation of the speech of an 8-year-old autistic boy. Three approaches were used for elicitation of speech: delayed imitation, object naming, and a connected speech sample. Phonetic inventory analysis revealed that stops, nasals, and glides were generally present, whereas fricatives, affricates, and the liquid /r/ were absent. This information, together with a phonological process analysis, revealed: (a) the existence of several phonological processes that are common in normal development; (b) the persistence of several phonological processes, e.g., velar fronting, beyond the expected age; (c) the occurrence of some unusual sound changes, e.g., extensive glottal replacement and segment coalescence; (d) evidence of “chronological mismatch” (Grunwell, 1981); and (e) restricted use of contrasts (Ingram, 1976). The subject's use of phonological processes resulted in extensive homonymy, which, together with process interactions and the use of jargon, resulted in severely reduced intelligibility. This child appeared to be acquiring his phonological system in at least a partly unique way, showing some typical patterns as well as some patterns that rarely appear in normally developing children.

Based on a study on 6 year old hard of hearing child, Oller, Lafayette and Jensen (1978) reported two main results (a) the phonological substitutions and deletions of this hearing impaired child are basically same in kind as those found in the speech of younger normals and (b) the phonological processes of the child’s system fit into groups of processes, each group operationalizing some phonetic preference of the child.

The comparative research of Hodson and Paden (1981) sought to determine the phonological processes used by 60 unintelligible and 60 intelligible 4 years old. It was found that the use of specific phonological processes differentiated the intelligible and unintelligible groups. For example, the unintelligible children used cluster reduction, stridency deletion, and stopping in their speech, but most (72%) of the intelligible children did not. This work suggests that the productivity of selected processes may be important in differentiating intelligible and unintelligible 4 year- old children. If so children with functional, multiple articulation disorders are being redefined as phonologically disordered (Locke,1983; Mc Reynolds & Elbert,1981), then the data-based profiles of phonological development become increasingly important (Ingram, 1981).

Suppression of Phonological Processes

The simplification processes described do not disappear in child speech at the same time. Different processes have varying permanence in developing phonologies. Focusing on age norms, some investigations are worth mentioning. Stoel- Gammon and Dunn (1985) divided processes into two categories as those processes disappearing by age 3 years and as those persisting after 3 years (Table 4).

PROCESSES DISSAPEARING BY 3 YEARS	**PROCESSES PERSISTING AFTER 3 YEARS**
Unstressed syllable deletion	Cluster reduction
Final consonant deletion	Epenthesis
Velar fronting	Gliding
Consonant harmony	Vocalization
Reduplication	Stopping
Prevocalic voicing	De-palatalization
-----	Final Devoicing

Table 4: Phonological processes before and after 3 years

Based on the results of various studies and often cited sources (Grunwell, 1987; Lowe, 1995, Smit, 1993a, 1993b, 2004), disappearance of individual processes that apply to at least 75% of sampled children may be suggested as follows (Penna- Brooks & Hegde, 2007) as shown in Table 5.

SL NO	PHONOLOGIC PROCESS	LIKELY AGE OF DISAPPEARANCE (IN YEARS)	SL NO	PHONOLOGIC PROCESS	LIKELY AGE OF DISAPPEARANCE (IN YEARS)
1	Denasalization	2.6	11	Depalatalization of initial singles	5
2	Assimilations	3	12	Alveorization	5
3	Affrication	3	13	Cluster reduction (with /s/)	5
4	Context- sensitive voicing change	3	14	Final devoicing	5
5	Final consonant deletion	3	15	Labialization	6
6	Frontinf of initial velar singles	4	16	Initial voicing	6
7	Deaffrication	4	17	Gliding of initial liquids	7
8	Derhotacization	4	18	Vocalization of prevocalic liquids	7
9	Cluster reduction (without /s/)	4	19	Epenthesis	8
10	Depalatalization of final singles	4.6	20	Consonant cluster substitution	9

Table 5: Likely age of disappearance of phonological processes

Clinical application of Phonological processes

Before phonological processes came to use into clinical assessment procedures, the traditional method prevalent for treatment were sound-by-sound approaches that taught one sound at a time, usually in a developmental order. Hence behavioral modification strategies were used to teach the target sounds. According to natural phonology, learning to pronounce requires suppression of the innate phonological system (Stampe, 1979). Evidence for this claim is provided by the observation that children make across-the-board changes once they produce a segment that they did not use previously. This view is popular among many practitioners as it asserts that a child knows the sound; consequently, he or she simply needs to learn from experience to suppress the innate processes in question.

Clinicians used standardized articulation tests for assessment that do not differentiate among error types. With the publication of a number of phonological process analysis procedures, process analysis became more widely applied in clinical practice, especially during the 1980s and 1990s (Dean, Howell, Hill, & Waters, 1990; Grunwell, 1985; Hodson, 1980; Ingram, 1981; Shriberg & Kwiatkowski, 1980; Weiner, 1979).

Issues in the Clinical Application of Phonological Processes

In spite of its wide acceptance of the phonological processes analysis, there are a few issues pertaining to the procedure that have been widely discussed. Some of the issues are discussed below.

1. Lack of agreement on what constitutes a process

Natural phonology theory is based on observations of ‘normal’ phonological acquisition, not the clinical observation of phonological disorders. Patterns observed in disordered systems cannot always be described by natural phonological processes. As a result, most clinicians use phonological processes to label the patterns observed in a child's speech production without regard to theoretical underpinnings. Subsequently, most clinical procedures now use the term phonological patterns to refer not only to natural phonological processes, but to any patterns observed in children's productions. Totally discarding the concepts put forth in natural phonology allows clinicians to label more patterns, but it results in a lack of distinction between patterns that occur in typical development and those that are atypical or unusual (Edwards, 1992). Determining the presence of typical patterns vs. unusual ones provides information on intelligibility, severity of disorder, prognosis and appropriate targets for intervention.

2. Lack of agreement on labels

The same pattern is not described uniformly across process analyses. Fronting, for example, may refer to velar fronting or to any phone produced more anterior to the target, for example, producing [p] for [k]. Some terms used to describe processes result in contradictory or redundant processes within an individual and lead to confusion when analyzing data.

a. Conflicting processes

Fronting and backing, for example, may be reported in the same child. Productions of [kap] for 'tap' and [ri] for 'key' may be described as backing and fronting respectively. When this happens, a key pattern is ignored. A more likely explanation of this example, and a more helpful one with regard to treatment planning, is that both instances are the result of assimilation, with front vowels triggering a more anterior production and back vowels triggering the dorsal stop. Teaching this child to produce more words with /k/ or /t/ without consideration of vowel context would not be useful.

b. Redundant processes

Stridency deletion refers to the lack of a stridency contrast. Although this label is not common across all analysis programs, it is often used to refer to any pattern that result in the loss of a strident phoneme regardless of whether or not the two segments in question contrast in stridency. Producing 'sea' as [ti], for example, may be described as both stridency deletion and as stopping. The two opposing segments, /s/ and /t/, however, do not contrast in stridency. In English, the only non-redundant stridency contrasts are /s/ and voiceless /θ/ as in 'sink' and 'think' and the contrast between /z/ and /∂/. Ignoring this distinction prevents the understanding of what a child is doing. To produce 'sink' as 'think' is not the same process as producing 'sink' as ‘rink’. Clearly distinguishing among patterns describes a child's system more accurately and yields more useful information regarding treatment priorities.

3. Lack of understanding of what a child can produce

Process analyses describe each word in a sample and assign processes to that individual word without looking at the entire sample for commonalities in the actual productions. Velleman (1998) described the process analysis of a hypothetical child's speech that revealed eight processes: fronting, backing, initial consonant devoicing, stopping of fricatives, stopping of liquids, cluster reduction, alveolar consonant harmony and reduplication. One process, alveolar consonant harmony, described the largest number of errors. There were, however, a number of errors that did not conform to this pattern. In addition, contradictory processes occurred, such as fronting and backing. A reanalysis of the data, with attention to the entire sample and using the most general possible description of the child's productions, revealed that the child's phonological system contained two singleton consonants, [d] and [n]. Typically, attention is paid to what a child cannot do in relation to the adult, but not to what a child can do. Understanding that a child's phonetic inventory is limited to two consonants explains the problem and provides the information needed to design an efficacious treatment. A process account does not allow for a description of a system of this type. Recent constraints-based theories show promise for facilitating more elegant descriptions of highly constrained phonological systems.

Phonological process analysis

Once the speaker’s phonological profile is reviewed in terms of intelligibility and/or severity and age appropriateness, the clinician reviews the nature and pattern of the error production to determine the nature of a client’s phonological system. Procedures designed to provide a composite of individual productions are sometimes referred to as pattern analysis and are particularly appropriate for those clients with multiple errors. This type of analysis is based on the assumption that children's speech sound errors are not random, but represent systematic variations from the adult standard. Clinicians compare the child's productions with the adult standard, and then categorize individual errors into phonological patterns. Until 1970s and 1980s clinician used substitutional analysis and organized speech sound errors into patterns. But later clinician began to emphasize the identification of phonological processes, patterns and rules. Pattern analysis procedures provide a better description of the child's phonological system than does a traditional categorization of errors such as substitutions, distortions and omissions.

In phonological analysis, gather a spontaneous speech sample, transcribe it in the International Phonetic Alphabet, and attempt to discern patterns of error (processes) in the data. This is obviously more time consuming than the measures mentioned above, but it is also more valid because the clinician is examining actual utterances that were generated by the client's cognitive linguistic system. The analysis of a spontaneous speech sample is recommended by Shriberg and Kwiatkowski (1980) in the Natural Process Analysis (NPA). This procedure specifically targets eight processes for analysis and provides valuable information for the practitioner and represents a well planned procedure.

Ingram (1981) developed the Procedures for the Phonological Analysis of Children's Language (PPACL), which includes a phonetic analysis, homonym analysis, substitution analysis, and phonological process analysis. Twenty seven specific processes are targeted. However, Ingram stated that the analysis is "open ended" and can continue "until all the substitutions in a child's speech have been explained".

Grunwell (1985) developed the Phonological Assessment of Child Speech (PACS), which provides a description of analysis procedures for a preferably spontaneous connected-speech sample of more than 200 words. The procedure results in phonetic analysis, contrastive analysis to determine which phones are used to make meaning differences, and a phonological process analysis. The Phonological Assessment of Child speech also provides a developmental framework that is missing in many phonological analysis techniques.

Identification criteria for the phonological processes

- ✓ Non- quantitative criteria

There is only one criterion for demonstrating the child's error as the presence of processes. The child's error conforms to the description of it. The error should occur only once, for an utterance to qualify for inclusion under that processes. For example, if a child omitted /k/ in /make/, the production was listed under the process of Final Consonant Deletion. Other instances of omission of final /k/ or consonants in a variety of words were not required to list Final Consonant Deletion as a process in the child's system.

Test instruments such as ALPHA (Lowe, 1986) rely on normative data to determine if a process should be targeted for intervention but, other than meeting the pattern of sound change described by the process description, no quantitative data is used. Thus if a particular sound change occurs even once, a phonological process is identified.

- ✓ Quantitative criteria

Different researchers gave different quantitative criteria for validating the presence of processes. More stringent criteria would not identify as many processes, while less stringent criteria would identify more. Mc Reynolds and Elbert (1981) suggested two quantitative criteria, and unlike non quantitative criteria, one occurrence of a sound change does not necessarily signify the presence of a process. After all, by definition a process is a sound change that affects a class of sounds. Their suggested criteria are (a) specific errors must have an opportunity to occur in at least four instances, and (b) the error has to occur in at least 20% of the items that could be affected by the process.

More stringent criteria is offered by Hodson and Paden (1991), who suggest that a phonological process must have at least a 40% occurrence before it is selected as a treatment target. Processes that occur in less than 40% of opportunities would be monitored but not addressed in therapy. It should be noted that Hodson's and Paden's criteria is intended for the identification of Phonological processes that are in need of remediation rather than for the classification of specific phonological processes.

Lowe (1996) suggest that the minimal requirements for qualifying a sound change as a phonological processes are that (a) the process must affect more than one sound from a given sound class, and (2) the sound change must occur in at least 40% of the time.

Sound change affects classes of sounds rather than individual segments or unrelated segments because the rules required affecting isolated sounds would involve more features and thus be more complex. In any case, the smallest grouping possible would have two members that share some dimension. Given this criteria, the identification of a phonological processes would require that at least two sounds (having a common dimension) can be changed in a similar manner.

Ramadevi (2006) classified phonological processes into three categories based on the percentage of subjects exhibiting these phonological processes. First category comprised of phonological processes occurring in 20% or less than 20% of subjects which is considered as **occasionally occurring processes**. In the second category, phonological processes occurring in 20%-60% of children were considered as **frequently occurring phonological processes** and the third category comprised of more than 60% of children exhibiting phonological processes and is considered as **occurring most of the time**. Rahul (2006) and Merin (2010) used similar quantification of phonological processes in 2.0 - 3.0 and 3.0 - 3.6 years respectively.

Computerized Assessment of Phonological Processes

With computer extending its application in every field, speech language pathologists also sought to increase the efficiency of their analysis of phonological samples through the assistance of computer analysis. With varied analysis procedures used rather than the traditional substitution- distortion- omission analysis of articulation inventories as the primary data base for making clinical decisions, the amount of time required to analyze phonological samples became a major practical consideration. Moreover much of the work in phonological analysis is laborious and repetitive. Major difficulties of keeping track of the data on a host of different worksheets, tallying up percentages and frequency counts, and cross checking a variety of relationships found in different portions of the client's transcript. All these procedures were time taking. In short as the clinician started analyzing the speech sample for distinctive features and later, phonological processes, the kinds of things that were being done "by hand" seemed to be tailor-made for computer analysis.

The nature of these tasks is ideally suited to computer analysis. The computer can take a corpus of language and the gloss of each utterance and produce more information than even the most zealous clinician would even like to know about a child's phonological system. In some cases, computer analyses of human behavior are rather superficial, and the programs available are just in the early stages of development.

However in the case of phonological analysis, the computer programs are detailed and user friendly. An analysis that might take a clinician's several hours to accomplish can actually be completed in less than a few minutes by most programs. The software is compatible with most popular types of microcomputers available. The programs differ in their scope, ranging from those designed to analyze the responses from a particular test of phonology to those focusing on the assessment of spontaneous samples of connected speech (Hodson 1985; Long, Fey, and Channell 2002; Shriberg 1986). There is no question that computer application offer the clinician tremendous options for analysis (Louko & Edwards 2001; Masterson 1999).

Ingram and Ingram (2002) advocate using computer- assisted methods for sampling, transcription and storage. They suggested recording the sample directly onto the computer as WAVE file so the clinician will have a digital copy of the sample. This allows for ease in transcription, since there is no need to rewind an audiotape and the sample can be copied to a CD-ROM for storage and later comparisons. It is also possible to interface this sample with various speech analysis programs so that waveforms can be analyzed, if this will aid in interpretation of the sample. One example of such a program is provided by www.sil.org and is called Speech Analyzer. This program is freeware and can be downloaded for use in analyzing wave files and subjecting them to spectrographic analysis.

Masterson and Long (2004) indicated that there are two primary reasons for using a computer based analysis of a phonological sample: (1) it saves time, and (2) it provides greater details of analysis than one typically produces with traditional paper and pencil (manual) analysis procedures.

In order for the computer to analyze a phonological sample, there should be an input to the system. This input typically involves typing into the computer based on the response of the client. Once the phonetic transcriptions have been entered, the computer can carry out the types of analysis prescribed by a given program. Some of the analyses that a computer can perform (depending on the program) are the following

- ✓ Determination of phonological processes that is common to multiple error productions.
- ✓ Determination of distinctive feature error patterns.
- ✓ Delineation of substitutions and deletions by word positions
- ✓ Provision of quantitative data, such as frequency and/or percentage of occurrence.

In English, several such computer based analysis have been developed. The computerized Articulation and Phonology Evaluation System (CAPES) (Masterson and Bernhardt, 2002) is a good example of such a system that was developed to elicit and analyze phonological productions. Some other Computerized phonological analysis programs are Computer Analysis of Phonological Processes (CAPP) version 1.0 (Hodson, 1985), Computer Profiling (CP) (Long & Fey, 1988), Logical International Phonetic Programs Version 1.03 (LIPP) (Oller & Delgado, 1990), and Programs to Examine Phonetic and Phonologic Evaluation Records Version 4.0

(PEPPER) (Shriberg, 1986). Each of these programs has its own strengths and limitations, and undoubtedly future procedures will add new and helpful procedures for clinicians.

The chief advantage of using a computer to analyze phonological patterns lies in expected time savings for the analysis, and a potential for obtaining and organizing large amounts of data in a more systematic fashion. Moreover the accuracy of quantitative data derived through computer analyzes is more certain. However computer doesn't "do it all". As Stoel, Gammon and Dunn (1985) pointed out, in some instances (particularly in the cases of assimilation and metathesis processes). Speech sound productions may be incorrectly analyzed since most computer programs have difficulty with relational analyzes within words. Furthermore, most computer analysis procedures are not yet sophisticated enough to determine process ordering. In computer assisted analysis since the input given is usually limited to a preselected number of phonological rules, the final analysis may be limited indeed.

There are five parameters by which various programs can be evaluated and judged. These parameters are;

- ✓ Method of data entry
- ✓ Method of data processing
- ✓ The options for output analysis
- ✓ Hardware requirements
- ✓ Documentation and support.

From the consumer's perspective, these five features largely determine whether a program is affordable, whether it is practical to use, and whether it analyzes that are clinically valuable.

Computer based Phonological Tests

1. Computer Analysis of Phonological Processes Version 1.0 (CAPP; Hodson, 1985)

This test yields data on percentage of occurrence for phonological processes described by Hodson (1985). CAPP includes a closed set of 50 words for which the user enters the transcription form produced by the client in a modified IPA format. IPA characters are included on a standard keyboard are used that are not are entered with alternate symbols. Vowel characters are not analyzed. The orthographic glosses of each target words are provided. A space corresponding to each target character is provided and the user enters the client's transcription form. The space bar is denoted to indicate deletions. The program does not accept a transcription form entry until characters corresponding to each of the target characters have been entered. A transcription form must be entered for all target words. An editing function is available to users before the analysis is performed. However, once the analysis is completed, users cannot access the data that were entered.

Data cannot be saved to a disk. Consequently, users cannot enter transcriptions for part of the words at one time and finish at a later time, nor can data be saved for future comparisons. The program contains no utility for printing or viewing the entire data file at once.

The program yields the following:

- Percentage of occurrence for 10 target patterns
- Overall average percentage of occurrence of phonological processes
- Phonological deviance score
- Severity interval
- List of target patterns that should be initially targeted as goals in therapy

No information regarding conventions used in process assignment is included. The program does not allow the user to view words containing errors classified as an occurrence of a phonological process.

CAPP runs in any of the Apple II series computers. The program disk is self booting, so no additional software is necessary. CAPP is easy to use and data can be entered quickly. Clinicians with little or no experience with microcomputers should able to use this software. It takes less than 10 minutes to enter the client's response to the 50 word items. It uses closed set and spontaneous speech data cannot be analyzed. No phonetic information, such as consonant inventory, is provided. Words classified as containing an error are not displayed so users cannot judge for themselves whether the classification is appropriate.

2. Computerized Profiling (CP; Long & Fey, 1988)

Computerized profiling is a diverse set of programs that can be used to perform various analyses of speech sample data. Included in the data is a set of modules for doing a Profile of Phonology (PROPH). PROPH was developed by Crystal and Fletcher (1982) and the computer program is derived from their manual procedure. The major difference in the computerized version is the omission of a syllable stress analysis and the replacement of the distinctive feature analysis by a phonological process analysis based on the descriptions by Grunwell (1987).

CP runs on different types of microcomputers, and data entry varies according to the version of the program. In the MS-DOS (IBM- compatible) and ProDOS (Apple II series) versions, a transliterated version of the IPA is used. Phonetic symbols that are identical with English letters or standard keyboard symbols are entered by pressing the appropriate key. For each item to be analyzed, the program requires three forms to be entered: the gloss, the target form, and the transcription form produced by the client. To simplify the task of data entry for articulation tests, gloss and target forms may be stored in disk files and then retrieved for each client. Thus the user needs to enter only the transcription form. To simplify entry of connected speech data, the program includes a modifiable phonetic dictionary.

CP offers nine options for its analysis of the data:

- Listing of gloss, target, and transcription forms.
- Word shape analysis
- Classification of correct vowel productions and vowel changes
- Classification of consonant productions as correct, substituted, or omitted, and organized by sound- position and manner
- Percentage consonants correct
- Phonetic inventory, organized by sound- position and manner class
- Phonological process analysis, organized by sound- position and developmental order
- Alphabetized word listing
- Printing of a diacritics key.

The user may select any or all of these options to be included in a profile report. The simplified procedures for data entry make the program very accessible to beginning clinicians and save time for all users. CP also includes modules for semantic, syntactic, pragmatic, and prosodic analyses. The users need to only enter a sample once to obtain results regarding not only phonology but also other linguistic skills. All output from the program is automatically saved in the text files, which may be viewed on the screen, printed, or loaded into other applications such as word processor.

3. Logical International Phonetic Programs - Version 1.03 (LIPP; Oller & Delgado, 1990)

LIPP is highly innovative and flexible approach to computerized phonological analysis. Unlike other software developed for this purpose, nearly every feature of LIPP- the phonetic alphabet it uses, the arrangements of the symbols on the keyboard, the number and type of analyses it performs- can be modified by the user.

Data can be entered on three lines representing the gloss, target and transcription forms, respectively. LIPP is well designed for the analysis of both articulation test and connected speech data. A template file containing the gloss and target forms from ay test can be created and stored. To enter a client's data, this file is retrieved, the transcription forms are entered, and the file is saved under a different name. To simplify the analysis of connected speech, LIPP contains a modifiable phonetic dictionary. LIPP has a very sophisticated scheme for representing phonetic values. Every symbol in a phonetic alphabet is assigned a value for 16 different phonetic parameters. This allows the user to define individual sounds, diacritics, and sound classes in terms of unique parameter configurations. LIPP provides two types of analysis: (1) an inventory analyses, which compares the corresponding segments on the target and transcription lines; and (2) rule driven analyses, which are flexible and may be used to count sounds, calculate percentage of correctness, evaluate structural characteristics of the sample, perform phonological process analysis, and many other tasks.

LIPP is sold in three packages: The low- end version (Thin LIPP) includes only the modules for creating transcription data files; the middle version (Lower LIPP) adds a set of rule- statement files along with the modules needed to execute the analysis.; and the complete version (Upper LIPP) adds the modules that allow users to modify symbols and alphabets and to write their own rule statement files. All versions of LIPP require an IBM- compatible computer with 640K of RAM, a hard disk, and an EGA or VGA graphics monitor.

LIPP is an expensive product but a unique program. It is unique because of the amount of flexibility it offers to the users. LIPP is extremely well designed to take advantage of menus and word processing editing features; it remains an elaborate program and takes time to master. Moreover, LIPP assumes that the user is well versed in phonetic symbology and phonological theory and terminology.

4. Process Analyses -Version 2.0 (PAC; Weiner, 1986)

Process Analysis (PAC) analyses phonetic responses to a closed set of 59 monosyllabic words. The program yields a phonetic inventory of initial and final sounds and a frequency count of several phonological processes. Words elicited via formal tests or during conversational speech cannot be analysed by PAC. The program user is shown the gloss form of each word and then must enter a transcription of the client's production. Vowels are not considered in the analysis. The number of consonants in the transcription form must equal the number included in the target. If the user attempts to enter more or fewer consonants that are included in the target word, the computer will beep and display a reminder message to enter the response correctly. Consonants entered appear as IPA symbols on the screen. The user must become familiar with how phonetic symbols are entered via the keyboard.

Output includes phonetic inventories with frequency counts for each initial and final sound that appears in a transcription form. The number of possible occurrences and corresponding percentages are provided for approximately 15 phonological processes including deletion of initial or final consonants, stopping, fronting, assimilation, cluster simplification, and gliding of liquids. The program does not list the words in which specific phones or phonological processes were found. Analysis results can be viewed on the screen and/ or printed. PAC does not allow the results of an analysis to be saved to a disk. However, the analyses performed are completed rapidly, so little time is lost in repeating the analysis of a previously saved file.

PAC's primary weakness is its inability to handle words elicited spontaneously or via formal tests. The stimulus set included monosyllabic words only, so word-medial consonant production is not considered. Further, the use of only simple phonological structures prohibits the exploration of the influence of increased phonological complexity on the occurrence of errors or the contents of phonetic inventories. The assignment of error to only one process precludes identification of any processes that may be operating simultaneously.

5. Pye Analysis of Language Version 2.0 (PAL; Pye, 1987)

It is a set of programs for carrying out linguistic analysis of transcript data. The PHONIX program, in particular, is intended to facilitate a number of phonological analysis procedures recommended by Ingram (1981).

Analysis of a sample occurs in five steps. First, a transcript is created and saved in text (ASCII) format. This file is then input to the FORMIX module of PAL and checked for format errors. If errors are found, they must be edited with a word processor. Otherwise, the third step is to input the file to the PHONIX module of PAL and create a phonological lexican file. This lexicon lists all the word types that occurred in the sample along with their phonetic tokens. The file, in the form of a report, must then be edited with a word processor so that it contains only the data that user wishes to analyze. The fourth step is to run this edited file through a phonetic dictionary, which automatically finds the target form for each of the words in the sample. For words not contained in the dictionary, the user must add the target form to the file with a word processor. Finally, the file containing the lexical, target, and production forms is submitted for phonological analysis by the program.

PAL's phonological analysis consists of a phonetic inventory and a substitution analysis. Both analysis display initial consonants, vowels, and final consonants separately. Word- medial consonants are not analyzed. The phonetic inventory does not yield a count for each sound but rather lists all the production forms in which the sound occurred. The program does calculate the number of phonetic types occurring for each sound class (vowel, consonant) and position (initial, final). Clusters are analyzed in terms of the individual segments they contain.

PAL may be viewed as a program that can provide assistance to a clinician doing a phonological analysis by hand. Unlike other programs, PAL is not designed to yield a finished phonological analysis. Instead, it helps the user with several of the most time consuming and tedious tasks of organizing a data set, alphabetizing the word list, finding and listing all productions of the same word, organizing and listing all the sounds contained in the transcription forms, and so on.

The strengths of PAL includes (a) It is able to analyze any set of words, including connected speech data; (b) it analyzes vowels; (c) it is extremely fast; and (d) it handles very large data sets.

6. Programs to Examine Phonetic and Phonologic Evaluation Records - Version 4.0 (PEPPER; Shriberg, 1986)

It is a comprehensive approach to the analysis and interpretation of phonological data. The software provides information about an individual's phonetic abilities and the phonological simplifications used. Three lines of data are entered: (1) the orthographic gloss form, (2) the phonetic target form, (3) the phonetic transcription form produced by the subjects. Entry lines can accommodate either single words or connected speech. PEPPER employs a graphics mode which allows data for the target and transcription lines to be entered in IPA symbols. Diacritics also are allowed, as are several other useful symbols to represent segments as on- or off glides, unintelligible, and so on, or to indicate suprasegmentals.

The software yields the following:

- Structural statistics, which include the syllabic structures intended and obtained, average words per utterance, and type token percentages.
- Artic tests, which provide percentage of occurrence for correct use, deletion, substitution, and distortion for each individual consonant and for vowel and for each class, place, manner, and voicing classification of consonants and vowels; and an item analysis that lists each target word along with the correct, omitted, substituted, or distorted phonemes it contains
- Percentage consonants correct figures for various data sets
- Phonetic inventories for word-initial and –final phonesPhonological process analysis, which includes percentage of occurrence of each of the eight natural phonological processes described in Shriberg and Kwiatkowski (1980), a listing of words by vowels and canonical form, and phonological processes occurring in each word.

In addition to the output provided by the software, the PEPPER manual contains several tables that are beneficial in interpretation of results. The documentation contains explicit definitions that are used by the software to classify errors as phonological processes.

7. The Computerized Articulation and Phonology Evaluation System (CAPES; Masterson & Bernhardt, 2001)

As the name implies; a computer program analyses the phonological data. The stimuli are photographs of 46 words with various word lengths, structures and stress patterns in the single-word tasks that are displayed on the computer screen. Words from other articulation tests and words from a connected speech sample can also be analyzed using the CAPES. The testee names the items, the computer audio records the responses (which can be played back later), and the clinician transcribes the client's words directly into the computer during the test. The results of the profile are used by the computer program to display 10 to 115 additional words for the Individualized Phonological Evaluation, which is a deeper analysis: the words selected are based on the client's performance on the 46 - word profile. The CAPES also provide video clips that can be used to elicit narratives. Transcription of the responses incorporates the English IPA and the stress markers. On the computer screen, the tester chooses among predicted word productions or transcribes the client's productions using the IPA. The types of analysis that can be done are quite extensive and include independent and relational analysis. Word length, word shape and consonant and vowel productions (segment by segment, phonetic features, nonlinear features, and phonological processes) can be analyzed. The analysis can be performed with a dialect filter for African American English for Spanish influenced English. The computer program generates reports that can be edited and provides treatment recommendations.

8. The Hodson Computerized Analysis of Phonological Patterns (HCAPP; Hodson, 2003)

It is a computer software program that was developed to analyze the major phonological deviations appearing on the HAPP-3. *HCAPP, "*user friendly" method, was designed for preschool and school-age children with highly unintelligible speech. This simple program compares the client's phoneme by phoneme productions to the adult standard production. The program works on IBM- compatible and Macintosh computers. The computer analysis yields the percentage of occurrence of each of the 11 major phonological deviations described by Hodson (2004), including the severity rating of the client's phonological system and a goal statement specifying potential target patterns. Analysis by the HCAPP is considerably faster than analysis by hand of the HAPP-3, but the computer program does not identify substitutions and other strategy patterns.

Phonetic symbols representing the child's productions of 50 words can be entered into the computer in approximately 5 minutes [depending on one's typing skills and the individual client's level of severity]. The utterances are analyzed for phonological deviations as soon as the "Results" key is "clicked." Client data can be stored on the hard drive [or on a floppy or CD or flash drive] for future retrieval.

In addition, the printout provides the following:

- Percentage-of-Occurrence scores for Major Phonological Deviations,
- Severity Rating specification [Mild, Moderate, Severe, Profound] for the child's phonological system,
- Goal Statement specifying potential optimal Target Patterns for a highly unintelligible client.

Computerized tests for phonological analysis in the Indian context

In India, attempts made to computerize the assessment of phonological processes were in a base line until the recent past. Ramadevi (2006) developed a phonological profile which used computer for stimulus presentation. Another attempt was made by Merin (2010) for the computerized analysis of phonological processes in Malayalam. The descriptions of these tests are as follows.

1. Phonological profile in Kannada: A study on Hearing Impaired (Ramadevi, 2006)

Ramadevi (2006) developed a computerized module for the presentation of the stimuli in the administration of Phonological profile in Kannada for Phonological assessment in children with hearing impairment.

The assessment tool used Microsoft power point to develop computerized presentation of stimuli. A compact disk contained the assessment tool, which is developed in Kannada language for phonological assessment. When the CD is fed into a computer and played, three icons namely Task1, Task 2 and Task 3 appear on the monitor. When the task 1 is clicked and the slide show and view show is selected, 92 pictures appear on the monitor, one at a time by using the enter button. The subject is asked to name the picture shown. The responses are manually transcribed using a broad transcription. When the correct response is obtained for the picture, we can move to second picture by pressing the "Enter" button thrice. If the correct response is not obtained for the picture, "Enter" button is pressed once, and then the written word is displayed. The response obtained can be recorded. Repetition task can also be employed, then, written word display may be ignored. This form of presentation have many advantages a) the children will be cooperative for testing as it is very interesting and appealing b) it is less time consuming c) less effort involved on the part of the examiner.

2. **Computer based Assessment of Phonological Processes in Malayalam (CAPP-M; Merin, 2010)**

CAPP-M is a user friendly software developed using Malayalam Articulation Test (MAT; Maya, 1990), which was administered on Malayalam speaking children, in the age range of 3-3.6 years. A total of 20 picture stimuli are included in this tool. The clinician listens to the individual child's utterance and clicks on the correct production or any of the three possible patterns of that word or the option "any other" indicating an idiosyncratic process. The software assesses 8 most commonly occurring phonological processes i.e., cluster reduction, epenthesis, affrication, stopping, palatalization, fronting, metathesis and de-affrication. After the administration of the complete test, the clinician clicks on "report" to obtain a summary of the processes exhibited by the child along with its frequency in descending order. The test yields the following;

- ✓ The common phonological processes in each child's utterance
- ✓ The frequency of their occurrence
- ✓ The order in which phonological processes are prevalent

CAPP-M is a quick screening tool, where the phonological processes can be identified in 5 to 8 minutes. The tedious task of identification of phonological processes manually is overcome with the development of this tool. However CAPP-M identifies only 8 phonological processes and considers only three different patterns of production of the children which are limitations of this tool. The output obtained cannot be saved for later purpose and an option selected once cannot be changed once clicked. The entire test has to be repeated if such a situation arises.

To conclude, in this era of computer technology, computer analysis of phonological processes has made test administration less effortful, uncomplicated and a big leap in achieving the goal in a short time. Thus, such tools will reduce the laborious and repetitive manual work involved in traditional phonological analysis and will be an important milestone in the field of computer based assessment of phonological processes.

METHOD

The present study intended to obtain the phonological processes prevalent in the age range of 2.0-3.0 years in Malayalam and based on the results obtained, to develop user friendly software which automatically estimates the phonological processes prevalent in the child's language system in this age range. The study was conducted in 3 phases.

Phase I: To obtain the normative data on the phonological processes prevalent in the age range of 2.0-3.0 years

Phase II: To develop the computerized tool which aids in the assessment of phonological processes based on the normative data collected in phase 1

Phase III: To evaluate the sensitivity of the tool developed in children with hearing impairment and children with mental retardation

Phase I: To obtain norms

Participants: A total of 120 subjects were enrolled in the study. The age range considered for the study was 2.0 - 3.0 years. Out of the 120 subjects, 60 participants each were considered in 2.0-2.6 years and 2.6 to 3.0 years respectively. All the subjects had Malayalam as their native language and were selected from different localities of Alappuzha, a southern district in the state of Kerala. All the participants enrolled in the study were subjected to an informal screening and the inclusion criteria were;

- ✓ Native speakers of Malayalam, belonging to middle socio economic status.
- ✓ Normal speech, language and hearing development

- ✓ No known reports of difficulties in behavioral and /or intellectual functioning
- ✓ No known reports of any neurological illness or trauma

Test material: All the subjects are tested with the Malayalam Diagnostic Articulation Test (Maya, 1990). Malayalam articulation test contains 86 test words where in 14 words assess vowels and 72 test words assess consonants. These words are depicted in familiar pictures of convenient size, which are unambiguous and elicit only a single response. All consonants are tested in initial and medial positions of words. The items of the articulation test are arranged based on the age at which each phoneme is acquired (ie in the order of difficulty). All the subjects are tested with 72 test words which intended to test the consonants with the presumption that vowels will be achieved by 2 – 3 years of age. Divya (2010) studied articulatory acquisition in 2.0 - 3.0 years Malayalam speaking children and found 90% of acquisition for the vowels /a/, /a:/, /i/, /i:/, /c/, /c:/, /o/ and /o:/ by 2.3 years.

The picture stimuli of the 72 test words were recorded in Microsoft Power Point on a laptop computer, for better appeal and attraction for the children. Care was taken to depict the target words in colorful pictures of convenient size which were unambiguous and elicited only a single response.

Procedure: The clinician established rapport with each child before the administration of the Malayalam Articulation Test (Maya, 1990). The participant was seated on one side of the examiner in a quiet room. The stimulus picture was presented through Microsoft Power Point mode using a laptop (Dell- Vostro 1400) computer. The responses obtained were audio recorded using a multimedia microphone. If any of the subjects failed to identify a target word, additional cues were presented by the examiner. In spite of the additional cues, if the child failed to name the target picture, 'repeat after the examiner mode' was used for elicitation. In this way, approximately the test procedure was carried out in a time span of 20-30 minutes for each subject. The test procedure involved the following steps:

1. Transcription: The researcher listened to the recorded speech sample of all the 120 subjects one by one. These speech samples were transcribed using broad and narrow transcription (IPA, 2005).

2. Identification of the Phonological Processes: The phonological process was identified by analyzing the whole target word sound by sound and not just the target phoneme in the word. Based on the sound changes in the word, the phonological processes operating were identified.

3. Calculating the percentage of subjects using the processes: As we know, calculating the percentage of occurrence of each process is tedious since determining total opportunities for occurrence of a particular process is very difficult. Also it is inappropriate to derive percentages for phonological processes that have only a few opportunities for occurrence. For example, there are only two affricates in Malayalam, and then most speech samples would have limited opportunities for de-affrication to occur. According Hodson and Paden (1991), deriving percentages for phonological processes that have fewer than 10 opportunities for occurrence may yield rather skewed results which may give a false impression regarding the importance of the percentage score. Hence in the present study the percentage of children using a particular process was calculated instead of the percentage of occurrence of each process. The percentage of children using a process was calculated by the formula;

$$\text{Percentage of children using a process} = \frac{\text{Number of children using a process}}{\text{Total number of children tested}} \times 100$$

4. Statistical Analysis: Manual statistical procedure was employed to obtain significant difference across gender and age.

Phase II - Development of the Assessment Software

Preparation of the software involved the following steps.

1. Ordering the target words produced incorrectly: The number of subjects producing each test word erroneously was estimated. Then the erroneous words were ordered from the most errored word to the least erroneously produced word. For example, the word /dōktəR/ was produced incorrectly by all the 60 subjects in both the age groups. The word /sImhəm/ was erroneously produced by 59 out of 60 subjects. Hence while ordering; the target word /dōktər/ was followed by the target word /sImhəm and so on.

2. Selection of words for the software: Out of the 72 test words administered, children errored on 62 words in the 2.0-2.6 year age range and on 55 target words in the 2.6 - 3.0 years age group. From the descending ordered list of 62 and 55 erroneous words in the two age groups, the words that were produced erroneously by more than 40% of the children in each age group were selected for inclusion in the assessment software. 40% criteria were suggested by Hodson and Paden (1991). In the younger group, 35 words and in the older group 25 words were errored by more than 40% of the children tested. Hence 35 words in the age range of 2.0-2.6 years and 25 test words in 2.6-3.0 years range were included in the assessment tool. The details of the list of the erroneous words are provided in the results section.

3. Selection of the possible utterances of each target word: For the 35 words from the 2.0 – 2.6 years group and 25 words from the 2.6 – 3.0 years age range selected for inclusion in the software, four different utterances of the same target word obtained from the sample were identified. For this, all the possible productions of the subjects for a particular target word were noted down along with the number of subjects using that particular pattern of production. Among the different possible productions, three patterns which outnumbered the other patterns were selected. For example, for the word /nəkʂət̪Rəm/ in the age range 2.0 - 2.6 years, the different productions by the subjects were as follows:

TARGET WORD	1	2	3	4	5	6	7	8	9	10
nəkʂət̪Rəm	**nətʃət̪ərəm** **(10)**	**nətʃət̪əRəm** **(18)**	**nətʃət̪əm** **(14)**	**nətʃət̪Rəm** **(2)**	**nəʃət̪əRəm** **(4)**	**nət̪ət̪əRəm** **(5)**	**nəʃət̪ərəm** **(3)**	**nətʃəm** **(1)**	**nət̪ət̪Rəm** **(1)**	**nəʃət̪əm** **(1)**

(Numbers in the bracket indicate the number of subjects producing that particular pattern)

So from the different patterns of productions seen, the four most common patterns used by the children, i.e., /nətʃət̪əRəm/, /nətʃət̪əm/, /nətʃət̪ərəm/ and /nət̪ət̪əRəm/ were selected. The various patterns obtained for each target word are listed in the results section. So the most erroneous words (35 words in 2 - 2.6 years and 25 in 2.6 - 3.0 years) along with its 4 most commonly occurring patterns were selected for the software making. This is based on the presumption that most children in these age groups will be producing such patterns of phonological processes.

4. Collaboration with software professionals: Once the words along with their most possible commonly occurring patterns were selected, this material was provided to a software professional in Bangalore (ENFIN Technologies India Pvt Ltd), for the preparation of the analysis software, which was the main objective of the present study.

Phase III - Sensitivity Evaluation of the assessment tool

Verification of sensitivity on a pilot basis: The developed assessment software was administered on 10 children with hearing impairment and 10 children with mental retardation each in 2 – 2.6 and 2.6 – 3 years age range for carrying out the sensitivity evaluation of the tool developed. Hence sensitivity evaluation involved a total number of 40 children with communication impairment.

Selection of participants: Initially the examiner obtained a list of children with mental retardation and hearing impairment who were attending speech and language therapy or special schools. Once the list was made, examiner administered Receptive Expressive Emergent Language Scales (REELS; Bzoch & League, 1991) on each child selected to assess their language age. The children whose language age was between 2.0 – 2.6 and 2.6 – 3.0 years were shortlisted. From these groups, 10 children with Hearing impairment and 10 children with mental retardation each in the age range of 2.0 -2.6 and 2.6 – 3.0 years were selected for the sensitivity evaluation of the developed tool. Hence the tool was administered on 20 children with hearing impairment and 20 children with mental retardation for sensitivity evaluation.

Administration of CAPP-M: CAPP-M was administered to all the 40 participants and their pattern of productions for the target words were noted down. Later the examiner counted the number of productions of each child tested that matched with the pattern of productions provided in the software. Further the percentage of correlation between the production of the individual child and the patterns in the tool were calculated for each subject in the two groups. Also a mean percentage of correlation was obtained for each group separately.

RESULTS AND DISCUSSION

The aim of the study was to develop an indigenous software to identify the phonological processes prevalent in Malayalam speaking children in the age range of 2.0-3.6 years. In the present study age group of 2 – 3 years was considered for the software making. However a similar tool developed by Merin (2010) for the age range of 3-3.6 years was appended to the tool developed in the current study. For this purpose the present study was conducted in 3 phases. Phase I intended to obtain the phonological processes present in children in the age range of 2.0 - 3.0 years. The making of the software was done in Phase II. Phase II also included appending the existing tool (Merin, 2012) to the one developed in this study. In Phase III, the sensitivity of the developed tool was assessed in children with mental retardation and in children with hearing impairment.

Results of Phase I

Out of the 71 test words administered in both the age groups, children errored on 62 words in 2.0 - 2.6 years and 55 test words in the 2.6 - 3.0 years group. On sound by sound analysis, a total of 29 phonological processes were prevalent in the lower age group and 24 phonological processes in the higher age group. The distributions of phonological processes in both the age groups are shown in Table 6 (a), (b), (c) and (d).

SUB No.	CR	C si	Epn	C su	Aff	Daff	Stp	PF	VF	RF	IC D	MCD	FCD	Nasm	PL	LAT	Pr v	BAK	Gcr	MT	Dasp	GLD	Drot	Dlat	NF	FVD	D I S	PDv	MSD
M1	15		1		5	3	4	2	1	2		5		1		4					1			1					1
M2	10			1		2	6	2		4		3	5		2	1	1	1	1	1	1	1	1		1	1			1
M3	8	5			1	2	1	1		6		3	2		4			2	1		1						/dz/ 1		
M4	11	1	3		3	4	6			2					1	1													1
M5	8	2	3	2	6		3	1		2											1								
M6	13		3	1	1	2	9	1		4		2				1			1		1								1
M7	13	1		2	1	1	6	1				3			1	1													
M8	11		5		1	5	8	1		5		1			1														
M9	9	3	4	1	1	3	8		2	4		2							1		1	2						1	1
M10	7		3	2			1								4														
M11	12	2	2		2	3	5	1		2		2	1		2														
M12	10	1	3	1	7		3			6		5				2	1	1			1								1
M11	9		5	1	1		3			1		1			3				1										
M14	15		1	1	2	4	8	2		6						1					1		2						
M15	12	3	2		4	5	6	1		2		2							1										1
M16	13	1	1	1	5		7	2		4		4						2	1		1		3	1					
M17	8		5		2					2					4								1						1
M18	10	1	5		4	2	3	1		5		1			1				1		1								1
M19	8		5	1	4	2	2	1	2	6	5	4	1								1						/r/ 1		
M20	11		4	1	2	4	7		1	2					1						1								1
M21	11	1	3	1	5		1		1	4	1	2		1	1								1				/R/ 1		1
M22	19		2		3	1	8	1	1	4		4	6								1		1						
M23	10		3	1	1	2	7			2		1			1								1						1
M24	13		2	1	2	2	7			4		4	1			1			1			1	1		1		/dz/ 1		1
M25	11		5	1	5	1	3	2		2		1				1					1			1					1
M26	13	1		1	5		3	1	2	5		2				2			1										
M27	8		5	3						4		3		1	6			1											
M28	10		5	1	1	3	5	1		6					2	2		1			1	1	1						1
M29	12		4	1	5	2	5	2		5		5	1			1			1		1		1	1	1	1			
M30	11		5	1	8		2	1		5		1				1		1			1								

Table 6a: Distribution of phonological processes in male subjects in the age range of 2.0 - 2.6 years.

	CR	C si	Epn	C su	Aff	Daff	Stp	PF	VF	RF	IC D	MC D	FCD	N asm	PL	LAT	BAK	Gcr	MT	Dasp	GLD	Drot	DLT	N F	DIS	MSD
F1	10		6		6	1	3			4		3				3				1		1				1
F2	11		5	1	4		3			3					3	2						1				
F3	10		6	1	5		4			3	1	4				1										1
F4	13		3	1	2	2	8	2	1	5		5		1		2	1									
F5	11		5	1	6		3			6		2	1			2					1					
F6	8		4	1	4	1	7	2	1	7								1		1						
F7	11		5		1	1	7			4		2	5		1			1		1					/dz/ 1	1
F8	10	1	4		4		5			6		5	4	1		1		1				1			/dz/1	
F9	9		5		4					1			1		4					2						1
F10	9		6	1	10					3		1		1		1					1					
F11	14		1	1	3	3	4	3		6	1	5	4		1			1								
F12	12				4	1	5		2	6	6	5	1			1				1						1
F13	15		1		2	3	2	1		1		5	3		3						1					1
F14	11		4		2	2	7		1	4		5	1			1										
F15	13			1	5	6	6			5		8				1				1	1	1			/ḍ/ 1	1
F16	9		5	1		5	11	3		4					1			1		1		3	1			1
F17	11		5		1	3	9			3		3	1												/dz/ 1	
F18	11		4		6	3	3			6		5			1	1						1				1
F19	8		5			1	2			1					4											
F20	13		1	1		1		2		8		2			5	1				1	1		1			1
F21	8		4	1	1	5	5			3		2			1			1								1
F22	11		6		2	3	8	1	4	4		4				1		1		1		1	3		/ṭ/ 1	
F23	14				7	6	4	1		4		4	3		1	1	1	1	1	1	1				/ḍ/1	1
F24	13		4			5	11	1		5		4	1	1		1		1		1		2				1
F25	12		4	1	5		5	1		4										1	1	2				1
F26	9		4	1	3					3		1	1		2											
F27	13			1	5	2	2			3		4	5		1											
F28	9		1		3	2	1	1		4		3			1							1				
F29	13		2		7		1			4		3														
F30	13	1	1		6	1	2			5		4				3		1		1	1					

Table 6b: Distribution of phonological processes in female subjects in the age range of 2- 2.6 years

	CR	C si	Epn	C su	Aff	Daff	Stp	PF	VF	RF	ICD	MCD	FCD	Nasm	PL	LAT	BAK	Gcr	Dasp	GLD	Drot	Dlat	NF	DIS
M1	9		2			1				2					2		1	1			1			
M2	11		4		1	4	7	2		6		1	3			1					1			
M3	10	1	1	1	4	3	3			1	1	3	2		1			1						
M4	10	6		1	6	2	4			2		2	1			1			1	3	4			
M5	9		5		4		3			5		1			1									
M6	11		5		1	2	1	1		3	1	2			1			1			1			
M7	10		4	1	4		4			4		1						1						
M8	15			1	2		3			3	1	6	1		2	1			1				1	
M9	10		5	1	9		1			3								1						
M10	14	1	1		6		1			2		2	1		2	1		1	1		2	1		
M11	10		1		3	3	5					1						1						
M12	12			1	7		4			2		4				2	3		1			1		/r/ 1
M13	12		1	1	1	4	9	2	1	2		1				1		1	1			3		
M14	9	3	3	1	6		5			1	1	2	1				2	1	1					/R/ 1
M15	7		3		2		1			3		1			2						1			
M16	12		2		6			1		2		4			1						1			/R//1
M17	10		3	1	2		1			3		1			1				1					
M18	8	2	4	1	7		1			3		1												
M19	9	3	3		6		3						1			1								/r/ 1
M20	8		6	1	8	1	2			1														
M21	11	1	4		5	1	4			1			1						1					
M22	10		5	1	7		4	1		3														
M23	11		4		7		2	1		5					1			1			1			
M24	10		3		7		1			2														
M25	15				4	1	7			5		2	1			1		1				2		
M26	12		4	1	5		2			4		2	5		2									
M27	13		2		3		6	2		5		1	1	1	1									
M28	9		6	1	9					4								1						
M29	14	2	1		1		6			6		1			2									
M30	10		2	1	4	1	1			2					4			1	1					

Table 6c: Distribution of Phonological Process in Male subjects in the age range of 2.6 - 3.0 years.

	CR	C si	Epn	C su	Aff	Daff	Stp	PF	VF	RF	ICD	MCD	FCD	Nasm	PL	L AT	Prv	B AK	Gcr	MT	Dasp	GLD	D rot	Dlat	NF	DIS
F1	8			1	5	1	11			3		1										1				
F2	9	1	3					1		2					2			1								/r/ 1
F3	9		4			2	1			3					2				1				1			
F4	7		3	1	1			1							3								1			
F5	13		2	1	5	4	6		4	2		3		1		2			1		1		2			
F6	9		4	1				1							3						1				1	
F7	8		2	1		3	9			1		1											1	1		
F8	10		3	1	1		2			1		1			2				1			1	2	1		ncha 1
zF9	10		4		2	1	1			1									1							
F10	8		2	1											2											
F11	9		6	2	3	2	5			3					1	1					1		2			/dz// 1
F12	15			1			1		1	2					3	1						1				/r/ 1
F13	4		1	1			1								1			1								
F14	13				2		4			1					1											
F15	12	1	3	1	4	3	4			4		3			1	1					1					
F16	10	1	5	5	5	2	4			3		3				1			1		1					/dz/ 1
F17	9		6	1		1	2			3		1			4											/dz/ 1
F18	9		3	1		1				1	1	1			2											
F19	10		5	1	7		4	1	1	4	3								1				4			/dz /1
F20	5		2		1					3					3				1							
F21	8		6	1			4			1					2											
F22	10	2	3	1	6	5	4		1	7													1			
F23	8		5	1	1		2	2							2											
F24	10		4		4	3	1			5					1				1							
F25	6		3	3						5					2	2										
F26	10		5	1	6	1	3			3		2							1			1				
F27	9		5	1						2					3				1							
F28	8		6	1	1		5			2		1							1							/dz/ 1
F29	8		2	1	2		2			1					2				1							
F30	6		2	1	1										3											

Table 6d: Distribution of Phonological Process in Female subjects in the age range of 2.6 - 3.0 years.

Abbreviations used are;

Sl no		Phonological processes	Sl no		Phonological processes	Sl no		Phonological processes
1	CR	Cluster reduction	11	ICD	Initial consonant deletion	21	Dasp	Deaspiration
2	C si	Cluster simplification	12	MCD	Medial consonant deletion	22	GLD	Gliding
3	Epn	Epenthesis	13	FCD	Final consonant deletion	23	Drot	Derhotarization
4	C Su	Cluster substitution	14	Nasm	Nasal assimilation	24	Dlat	Delateralization
5	Aff	Affrication	15	PL	Palatalization	25	NF	Nasal fronting
6	Daff	Deaffrication	16	LAT	Lateralization	26	FVD	Final vowel deletion
7	Stp	Stopping	17	Prv	Prevocalic voicing	27	DIS	Distortion
8	PF	Palatal fronting	18	BAK	Backing	28	PDV	Postvocalic devoicing
9	VF	Velar fronting	19	Gcr	Geminate cluster reduction	29	MSD	Medial consonant deletion
10	RF	Retroflex fronting	20	MT	Metathesis			

In this study the percentage of the subjects using a particular phonological process was calculated and not the number of occurrences of each process. Number and percentage of subjects exhibiting different phonological processes in the age range of 2.0 - 2.6 years and 2.0-3.0 years are provided in Table 7 (a) and (b).

Sl.no	Phonological processes	No. of subjects exhibiting the process		Percentage of subjects exhibiting the process	
		Males	**Females**	**Males**	**Females**
1	**Cluster Reduction**	30	30	100	100
2	**Cluster Simplification**	12	2	40	7
3	**Epenthesis/cluster simplification**	26	26	87	87
4	**Cluster Substitution**	21	14	70	47
5	**Affrication**	27	26	90	87
6	**Deaffrication**	20	21	67	70
7	**Stopping**	28	26	93	87
8	**Palatal Fronting**	19	11	63	37
9	**Velar fronting**	7	5	23	17
10	**Retroflex fronting**	28	30	93	100
11	**Nasal fronting**	3	-	10	-
12	**Initial Consonant deletion**	2	3	7	10
13	**Medial consonant deletion**	23	24	77	80
14	**Final Consonant Deletion**	7	13	23	43
15	**Nasal Assimilation**	3	4	10	13
16	**Palatalization**	15	14	50	47
17	**Lateralization**	13	16	43	53
18	**Prevocalic Devoicing**	1	-	3	-
19	**Prevocalic voicing**	3	1	10	3
20	**Backing**	7	2	23	7
21	**Geminate cluster Reduction**	11	10	37	33
22	**Metathesis**	1	1	3	3
23	**Deaspiration**	17	13	57	47
24	**Gliding**	4	8	13	23
25	**Derhotarization**	10	10	33	33
26	**Delateralization**	4	3	13	10
27	**Distortions**	5	6	17	20
28	**Medial syllable deletions**	15	14	50	47
29	**Final vowel deletion**	2	-	7	-

Table 7 (a): Number and percentage of subjects exhibiting different phonological processes in the age range of 2-2.6 years in both males and females.

Sl.no	Phonological processes	No. of subjects exhibiting the process		Percentage of subjects exhibiting the process	
		Males	Females	Males	Females
1	Cluster Reduction	30	30	100	100
2	Cluster Simplification	8	4	27	13
3	Epenthesis/cluster simplification	26	27	87	90
4	Cluster Substitution	15	24	50	80
5	Affrication	29	18	97	60
6	Deaffrication	11	13	37	43
7	Stopping	27	21	90	70
8	Palatal Fronting	7	5	23	17
9	Velar fronting	1	4	3	13
10	Retroflex fronting	28	24	93	80
11	Nasal fronting	1	1	3	3
12	Initial Consonant deletion	4	2	13	7
13	Medial consonant deletion	20	10	67	33
14	Final Consonant Deletion	11	-	37	-
15	Nasal Assimilation	1	1	3	3
16	Palatalization	14	21	47	70
17	Lateralization	8	6	27	20
18	Backing	3	2	10	7
19	Geminate cluster Reduction	13	12	37	40
20	Deaspiration	9	5	30	17
21	Gliding	3	4	10	13
22	Derhotarization	8	8	27	27
23	Delateralization	4	2	14	7
24	Distortions	4	8	14	27

Table 7 (b): Number and percentage of subjects exhibiting different phonological processes in the age range of 2.6 - 3.0 years in both males and females.

The phonological processes identified in 2.0-3.0 years as shown in Tables 7 (a) and (b) in the present study are described below.

1. **Cluster reduction:** Cluster reduction may be defined as the deletion or substitution of some or all members of a cluster. That is cluster is reduced to one member of the consonant cluster. Cluster reduction is present in all the 120 subjects tested in both the age ranges. The results show that clusters are difficult to produce which requires more matured motor and articulatory sequencing which is not achieved even at the age of 3 years. The occurrence of cluster reduction in this study is in consonance with Sameer (1998) and Merin and Sreedevi (2010) who reported that the mastery of clusters continue even after 3 years of age.

Eg; /nəkʂət̪Rəm/ ⟶ / nətʃət̪əm/

2. **Cluster simplification:** Cluster simplification occurred in 40% of the male children and 7% of female children in 2.0 - 2.6 years and in 27% of males and 13 % of the females in 2.6 – 3 year old children respectively. This result is supported by Huttenlocher, Haight, Bryk, Seltzer, and Lyons who reported faster maturation in language capacities in girls than boys. Clusters are the most difficult to achieve and in the process of achieving, children tend to reduce the clusters first, and then try to produce the clusters in a more simplified manner. Cluster simplification is the result of such an attempt.

Eg; /tʃəkRəm/ ⟶ /tʃəkərəm/

3. **Epenthesis:** Epenthesis can be characterized by the insertion of an unstressed vowel, usually the schwa /ə/ between two consonants. Epenthesis is 87% each in both males and females in the age range of 2.0 - 2.6 years and 87% in males and 90% in females in 2.6 - 3.0 years respectively. Stoel- Gammon and Dunn (1985) have considered epenthesis as a process that persists even after 3 years of age. Epenthesis was observed in 3.0-3.6 years children in high frequency (Merin & Sreedevi, 2010) which reflect the fact that children simplify the complex production by the insertion of vowel between them.

Eg; /paṱRəm/ ⟶ / paṱəRəm/

4. **Cluster substitution:** Cluster substitution is the substitution of one or all members of a cluster by another sound. Cluster substitution tends to follow a general developmental pattern, in that the sound that is more difficult to produce or later developing is typically the one substituted. Cluster substitution is prevalent in 70% of males and 47% of females in 2.0 - 2.6 years age group and in 80% of males and 50% of females in 2.6 - 3.0 years age group respectively. This result is supported by Huttenlocher et al (1991), who reported faster maturation in language capacities in girls than boys. Substituting one or all members of a cluster by another sound suggest that the child is attempting to producing the cluster, but because of the child's incapability more easy sounds are substituted instead.

Eg; /sImhəm/ ⟶ / sImgəm/

5. **Affrication:** Out of 30 males and 30 females tested in each age group (2.0 - 2.6 and 2.6 - 3.0), affrication was present in 27 male subjects (90%) and 26 female subjects (87%) in the 2.0 - 2.6 years age range and in 29 males (97%) and 19 females (60%) in the 2.6 - 3.0 years age range. In affrication, a non affricate becomes an affricate. Usually a stop component is added to a continuant consonant, most commonly a fricative. The acquisition of fricatives occurs late after 3 years of age (Templin, 1957; Wellman, Case, Mengert and Bradbury, 1931) is reported in literature. The child is in the period of learning fricatives and hence the more easier affrication are seen in most of them.

Eg; /bəsə/ ⟶ /bətʃə/

6. **Deaffrication:** Deaffrication is the process of replacing an affricate with a stop or a fricative. Hodson and Paden (1991) state that during typical development of speech, children may use both patterns of affrication and deaffrication as they are learning to sort out the difference between fricatives and affricates. Deaffrication is prevalent in 67% of males and 70% of females in the lower age group and in 37% of male subjects and 43% of females in the higher age range.

Eg; /tʃerupə/ ⟶ /t̪erupə/

7. **Stopping:** Stopping is most frequently described as the substitution of stops for fricatives and affricates. Lowe (1996) gives an inclusive definition stating that stopping can affect fricatives, affricates, liquids and glides. Hodson (1986) question categorization of stops for affricates as stopping, since an affricate by definition already has a stop component. In the present study, substitution of stops for affricate is considered as deaffrication, not stopping. 28 males (93%) and 26 females (87%) out of

30 males and 30 females each in 2.0 - 2.6 years had stopping and in 2.6 - 3.0 years 27 males and 21 females i.e., 90% and 70% respectively exhibited the process of stopping. Rahul (2006) observed stopping in Hindi and Sreedevi, Jayaram and Shilpashree (2005) studied Kannada and identified stopping as a prevalent processes in 2-3 years of age.

Eg; /mɛʃa/ ⟶ /mɛt̪a/

8. **Palatal fronting:** Palatal fronting occurs when a palatal sound is replaced by an alveolar or labial sound. 63% of males and 37% of females exhibited this processes in 2.0 - 2.6 years. In 2.6 - 3.0 years, 23% of males and 17% of females had this process. There is a decrease in the percentage of palatal fronting suggesting that the mastery of palatals is occurring in this age range.

Eg; /ɲədə/ ⟶ /nədə/

9. **Velar fronting:** Seven males constituting 23% and 5 females constituting 17% exhibited this process in the lower age range, whereas in the higher age group, this process was observed in only 1 male (3%) and 4 female (13%) subjects tested.

Eg; /ʃə̃kʰə/ ⟶ /ʃə̃t̪ə/

10. **Retroflex fronting:** Retroflex are the sounds which involve the tongue to curl back and touch the palate. These are the sounds which are produced with greater difficulty. Malayalam is a language with many retroflex sounds. Retroflex fronting occurs when a retroflex sound is replaced by a more anterior sound. The prevalence of retroflex

fronting is higher in both the age groups with 93% and 100% in males and females respectively in 2.0 - 2.6 years and a slightly lower percentage of 93% and 80% in males and females respectively in 2.6 - 3.0 years. The high occurrence of retroflex fronting suggests that these sounds are still not mastered by children in this age range.

Eg; /uRũbə/ ⟶ /urũbə/

11. **Nasal fronting:** Nasal fronting occured only in 3 male children i.e., 10% in 2.0 - 2.6 year old children and in one male and female child each in 2.6 - 3.0 years age group. This low frequency of nasal fronting suggests the mastery of most of the nasal sounds by this age. Such processes have not been reported in other Indian languages studied.

Eg; /RIbəɳ/ ⟶ /rIbəm/

12. **Initial, Medial and Final consonant deletion:** Consonant deletions were observed in the initial medial and final positions. In 2.0 - 2.6 years, 2 males and 3 females had initial consonant deletion, 23 males and 24 females had medial consonant deletion and 7 males and 13 females had consonant deletion in final position. In 2.6 – 3.0 years, in males, 4 subjects had initial consonant deletion, 20 had medial consonant deletion and 11 subjects exhibited consonant deletion in the final position. Whereas in females, 2 and 10 subjects exhibited consonant deletion in initial and medial positions respectively. Final consonant deletion was not observed in females. The high frequency of medial consonant deletion compared to initial and final consonant deletion indicate the difficulty in mastering the consonants in the medial position compared to initial and final positions.

Eg;

/sə̃dʒi/ ⟶ / ə̃dʒi/

/tʃerupə/ ⟶ /tʃeupə/

/kIɳəʀ / ⟶ /kIɳə/

13. **Nasal assimilation:** Nasal assimilation occurs when a non nasal sound is replaced by a nasal sound in the presence of a nasal sound in the target word. In 2.0 - 2.6 years, 10% of males and 13% of females had nasal assimilation. In 2.6 - 3.0 years, the percentage declined to just 3% each for both males and females.

Eg; /dʒənɛl/ ⟶ /ɲənɛl/

14. **Palatalization:** Palatalization occurs when a sound is produced as a palatal consonant rather than as a non palatal. Hodson and Paden (1991) reported of palatalization among preschoolers as a method of sorting out the contrast between alveolars and palatals. Out of 30 males and 30 females tested in each age range, 50% of male subjects i.e., 15 males and 47% of female children i.e., 14 females had the process palatalization in 2.0 - 2.6 years and in 2.6 - 3.0 years palatalization were observed in 47 % i.e., 14 males and 70% females i.e., 21 in number. This result is supported by Huttenlocher et al (1991), who reported faster maturation in language capacities in girls than boys.

Eg; /sə̃dʒi/ ⟶ /ʃə̃dʒi/

15. **Lateralization:** When a non lateral sound is lateralized, lateralization occurs. 13 males (43%) and 16 females (53%) exhibited this process in 2.0 - 2.6 years and 8 males (27%) and 6 females (20%) exhibited lateralization in 2.6 - 3.0 years.

Eg; /kIɳəʀ/ ⟶ /kIɳəl/

16. **Backing:** Backing occurs as opposite of velar fronting. That is sound with anterior place of articulation are replaced by posterior sounds. This deviation is seldom seen in normal development in English language. In an attempt to stop the airflow, children with cleft palate may use the phonological deviation of backing. In the present study, 23% of males and 7% of female subjects had the process backing in 2.0 - 2.6 years and in higher age group, it was observed in 10% of male children and 7 % of female children only. In Hindi, Rahul (2006) reported the occurrence of backing in 2.0 - 2.6 years, though in negligible percentage.

Eg; /tʃəkRəm/ ⟶ /kəkRəm/

17. **Prevocalic voicing:** It is the process by which a voiceless sound preceding a vowel becomes voiced. Stoel- Gammon and Dunn (1985) indicate that prevocalic voicing can affect all obstruents, but of these the most commonly affected are stops. It was prevalent only in 3 males and 1 female child i.e., 10% and 3% respectively of 2.0 - 2.6 years. It is totally absent in 2.6 - 3.0 years.

Eg; /p^həlam/ ⟶ /bəlam/

18. **Post vocalic devoicing:** In post vocalic devoicing a voiced obstruent following a vowel (postvocalic) becomes voiceless or devoiced. This process was found only in 1 male subject out of 30 subjects in 2.0 - 2.6 years.

Eg; /gəd̪a/ → /gət̪a/

19. **Geminate cluster reduction:** Geminate cluster reduction occured in 11 (37%) males and 10 (33%) females in the 2.0 - 2.6 years age range and in 13 (37%) males and 12 (40%) females in the 2.6 - 3.0 years age range. In phonetics, gemination happens when a spoken consonant is pronounced for an audibly longer period of time than a short consonant. Gemination is distinct from stress and may appear independently of it. In geminate cluster reduction, one of the consonants is deleted, which makes it a single consonant.

Eg; /məd̪d̪aḷəm/ → /məd̪aḷəm/

20. **Metathesis:** Metathesis is the pattern of transporting or reversing consonant in a word. This process is usually atypical. Metathesis is observed only in 1 male and female subject respectively out of the 30 males and 30 females tested in the 2.0 - 2.6 years age range. This particular processes is absent in the 2.6 - 3.0 years group.

Eg; /mujəl/ → /muləjə/

21. **Deaspiration:** Deaspiration was seen in 17 males which constituted 57% of male subjects and 13 females which is 47% of female subjects in the lower age range and in 9

males i.e., 30% of males and 5 females (17%) in the age range of 2.6 - 3.0 years. The words in which de-aspiration was produced are not used in day to day conversation. This reduced familiarity to aspiration may be a possible reason for its occurrence. Also studies have indicated that aspiration is acquired in later stages, after their non aspirated cognates. Ramadevi (2002) in 5 - 6 year old Kannada speaking children and Rahul (2006) in 2 - 3 years old Hindi speaking children found de-aspiration process. Divya (2010) in Malayalam and Usha (2010) in Telugu reported unaspirated sounds are learned earlier than aspirated sounds in 2 – 3 year old children.

Eg; /p^həlam/ ⟶ /pəlam/

22. **Gliding:** Four out of 30 males (13%) and 8 out of 30 females (23%) had gliding in 2.0 - 2.6 years age range. 3 males and 4 females i.e., 10% and 13% respectively had gliding in the 2.6 - 3.0 years age group. Gliding refers to the use of a glide (/w, j/) for another consonant. Gliding occurs frequently on prevocalic liquids. (/r, l/) in singletons and clusters and sometimes on fricatives. Gliding of /r/ and /l/ seems to extend beyond 5.0 years of age (Grunwell, 1987; Smit, 1993b).

    Eg; /əlәmarI/ ⟶ /əlәmajI/

23. **Derhotacization:** It is observed in 10 males and 10 females (33% each) in 2.0 - 2.6 years group and in 8 males and 8 females (27% each) in 2.6 - 3.0 years age range.

    Eg; /uRũbə/ ⟶ /udũbə/

24. **Delateralization:** Delateralization occured in 4 males (13%) and 3 females (10%) in 2.0 -2.6 years and 4 males (13%) and 2 females (7%) in 2.6 - 3.0 years group.

Eg; /lōRI/ ⟶ /d̪ōrI/

25. **Distortion:** Distortions of /R/, /r/, /dʒ/, /t̪/ /d̪/ are also found in smaller percentage.

26. **Medial syllable deletion:** Syllables in initial and final positions were achieved in all the subjects. But deletion of syllable in medial position was observed in 15 males ie 30% and 16 females i.e., 47% out of 30 males and 30 female subjects tested in the 2.0 - 2.6 years age group.

Eg; /tʃerupə/ ⟶ /tʃepə/

27. **Final vowel deletion:** It is observed only in 2 males, which constituted 7% of male subjects in the lower age range. This is the only process related to vowels which were prevalent among all the other processes identified in the 2.0 - 3.0 years of age.

Eg; /RedIo/ ⟶ /RedI/

After the percentage of subjects exhibiting each process was calculated, these processes were classified into 3 major categories as summarized in Tables 8 (a) and (b). This was made on the basis of the method used by Ramadevi (2006). The classification is as follows.

1. First category included the phonological processes occurring in 20% or less than **20%** of the subjects. These are considered as **occasionally occurring processes.**

2. Second category, included the phonological processes occurring in **more than 20% and less than 60%** of the subjects. These are considered as **frequently occurring** phonological processes.

3. Third category included the phonological processes occurring in **more than 60%** of the subjects. These are considered as phonological processes occurring **most of the time** in children's speech.

Males			Females		
Percentage of subjects exhibiting the processes			Percentage of subjects exhibiting the processes		
Less than 20%	20-60%	More than 60%	Less than 20%	20-60%	More than 60%
NF	C si	CR	C si	C su	CR
ICD	Daff	Epn	VF	PF	Epn
Nasm	VF	C su	ICD	FCD	Aff
Prv	FCD	Aff	Nasm	PL	Daff
P dv	PL	Stp	Prv	LAT	Stp
MT	LAT	PF	BAK	Gcr	RF
GLD	BAK	RF	MT	Dasp	MCD
Dlat	Gcr	MCD	Dlat	GLD	
DIS	Dasp		DIS	Drot	
	Drot			MSD	
	MSD				

Table 8 (a): Categorization of phonological process based on the percentage of subjects exhibiting the processes in 2.0 - 2.6 years.

Abbreviations used:

Sl no		Phonological processes	Sl no		Phonological processes	Sl no		Phonological processes
1	CR	Cluster reduction	11	ICD	Initial consonant deletion	21	Dasp	Deaspiration
2	C si	Cluster simplification	12	MCD	Medial consonant deletion	22	GLD	Gliding
3	Epn	Epenthesis	13	FCD	Final consonant deletion	23	Drot	Derhotarization
4	C Su	Cluster substitution	14	Nasm	Nasal assimilation	24	Dlat	Delateralization
5	Aff	Affrication	15	PL	Palatalization	25	NF	Nasal fronting
6	Daff	Deaffrication	16	LAT	Lateralization	26	FVD	Final vowel deletion
7	Stp	Stopping	17	Prv	Prevocalic voicing	27	D I	Distortion

							S	
8	PF	Palatal fronting	18	BAK	Backing	28	PDV	Prevocalic devoicing
9	VF	Velar fronting	19	Gcr	Geminate cluster reduction	29	MSD	Medial consonant deletion
10	RF	Retroflex fronting	20	MT	Metathesis			

Table 8 (a) shows that cluster reduction, epenthesis, stopping, affrication, retroflex fronting and medial consonant deletion occurs most frequently in both males and females in the 2.0 - 2.6 years group. Apart from these phonological processes, palatal fronting and cluster substitution in males and deaffrication in females occured most frequently. Palatalization, lateralization, final consonant deletion, geminate cluster reduction, medial syllable deletion, deaspiration, derhotarization occurred frequently in both males and females in this age group. Another finding was that backing, deaffrication and velar fronting are prevalent in males, whereas in females, cluster substitution, gliding and palatal fronting are prevalent frequently. Apart from these processes, in males, nasal fronting, prevocalic devoicing and gliding are less prevalent and in females, cluster simplification, velar fronting and backing are less prevalent. Nasal assimilation, initial consonant deletion, prevocalic voicing, metathesis, delateralization, and distortion occured rarely in both males and females.

Males			**Females**		
Percentage of subjects exhibiting the processes			**Percentage of subjects exhibiting the processes**		
Less than 20%	**20-60%**	**More than 60%**	**Less than 20%**	**20-60%**	**More than 60%**
VF	C si	Epn	C si	Daff	CR
NF	C su	Aff	PF	MCD	Epn
ICD	Daff	Stp	VF	LAT	C su
Nasm	PF	RF	ICD	Gcr	Aff
BAK	FCD	MCD	Nasm	Drot	Stp
GLD	PL	CR	BAK	DIS	RF

DLAT	LAT		Dasp		PL
DIS	Gcr		GLD		
	Dasp		Dlat		
	Drot				

Table 8 (b): Categorization of phonological process based on percentage of subjects exhibiting the processes in 2.6 - 3.0 years

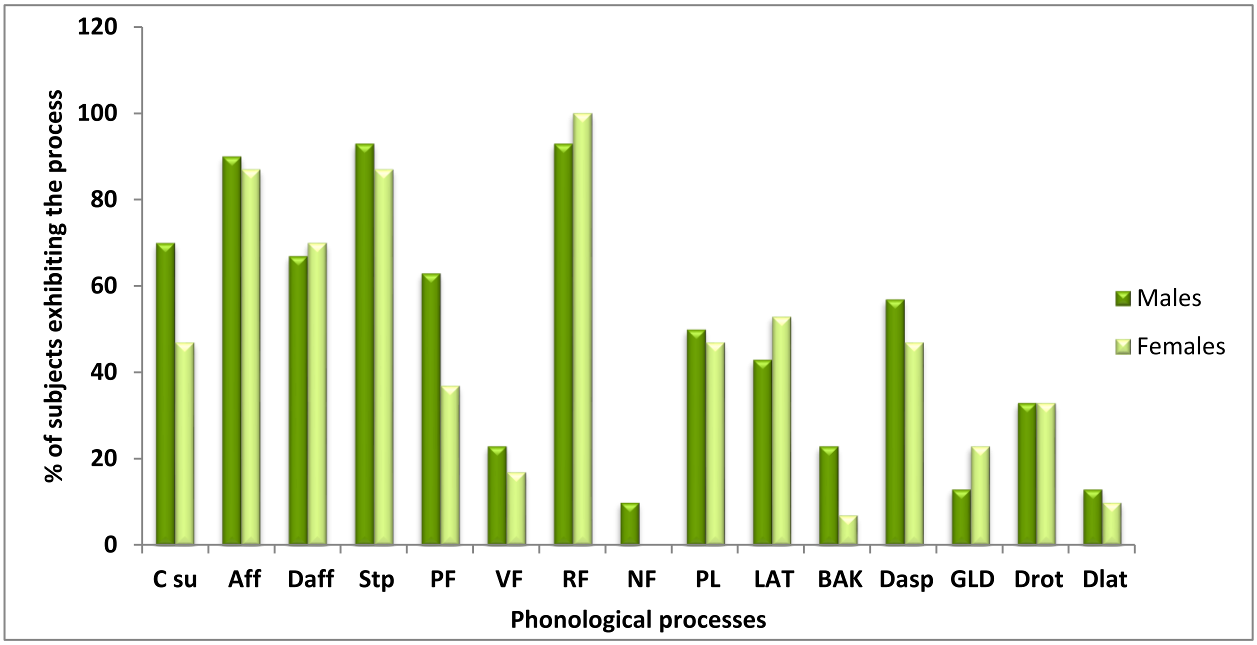
Abbreviations used:

Sl no		Phonological processes	Sl no		Phonological processes	Sl no		Phonological processes
1	CR	Cluster reduction	11	IC	Initial consonant deletion	21	DEAS	Deaspiration
2	C SI	Cluster simplification	12	MC	Medial consonant deletion	22	GLD	Gliding
3	EPN	Epenthesis	13	FC	Final consonant deletion	23	DRO	Derhotarization
4	C SU	Cluster substitution	14	NASM	Nasal assimilation	24	DE L	Delateralization
5	AF	Affrication	15	PL	Palatalization	25	NF	Nasal fronting
6	DEAF	Deaffrication	16	LT	Lateralization	26	FVD	Final vowel deletion
7	ST	Stopping	17	PR V	Prevocalic voicing	27	D I S	Distortion
8	PF	Palatal fronting	18	BK	Backing	28	PDV	Prevocalic devoicing
9	VF	Velar fronting	19	GR	Geminate cluster reduction	29	MSD	Medial consonant deletion
10	RF	Retroflex fronting	20	MT	Metathesis			

Cluster reduction, epenthesis, affrication, stopping and retroflex fronting continued to be the most prevalent processes occurring in both males and females of 2.6 - 3.0 years group also. Medial consonant deletion in males and cluster substitution and palatalization in females were the other most prevalent processes. Deaffrication, derhotarization, geminate cluster reduction and lateralization were found to be less frequently occurring category in both males and females. Cluster simplification, cluster substitution, palatal fronting, final consonant deletion, palatalization and deaspiration occured frequently in males and medial consonant deletion and distortions were seen frequently in females. Velar fronting, initial consonant deletion, nasal assimilation, backing, gliding, delateralization occured in less than 20% of the subjects in both males and females. Nasal fronting and distortions are less prevalent in males whereas cluster simplification, palatal fronting and deaspiration are less occurring processes in the female subjects.

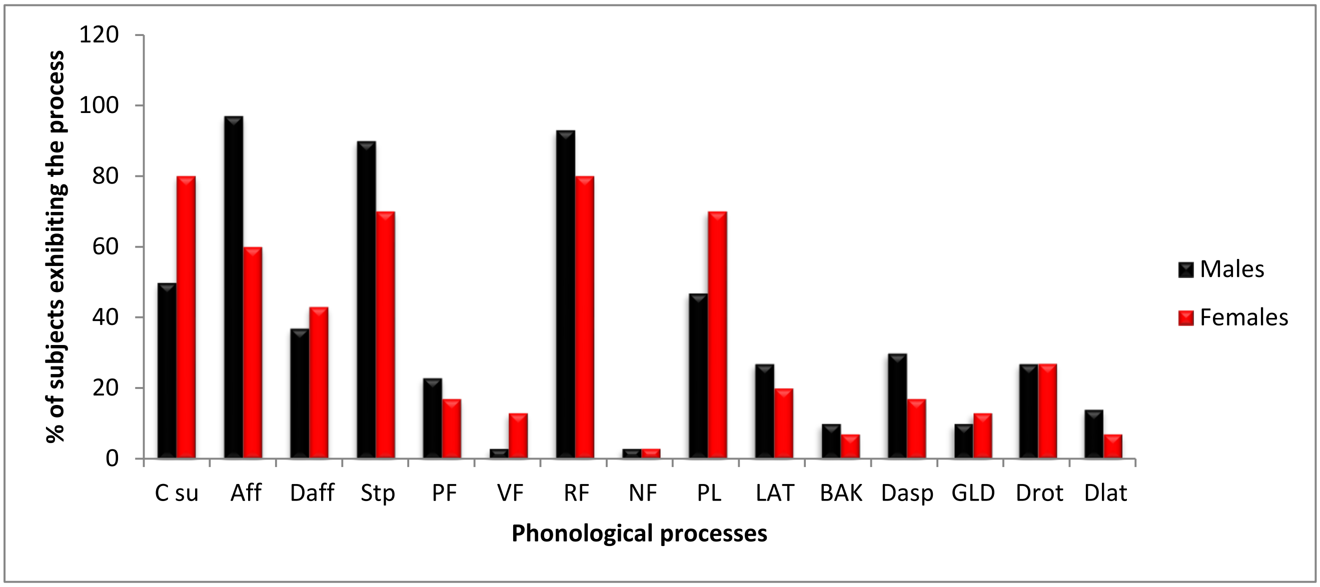
Apart from categorizing the phonological processes according to the classification given by Ramadevi (2006), several researchers classified the phonological processes as (a) Syllable structure, (b) assimilation or harmony, (c) substitution or feature contrast. The following graphs (Graph 1, 2, 3, 4 & 5) show the percentages of subjects exhibiting phonological processes under each type of processes in the present study. Out of three types of processes, substitution process was the major type of process in the children tested.

Substitution processes: Substitution processes involve replacing one sound by another sound without being influenced by the surrounding phonemes. These deviations affect liquids, stops, fricatives, affricates, nasals and glides. Most of these processes occur in the speech of typically developing children. In comparison to syllable structure deviations and assimilation processes, substitution process is the majorly occurring group of processes in Malayalam speaking children in the age range of 2.0 - 26 years (Figure 1). Retroflex fronting followed by affrication, stopping, deaffrication and cluster substitutions are the frequently occurring substitution processes. This is supported by the findings of Rahul (2006) who studied 2.0 – 2.6 years Hindi speaking children and found retroflex fronting, affrication and stopping to be the most frequently occurring processes in 2.0 - 2.6 years. Velar fronting, nasal fronting, backing, gliding and delateralization are occurring relatively less frequently. The process nasal fronting is present only in males and absent in female subjects.



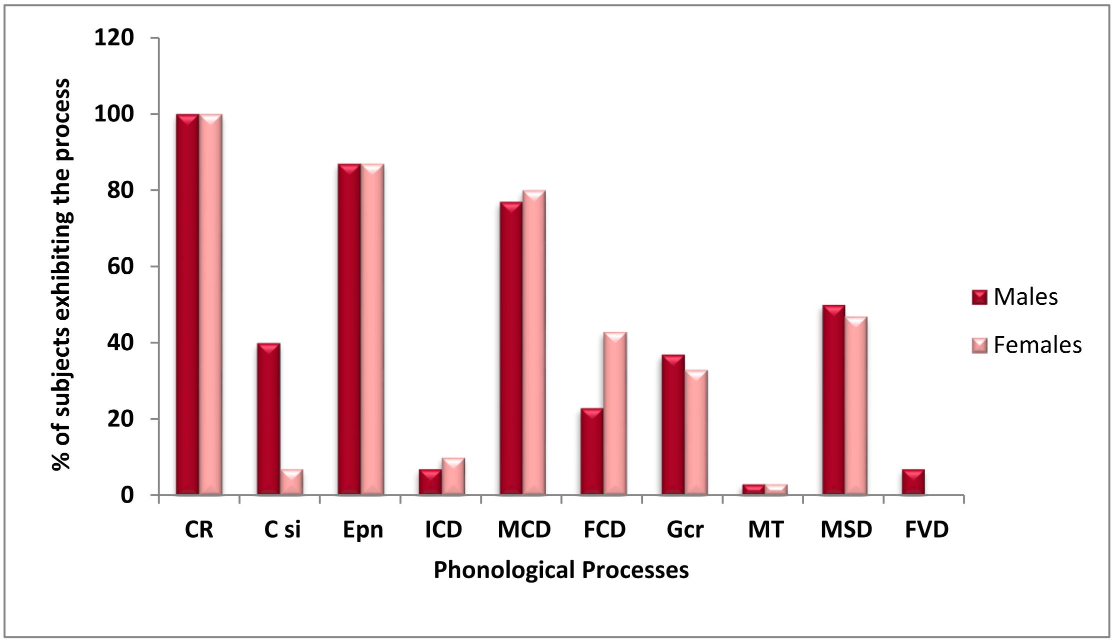
Graph 1: Percentage of subjects exhibiting the substitution processes in 2.0 – 2.6 years

Graph 2 shows the percentage of subjects exhibiting substitution processes in 2.6 – 3.0 years of age. Retroflex fronting, affrication, deaffrication continue to be the most occurring processes in this age group. There is a marked difference between male and female subjects for the processes cluster substitution, affrication, stopping, and palatalization. Velar fronting, nasal fronting, backing, gliding, delateralization are occurring in lesser number of subjects. Rahul (2006) also has reported retroflex fronting as a frequently occurring process in 2.6 – 3.0 years age group in Hindi speaking children.



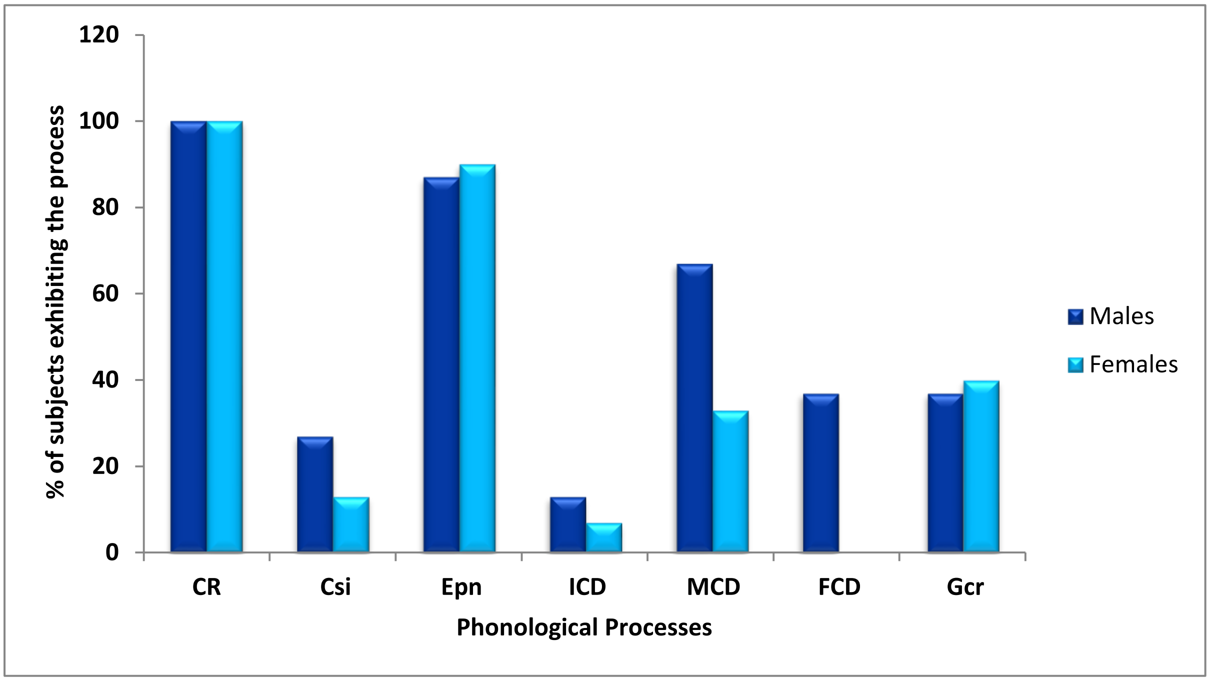
Graph 2: Percentage of subjects exhibiting the substitution processes in 2.6 – 3.0 years

Syllable structure processes: Syllable structure processes are changes in the consonant/vowel (CV) make up of the syllables of standard adult word forms. Thus the CV construction tends to be modified. The number and/or sequence of vowels and consonants in the surface form differ from that in the adult standard form of the target word. Graph 3 shows the percentage of subjects exhibiting different syllable structure deviations identified in male and female children in percentages. The different syllable structure processes identified in this age range are cluster reduction, cluster simplification, epenthesis, initial, medial and final consonant deletions, geminate cluster reduction, metathesis, medial syllable deletion and final vowel deletion. Among these processes cluster reduction occured maximally, i.e., in 100% of the subjects. Following cluster reduction, the processes epenthesis, medial consonant deletions and medial syllable deletion occur in more than 50% of the subjects. The processes initial consonant deletion, metathesis and final vowel deletion occured rarely in children in the age range of 2.0-2.6 years. Final vowel deletion unlike all other processes was present marginally only in the male children.



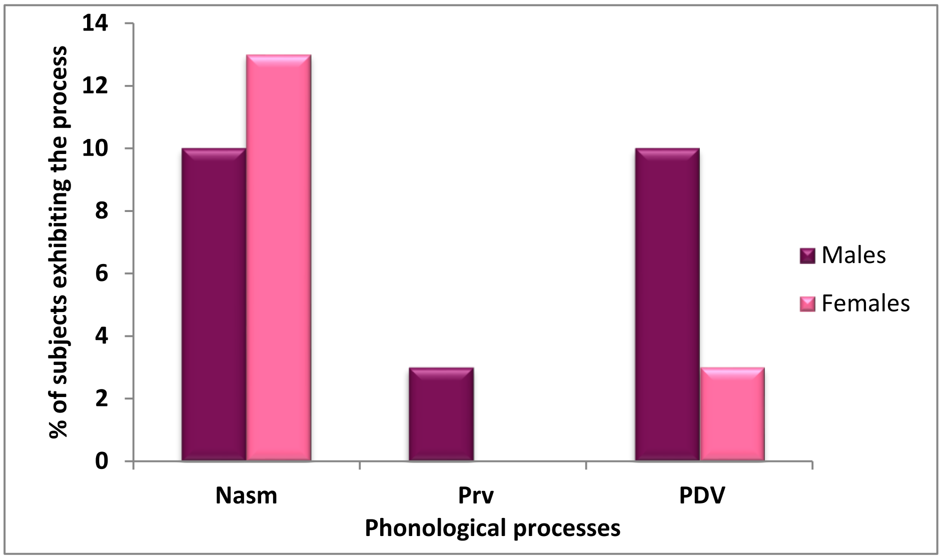
Graph 3: Percentage of subjects exhibiting the syllable structure processes in 2.0 – 2.6 years

As in the age range of 2.0 – 2.6 years, cluster reduction continued to be the most prevalent processes in the age range 2.6 – 3.0 years also. Following cluster reduction, epenthesis was identified in around 90% of the subjects tested. Cluster simplification and initial consonant deletion were the least prevalent processes. On comparison across gender, males were exhibiting medial consonant deletion and cluster simplification in relatively higher percentage than the female subjects tested. It is clearly evident from Graph 4 that final consonant deletion was present only in male subjects. In comparison with Graph 3, i.e., subjects in the age range 2.0 – 2.6 years, subjects in 2.6 – 3.0 years did not exhibit the processes metathesis, medial syllable deletions and final vowel deletion. These processes were suppressed by the age 2.6 – 3.0 years.



Graph 4: Percentage of subjects exhibiting the syllable structure processes in 2.6 – 3.0 years

Assimilation processes: Assimilation processes or harmony deviations are the processes where a sound or syllable is changed to become more similar to another sound or syllable in a word. Thus in these deviations, the sounds or syllables of a word becomes more alike. Graph 3 shows the assimilatory processes observed in the age range 2.0 – 2.6 years. The three processes evident were nasal assimilation, prevocalic voicing and post vocalic devoicing. All these three processes were identified in lesser than 20% of the subjects indicating that they are in the process of supression. Prevocalic voicing is present only in males and is totally absent in females. Apart from nasal assimilation there were no other assimilatory processes identified in the age range of 2.6 – 3.0 years.



Graph 5: Percentage of subjects exhibiting the assimilatory processes in 2.0 – 2.6 years

After obtaining the percentage of subjects exhibiting the various processes, the statistical technique "Equality of Proportion" was used to test the following hypothesis:

1. "The percentage of children exhibiting phonological processes in males is greater than females at 0.05 level of significance in 2.0 - 2.6 years and 2.6 - 3.0 years"
2. "The percentage of children exhibiting phonological processes in males of 2.6 -3.0 years is greater than males of 2.0 - 2.6 years at 0.05 level of significance"
3. "The percentage of children exhibiting phonological processes in females of 2.6 -3.0 years is greater than females of 2.0 - 2.6 years at 0.05 level of significance"

The results of the statistical test is shown in Tables 9 (a) and 9 (b), 10 (a) and 10 (b).

Sl.no	Phonological processes	No. of subjects exhibiting the process		Percentage of subjects exhibiting the process		/Z/
		Males	Females	Males	Females	
1	Cluster Reduction	30	30	100	100	0.00
2	Cluster Simplification	12	2	40	7	**3.05***
3	Epenthesis/cluster simplification	26	26	87	87	0.00
4	Cluster Substitution	21	14	70	47	1.83
5	Affrication	27	26	90	87	0.40
6	Deaffrication	20	21	67	70	0.28
7	Stopping	28	26	93	87	0.86
8	Palatal Fronting	19	11	63	37	**2.06***
9	Velar fronting	7	5	23	17	0.64
10	Retroflex fronting	28	30	93	100	1.43
11	Nasal fronting	3	-	10		1.77
12	Initial Consonant deletion	2	3	7	10	0.46
13	Medial consonant deletion	23	24	77	80	0.31
14	Final Consonant Deletion	7	13	23	43	1.64
15	Nasal Assimilation	3	4	10	13	0.40
16	Palatalization	15	14	50	47	0.25
17	Lateralization	13	16	43	53	0.77
18	Prevocalic Devoicing	1	-	3	-	1.01
19	Prevocalic voicing	3	1	10	3	1.03
20	Backing	7	2	23	7	1.80
21	Geminate cluster Reduction	11	10	37	33	0.27
22	Metathesis	1	1	3	3	0.00
23	Deaspiration	17	13	57	47	1.03
24	Gliding	4	8	13	23	1.29
25	Derhotarization	10	10	33	33	0.00
26	Delateralization	4	3	13	10	0.40
27	Distortions	5	6	17	20	0.33
28	Medial syllable deletions	15	14	50	47	0.25
29	Final vowel deletion	2	0	7	-	1.43

Table 9a: Indicates significant difference (*) between male and female subjects in the age range of 2.0 - 2.6 years

Statistical analysis reveals that there is a significant difference between males and females for cluster simplification and palatal fronting in 2.0 - 2.6 years group. For all the other processes there was no significant gender differences observed.

Sl.no	Phonological processes	No. of subjects exhibiting the process		Percentage of subjects exhibiting the process		/Z/
		Males	Females	Males	Females	
1	**Cluster Reduction**	30	30	100	100	0.00
2	**Cluster Simplification**	8	4	27	13	1.29
3	**Epenthesis/cluster simplification**	26	27	87	90	0.40
4	**Cluster Substitution**	15	24	50	80	2.43*
5	**Affrication**	29	18	97	60	3.44*
6	**Deaffrication**	11	13	37	43	0.53
7	**Stopping**	27	21	90	70	1.94
8	**Palatal Fronting**	7	5	23	17	0.64
9	**Velar fronting**	1	4	3	13	1.40
10	**Retroflex fronting**	28	24	93	80	1.52
11	**Nasal fronting**	1	1	3	3	0.00
12	**Initial Consonant deletion**	4	2	13	7	0.86
13	**Medial consonant deletion**	20	10	67	33	2.58*
14	**Final Consonant Deletion**	11	-	37	-	3.67*
15	**Nasal Assimilation**	1	1	3	3	0.00
16	**Palatalization**	14	21	47	70	1.83
17	**Lateralization**	8	6	27	20	0.61
18	**Backing**	3	2	10	7	0.47
19	**Geminate cluster Reduction**	13	12	37	40	0.26
20	**Deaspiration**	9	5	30	17	1.22
21	**Gliding**	3	4	10	13	0.40
22	**Derhotarization**	8	8	27	27	0.00
23	**Delateralization**	4	2	14	7	0.86
24	**Distortions**	4	8	14	27	1.29

Table 9b: Indicates significant difference (*) between male and female subjects in the age range of 2.6 – 3.0 years

The processes cluster substitution, affrication, medial and final consonant deletion was significantly higher in males than in females in the age range of 2.6 - 3.0 years. There was no significant difference noticed in the percentage of subjects exhibiting the other processes across gender in this age range.

Sl.no	Phonological processes	No. of subjects exhibiting the process		/Z/
		Males (2.0 - 2.6 yrs)	Males (2.6 - 3.0 yrs)	
1	Cluster Reduction	30	30	0.00
2	Cluster Simplification	12	8	1.09
3	Epenthesis/cluster simplification	26	26	0.00
4	Cluster Substitution	21	15	1.58
5	Affrication	27	29	1.03
6	Deaffrication	20	11	2.33*
7	Stopping	28	27	0.467
8	Palatal Fronting	19	7	3.13*
9	Velar fronting	7	1	2.27*
10	Retroflex fronting	28	28	0.00
11	Nasal fronting	3	1	1.04
12	Initial Consonant deletion	2	4	0.86
13	Medial consonant deletion	23	20	0.86
14	Final Consonant Deletion	7	11	1.13
15	Nasal Assimilation	3	1	1.04
16	Palatalization	15	14	0.26
17	Lateralization	13	8	1.35
18	Prevocalic Devoicing	1	0	1.01
19	Prevocalic voicing	3	0	1.77
20	Backing	7	3	1.39
21	Geminate cluster Reduction	11	13	0.53
22	Metathesis	1	0	1.01
23	Deaspiration	17	9	2.08*
24	Gliding	4	3	0.40
25	Derhotarization	10	8	0.56
26	Delateralization	4	4	0.00
27	Distortions	5	4	0.36
28	Medial syllable deletions	15	0	4.47*
29	Final vowel deletions	2	0	1.43

Table 10a: Indicates significant difference across males (*)

Sl.no	Phonological processes	No. of subjects exhibiting the process		/Z/
		Females (2.0 - 2.6 yrs)	Female (2.6 - 3.0 yrs)	
1	Cluster Reduction	30	30	0.00
2	Cluster Simplification	2	4	0.86
3	Epenthesis/cluster simplification	26	27	0.40
4	Cluster Substitution	14	24	2.68*
5	Affrication	26	18	2.35*
6	Deaffrication	21	13	2.08*
7	Stopping	26	21	1.57
8	Palatal Fronting	11	5	1.75
9	Velar fronting	5	4	0.36
10	Retroflex fronting	30	24	2.58*
11	Nasal fronting	-	1	1.01
12	Initial Consonant deletion	3	2	0.27
13	Medial consonant deletion	24	10	3.65*
14	Final Consonant Deletion	13	0	4.07*
15	Nasal Assimilation	4	1	1.40
16	Palatalization	14	21	1.83
17	Lateralization	16	6	2.68*
18	Prevocalic Devoicing	0	0	-
19	Prevocalic voicing	1	0	1.01
20	Backing	2	2	0.00
21	Geminate cluster Reduction	10	12	0.53
22	Metathesis	1	0	0.01
23	Deaspiration	13	5	2.25*
24	Gliding	8	4	1.29
25	Derhotarization	10	8	0.56
26	Delateralization	3	2	0.46
27	Distortions	6	8	0.61
28	Medial syllable deletions	14	0	4.27*

Table 10 b: Indicates significant difference across females (*)

Statistical analysis was carried out to delineate whether there is any significant difference across age for males and females separately. When males of 2.0 - 2.6 years was compared with males of 2.6 - 3.0 years, significant differences between age groups was observed for the processes deaffrication, palatal fronting, velar fronting, deaspiration and medial syllable deletion. The processes cluster substitution, affrication, deaffrication, medial consonant deletion, final consonant deletion, lateralization, deaspiration and medial syllable deletion were significantly higher in females of 2.6 - 3.0 compared to females of 2.0 - 2.6 years. There was no statistical difference for the remaining processes between these age ranges.

Results of Phase II

Phase II of the present study intended for the development of the software which will assist the clinician in assessing the phonological processes automatically with a minimum effort. Based on the administration of Malayalam Articulation Test (Maya, 1990) on 60 subjects each in the age range of 2.0 - 2.6 and 2.6- 3.0 years respectively, a word list was developed for inclusion in the software. Out of the 71 test stimuli, children errored on 62 words in the 2.0 - 2.6 years age range and on 55 test words in the 2.6 - 3.0 years group. Tables 11 (a) and (b) shows the number of subjects producing the incorrect responses for every target word out of the 60 children tested in each of the two age groups. The number of children producing the errors are presented in decending order.

SL.No.	Words	No of children with incorrect production	SL.No	Words	No of children with incorrect production
1.	dōktəR	60	32	m əd̪ d̪al̩əm	27
2.	nəkʂət̠Rəm	60	33	pʰaləm	26
3.	bRəʂə	60	34	tʃevI	25
4.	pust̪əkəm	60	35	koɻi	24
5.	vəst̪Rəm	60	36	ɲəɲul	22
6.	ʂəRtə	60	37	ka d̪əkal̩i	19
7.	kəsɛra	60	38	ɲədə	18
8.	sImhəm	59	39	gadʒəm	18
9.	pRāvə	59	40	dʒənɛl	17
10.	tʃəkRəm	59	41	mōd̪Irəm	17
11.	pRāvə	59	42	tʃʰaja	16
12.	tʃəkRəm	59	43	vIral	15
13.	tʃəd̪ rən	56	44	pūtʃa	10
14.	bəsə	56	45	tʃipə	9
15.	pat̪Rəm	55	46	gagʱ əm	8
16.	surjən	55	47	maraəm	7
17	RedIo	51	48	t̪akōl	7
18.	lōrI	50	49	val̩a	6
19.	sə̃dʒi	49	50	gəd̪a	5
20.	RIbən	48	51	mujəl	5
21	ʃə̃kʰə	47	52	mukʰəm	5
22	uRũbə	45	53	vɑ̄ lʲ	3
23	ɛʃu	43	54	kuda	2
24	mɛʃa	42	55	d̪ĩpəm	2
25	tʃərupə	36	56	ĩt̪ja	2
26	kIɳəR	35	57	pãga	2
27	Rōdə	33	58	bægə	2
28	aləmarI	30	59	mɑ̄ŋ:a	1
29	radʒavə	30	60	puvə	1
30	udupə	29	61	pãt̪ə	1
31	kɑ̄R	27	62	t̪ivãdI	1

Table 11a: Number of subjects producing incorrect responses in the 2.0 - 2.6 years age group

SL.No.	Words	No of children with incorrect production	SL.No	Words	No of children with incorrect production
1.	nəkʂət̠Rəm	60	29	tʃevI	17
2.	bRəʂ̣ə	60	30	radʒavə	17
3.	sImhəm	59	31	kIɳəR	15
4.	dōktəR	59	32	gadʒəm	15
5.	ṣ̌əRtə	59	33	pʰaləm	14
6.	skutəR	58	34	aləmarI	13
7.	vəst̪Rəm	57	35	dʒənɛl	12
8.	pRāvə	56	36	tʃərupə	11
9.	pust̪ə̪kəm	55	37	mōd̪Irəm	7
10.	bIskətə	53	38	ɲədə	7
11.	tʃə̃d̪r̠ən	48	39	ɲəɲul	7
12.	pat̪Rəm	48	40	kad̪ə̪kaḷi	6
13.	RIbən	45	41	t̪a̪kōl	6
14.	tʃəkRəm	44	42	udupə	6
15.	kəsɛra	43	43	vaḷa	5
16.	bəsə	42	44	tʃʰaja	5
17	surjən	41	45	mujəl	4
18.	ʃə̃kʰə	41	46	marəm	4
19.	sə̃dʒi	38	47	gəd̪a̪	3
20.	RedIo	36	48	pūtʃa	3
21	lōrI	33	49	vIral	2
22	uRũbə	31	50	tʃipə	2
23	mɛʃa	30	51	bægə	1
24	ɛʃu	30	52	ɪ̃t̪ja	1
25	m əd̪ d̪a̪ḷəm	27	53	kuda	1
26	koɻi	19	54	mɑ̄ŋ:a	1
27	kɑ̄R	19	55	vida	1
28	Rōdə	19			

Table 11b: Number of subjects producing incorrect responses in the 2.6 – 3.0 years age group

Merin (2010) developed similar software as part of the M Sc (SLP) dissertation which assesses phonological processes in Malayalam speaking children in the age range of 3.0 - 3.6 years using the same method. In the present study, this already developed software by Merin (2010) is appended along with CAPP-M which was prepared for the age range of 2 -3 years.

Hence the final output of the present study will be assessment software for the age range of 2 - 3.6 years in Malayalam.

SL.No.	Words	No of children with incorrect production	SL.No	Words	No of children with incorrect production
1.	dōktəR	30	21	surjən	10
2.	nəkʂət̠Rəm	30	22	sə̃dʒi	13
3.	sImhəm	29	23	ʃə̃kʰə	7
4.	tʃəd̪r̠ən	20	24.	mɛʃa	7
5.	bRəʂ̣ə	22	25.	mōd̪Irəm	1
6.	pust̪əkəm	20	26.	tʃevI	3
7.	skutəR	9	27	aləmarI	4
8.	bIskətə	23	28.	radʒavə	1
9.	vəst̪Rəm	28	29.	lōrI	3
10.	pRāvə	12	30.	mukʰəm	3
11.	tʃəkRəm	19	31.	ka d̪əkaḷi	1
12.	ʂ̣əRtə	25	32.	gaɡʱ əm	2
13.	pūtʃa	1	33.	tʃʰaja	1
14.	Rōdə	5	34	ɲədə	5
15.	bəsə	11	35.	ɲəɲul	2
16.	RIbən	6	36.	vIral	2
17	kəsɛra	12	37	dʒənɛl	4
18.	RedIo	5	38.	udupə	1
19.	pat̪Rəm	21	39	koɻ̠i	1
20.	ɛʃu	8	40.	pʰaləm	3

Table 11c: Number of subjects producing incorrect responses in the 3.0 - 3.6 years group (Merin, 2010).

Based on the normative data collected and analyzed, out of the 71 words tested, 40 words were found to be errored by the 30 children tested in Merin's (2010) study, i.e in the age range of 3.0 – 3.6 years. Table 11 (c) shows the number of subjects producing incorrect responses in the age range of 3.0 - 3.6 years (Merin, 2010). These errored words were arranged in the descending order, i.e., from the most erroneously produced word to the least erroneously produced test word by the subjects in this age group. From this list, all the words which were produced incorrectly by more than 40% of the children were selected for the software tool preparation. Similarly Table 12 (a) and (b) shows all the words selected based on the 40% criteria for the children in the age range of 2.0 - 2.6 years and 2.6 - 3.0 years in the present study.

Sl no	Words	Frequency	Sl no	Words	Frequency	Sl no	Words	Frequency	Sl no	Words	Frequency	Sl no	Words	Frequency
1	dōktəR	60	8	sImhəm	59	15	surjən	55	22	ʃə̃kʰə	47	29	radʒavə	30
2	nəkʂət̲Rəm	60	9	pRāvə	59	16	pat̪Rəm	55	23	ɛʃu	43	30	udupə	29
3	bRəʂə	60	10	tʃəkRəm	59	17	RedIo	51	24	mɛʃa	42	31	m əd̪d̪aḷəm	27
4	pust̪əkəm	60	11	skutəR	58	18	lōRI	50	25	tʃərupə	36	32	kɑ̄R	27
5	vəst̪Rəm	60	12	bIskətə	58	19	sə̃dʒi	49	26	kIɳəR	35	33	pʰaləm	26
6	ṣəRtə	60	13	tʃə̃d̪r̲ən	56	20	RIbən	48	27	Rōdə	33	34	tʃevI	25
7	kəsɛra	60	14	bəsə	56	21	uRũbə	45	28	aləmarI	30	35	koɻ̲i	24

Table 12a: Target words selected for the software development in 2.0 - 2.6 years range

Sl no	Words	Frequency	Sl no	Words	Frequency	Sl no	Words	Frequency	Sl no	Words	Frequency	Sl no	Words	Frequency
1	nəkʂət̲Rəm	60	6	skutəR	58	11	pat̪Rəm	48	16	bəsə	42	21	lōrI	33
2	bRəʂə	60	7	vəst̪Rəm	57	12	tʃə̃d̪r̲ən	48	17	ʃə̃kʰə	41	22	uRũbə	31
3	dōktəR	59	8	pRāvə	56	13	RIbən	45	18	surjən	41	23	ɛʃu	30
4	sImhəm	59	9	pust̪əkəm	55	14	tʃəkRəm	44	19	sə̃dʒi	38	24	mɛʃa	30
5	ṣəRtə	59	10	bIskətə	53	15	kəsɛra	43	20	RedIo	36	25	m əd̪d̪aḷəm	27

Table 12 b: Target words selected for the software development in 2.6 - 3.0 years range

For each of these selected words, all the possible productions for each target word along with the number of subjects producing that particular pattern of production was obtained. Among these different patterns of production, four varied utterances which outnumbered other patterns of production for each target word were selected for incorporating in the software.

Tables 13a and 13b shows all the possible utterances obtained from all the subjects for each of the words selected in the age group 2.0 – 2.6 years.

Sl.No	Target word	1	2	3	4	5	6	7	8	9	10
1	dōktəR	dōtəl (7)	dōtəR (50)	dōtə (3)	dōtərə (2)	-	-				
2	nəkʂət̠Rəm	nətʃət̠ərəm (10)	nətʃət̠əRəm (18)	nətʃət̠əm (14)	nətʃət̠Rəm (1)	nəʃət̠əRəm (4)	nət̠ət̠əRəm (5)	nəʃət̠ərəm (3)	nətʃəm (1)	nət̠ət̠Rəm (1)	nəʃət̠əm (1)
3	bRəʂ̣ə	bətʃə (24)	bRətʃə (2)	bət̠ə (17)	bəʃə (10)	bRəʃə (5)	bRət̠ə (2)				
4	pusʈ̪əkəm	puʈ̪əkəm (42)	puʈ̪əbəm (1)	puʃəkəm (3)	putʃəkəm (8)	put̠əm (3)	puʃʈ̪əkəm (2)	puʈ̪ət̠əm (1)			
5	vəsʈ̪Rəm	vəʈ̪əRəm (33)	vəʈ̪əm (7)	vəʈ̪ərəm (7)	vəʃərəm (1)	vəʃʈ̪əRəm (1)	vətʃə Rəm (1)	vəstəRəm (2)	vəsʈ̪əm (3)	vəʈ̪Rəm (2)	vətʃəm (1)
6	ʂ̣əRtə	tʃətə (14)	ʃətə (6)	ʈ̪ətə (22)	ʈ̪əRtə (9)	ʃəRtə (7)	tʃəRtə (2)	əRtə (1)	ʂ̣ətə (1)		
7	kəsɛra	kətʃɛra (25)	kəʈ̪ɛra (20)	kəʃɛra (12)	kə ʈ̪ɛla (1)						
8	sImhəm	tʃIməm (8)	ʃImgəm (3)	ʈ̪Imgəm (8)	tʃImgəm (6)	ʈ̪Imbəm (7)	sImgəm (7)	sIməm (4)	ʈ̪Iməm (4)	ʃImhəm (2)	Imgəm (2)
9	pRāvə	pāvə (56)	pābə (2)	pRābə (1)	pārə (1)						
10	tʃəkRəm	tʃəkəRəm (35)	tʃəkərəm (13)	əkRəm (2)	tʃəkə (1)	tʃəkəm (7)	kəkRəm (1)				
11	skutəR	kutəl (4)	kutəR (45)	kutə (1)	kutərə (3)	sutə (1)	tʃutəR (1)	tʃutəl (1)	ʈ̪utəR (1)	skutərə (1)	kutən (1)
12	bIskətə	bIkətə (53)	bIskətI (1)	bItʃkətə (2)	bIʃkətə (3)						
13	tʃə̃ɖ̪r̠ən	tʃə̃ɖ̪ər̠ən (27)	tʃə̃ɖ̪ən (24)	tʃə̃ɖ̪ə n̠ən (2)	tʃə̃ɖ̪əl (1)	ʈ̪ə̃ɖ̪r̠ən (1)	ʈ̪ə̃ɖ̪ə (1)				
14	bəsə	bətʃə (21)	bəʃə (13)	bəʈ̪ə (22)							
15	surjən	ʈ̪urjən (40)	ʃurjən (3)	tʃurjən (6)	tʃujən (2)	tʃurən (1)	urjən (2)	ʈ̪urjə (1)			
16	paʈ̪Rəm	paʈ̪əRəm (36)	paʈ̪ərəm (6)	paʈ̪əm (13)							
17	RedIo	redIo (39)	dedIo (3)	redIəm (1)	redI (6)	reo (2)	redo (1)				
18	lōRI	lōrI (40)	lōlI (5)	ōrI (1)	ɖ̪ōrI (2)	lōrIl (1)	lōjI (1)	ʈ̪ōrI (1)			
19	sə̃dʒi	ʈ̪ə̃dʒi (31)	tə̃dʒi (16)	ʃə̃dʒi (5)	ə̃dʒi (1)	tʃə̃dʒi (1)					

Table 13a: Various patterns of productions observed for the selected target words in 2.0 - 2.6 years

20	RIbəɳ	rIbəɳ (16)	rIbəm (5)	rIbə (6)	rIbən (23)	dIbəɳ (1)			
21	uRūbə	ūbə (36)	urūbə (9)	udūbə (1)					
22	ʃə̃kʰə	t̪ə̃kʰə (28)	tʃə̃kʰə (18)	t̪ə̃ t̪ə (1)	ə̃kʰə (1)				
23	εʃu	εtʃu (32)	ε t̪u (11)						
24	mεʃa	mεtʃa (30)	mεt̪a (12)	mεsa (1)					
25	tʃərupə	tʃəpə (24)	tʃəupə (6)	t̪ərupə (3)	t̪əpə (1)				
26	kIɳəR	kIɳəl (16)	kIɳəɳ (4)	kIɳə (11)	kIɳərə (1)	kIɳəl (1			
27	Rōdə	rōdə (26)	dōdə (4)	d̪ōdə (2)					
28	aləmarI	amarI (16)	ajəmarI (1)	aləmadI (1)	ad̪əmarI (1)	arəvI (1)	alarI (2)	arəmarI (1)	aḷəmarI (1)	aləmajI (1)
29	radʒavə	ra d̪avə (25)	radavə (3)	d̪adʒavə (1)					
30	udupə	upə (29)							
31	m əd̪ d̪aḷəm	m əd̪aḷəm (18)	m əd̪d̪am (1)	m əlaḷəm (1)	m əd̪ d̪aləm (2)	məd̪alə (1)	məd̪aləm (1)		
32	kāR	kārə (24)	kālə (2)	kājə (1)					
33	pʰaləm	palam (22)	panam (1)	balam (1)					
34	tʃevI	evi (2)	t̪evi (20)	tʃebi (2)	t̪ebi (1)				
35	ko<u>ɻi</u>	koI (14)	t̪o<u>ɻi</u> (1)	koḷI (4)	koji (5)	koli (1)			

Table 13b: Various patterns of productions observed for the selected target words in 2.0 – 2.6 years

Table 14a and 14b shows all the possible utterances obtained from all the subjects for each of the target words selected in the age group of 2.6 – 3.0 years.

Sl No	Target word	1	2	3	4	5	6	7	8	9	10
1	nəkʂ̣ət̠Rəm	nətʃət̠əRəm (22)	nətʃət̠əm (9)	nətʃət̠ərəm (4)	nət̠ət̠əm (4)	nəʃət̠əRəm (11)	nəʃət̠Rəm (3)	nəʃət̠əm (2)	nət̠ət̠əRəm (1)	nət̠ətʃəRəm (1)	nəkʂ̣ət̠əRəm (1)
2	bRəʂ̣ə	bətʃə (18)	bət̠ə (7)	bəʃə (15)	bRəʃə (11)	bRət̠ə (2)	bRətʃə (7)				
3	dōktəR	dōtəl (2)	dōtəR (54)	dōtə (3)							
4	sImhəm	tʃImgəm (15)	ʈ̪Iməm (2)	sIməm (8)	tʃIməm (6)	ʈ̪Imgəm (4)	sImgəm (14)	ʈ̪Imbəm (5)	Igəm (1)	sImbəm (2)	tʃImgəm
5	ʂ̣əRtə	ʈ̪əRtə (10)	tʃəRtə (7)	tʃətə (6)	ʃəRtə (15)	ʈ̪ətə (14)	ʃətə (4)	ʂ̣ətə (3)			
6	skutəR	kutəR (50)	tʃutəR (3)	sutəR (4)	ʈ̪utəR (1)						
7	vəsʈRəm	vəʈəm (9)	vəʈRəm (8)	vəʈ̪əRəm (20)	vəstəRəm (9)	vətʃə Rəm (3)	vəsʈəm (4)	vəʈərəm (1)	vətʃəm (1)	vəkə Rəm (1)	vəʈ̪rəm (1)
8	pRāvə	pāvə (58)	pābə (1)								
9	pusʈ̪əkəm	puʈ̪əkəm (41)	putʃəkəm (9)	puʃʈ̪əkəm (3)	pukək̠əm (1)	putʃəm (1)					
10	bIskətə	bIkətə (45)	bIʃkətə (5)	bItʃətə (2)							
11	paʈ̪Rəm	paʈ̪əm (11)	paʈ̪əRəm (31)	paʈ̪ərəm (5)							
12	tʃə̃ɖr̠ən	tʃə̃ɖər̠ən (23)	tʃə̃ɖəR (1)	tʃə̃ɖən (22)	tʃə̃ɖIr̠ən (1)	tʃə̃ɖəɟən (1)					
13	RIbəɳ	rIbəɳ (28)	rIbəm (2)	rIbə (1)	rIbən (13)						
14	tʃəkRəm	tʃəkəRəm (30)	tʃəkərəm (4)	tʃəkəm (8)	tʃəkə (1)	tʃəkəjəm (1)					
15	kəsɛra	kətʃɛra (27)	kəʈ̪ɛra (7)	kəʃɛra (8)							
16	bəsə	bətʃə (15)	bəʃə (14)	bəʈ̪ə (13)							
17	ʃə̃kʰə	tʃə̃kʰə (18)	ʈ̪ə̃kʰə (21)	ʈ̪ə̃ ʈ̪ə (1)	sə̃kʰə (1)						

Table 14a: Various patterns of productions observed for the selected words in 2.6 - 3.0 years

18	surjən	tʃujən (1)	t̪urjən (25)	tʃurjən (10)	ʃurjən (3)	urjən (1)	surən (1)
19	sə̃dʒi	t̪ə̃dʒi (31)	tʃə̃dʒi (5)	ʃə̃dʒi (1)			
20	RedIo	Redio (28)	Redi (1)	dedio (4)	edio (2)	t̪edio (1)	
21	lōrI	lōrI (25)	d̪ōrI (1)	lōlI (3)	t̪ōrI (2)	lōdI (2)	
22	uRũbə	ũbə (15)	urũbə (10)	udũbə (3)	ujũbə (1)	uḷũbə (1)	
23	ɛʃu	ɛtʃu (18)	ɛ t̪u (2)				
24	mɛʃa	mɛtʃa (26)	mɛt̪a (4)				
25	m əd̪ d̪aḷəm	m ə d̪aḷəm (23)	m əd̪aləm (2)				

Table 14b: Various patterns of productions observed for the selected words in 2.6 - 3.0 years

Among the different productions four most commonly occurring productions were selected. As evident from the tables, some words had as many as 11 different patterns of productions whereas some words had as few as 3 patterns of productions in the normal children tested. The four selected varied utterances for the target words for 2.0 – 2.6 years age group from the sample are listed in Tables 15a and 15b. The same lists are provided in Appendix A.

SL NO	CORRECT PRODUCTION	PATTERN 1	PATTERN 2	PATTERN 3	PATTERN 4
1	dōktəR	dōtəR	dōta	dōtəl	dōtərə
2.	Rōdə	rōdə	dōdə	d̪ōdə	
3.	kIɳəʀ	kIɳəl	kIɳə	kIɳəɳ	kIɳərə
4.	məd̪d̪aḷəm	məd̪aḷəm	məd̪aləm	məd̪d̪aləm	
5	nəkʂət̪Rəm	nətʃət̪əRəm	nətʃət̪əm	nətʃət̪ərəm	nət̪ət̪əRəm
6.	udupə	upə			
7.	bəsə	bətʃə	bət̪ə	bəʃə	
8.	RIbəɳ	rIbən	rIbəɳ	rIbə	rIbəm
9.	jɛʃu	ɛtʃu	ɛt̪u		
10.	lōRI	lōrI	d̪ōrI	lōlI	
11.	ələmarI	əmarI	əlarI	əjəmarI	ələmajI
12	tʃevI	t̪evI	tʃebI	t̪ebI	evI
13.	sImhəm	tʃImən	t̪Imgəm	t̪Imbəm	sImgəm
14.	sə̃dʒi	t̪ə̃dʒi	ʃə̃dʒi	tʃə̃dʒi	ə̃dʒi
15.	surjen	t̪urjen	tʃurjen	ʃurjen	tʃujen
16.	kəsɛra	kətʃɛra	kət̪ɛra	kəʃɛra	kət̪ɛla
17.	pʰəlam	pəlam	bəlam	pənam	
18.	radʒavə	rad̪avə	radavə	d̪adʒavə	
19.	tʃerupə	tʃepə	tʃeupə	t̪erupə	t̪epə

Table 15a: Selected words with their most frequent forms of productions for 2.0 - 2.6 years

20.	ʃə̃kʰə	t̪ə̪̃kʰə	tʃə̃kʰə	t̪ə̪̃t̪ə̪	
21.	mɛʃa	mɛtʃa	mɛt̪a̪	mɛsa	
22.	koɭ̳i̳	koi̱	koḷi	koli	
23.	RedIo	redIo	redI	dedIo	reo
24.	uRũbə	ũbə	urũbə	udũbə	
25	kāR	kār ə	kāl ə	kāj ə	
26.	tʃəd̪ ṟən	tʃəd̪ əṟən	tʃəd̪ə̪n	tʃəd̪ ənən	
27	pRāvə	pāvə	pābə	pRābə	
28.	tʃəkRəm	tʃəkəRəm	tʃəkəm	tʃəkrəm	kəkRəm
29.	pat̪Rəm	pat̪ə̪Rəm	pat̪ə̪m	pat̪ə̪rəm	
30	ṣ̪əRtə	t̪ə̪tə	tʃətə	t̪ə̪Rtə	ʃəRtə
31	bRəṣ̪ə	bətʃə	bət̪ə̪	bəʃə	bRəʃə
32.	pust̪ə̪kəm	put̪ə̪kəm	putʃəkəm	puʃəkəm	put̪ə̪m
33.	skutəR	kutəR	kutəl	kutərə	tʃutəl
34.	bIskətə	bIkətə	bIʃkətə	bItʃkətə	
35.	vəst̪ Rəm	vəst̪ə̪Rəm	vəst̪ əm	vəst̪ ərəm	vəst̪ əm

Table 15b: Selected words with their most frequent forms of productions for 2.0 - 2.6 years

Table 16 shows the four varied utterances for the target words for 2.6 – 3.0 years age group selected from the sample. The same list is provided in Appendix B.

SL. NO	CORRECT PRODUCTION	PATTERN 1	PATTERN 2	PATTERN 3	PATTERN 4
1	dōktəR	dōtəR	dōta	dōtəl	
2	məd̪d̪aḷəm	məd̪aḷəm	məd̪aləm		
3	nəkʂət̪Rəm	nətʃət̪əRəm	nətʃət̪əm	nəʃət̪əRəm	nətʃət̪ərəm
4	bəsə	bətʃə	bət̪ə	bəʃə	
5	RIbəɳ	rIbən	rIbəɳ	rIbə	rIbəm
6	jɛʃu	ɛtʃu	ɛt̪u		
7	lōRI	lōrI	lōlI	lōdI	t̪ōrI
8	sImhəm	tʃIməm	t̪Imgəm	sIməm	sImgəm
9	sə̃dʒi	t̪ə̃dʒi	ʃə̃dʒi	tʃə̃dʒi	
10	surjen	t̪urjen	tʃurjen	ʃurjen	tʃujen
11	kəsɛra	kətʃɛra	kət̪ɛra	kəʃɛra	
12	ʃə̃kʰə	t̪ə̃kʰə	tʃə̃kʰə	sə̃t̪ə	
13	mɛʃa	mɛtʃa	mɛt̪a		
14	RedIo	redIo	edIo	dedIo	
15	uRũbə	ũbə	urũbə	udũbə	ujũbə
16	tʃəd̪r̠ən	tʃəd̪ər̠ən	tʃəd̪ən	tʃəd̪əjən	
17	pRāvə	pāvə	pābə		
18	tʃəkRəm	tʃəkəRəm	tʃəkəm	tʃəkrəm	tʃəkəjəm
19	pat̪Rəm	pat̪əRəm	pat̪əm	pat̪ərəm	pat̪əjəm
20	ʂəRtə	t̪ətə	tʃəRtə	t̪əRtə	ʃəRtə
21	bRəʂə	bətʃə	bət̪ə	bəʃə	bRəʃə
22	pust̪əkəm	put̪əkəm	putʃəkəm	puʃt̪əkəm	putʃəm
23	skutəR	kutəR	sutəR	t̪utəR	tʃutəR
24	bIskətə	bIkətə	bIʃkətə	bItʃətə	
25	vəst̪Rəm	vəst̪əRəm	vət̪Rəm	vət̪əRəm	vət̪əm

Table 16: Selected words with their most frequent forms of production for 2.6 - 3.0 years

In the existing tool in Malayalam (Merin, 2010), 20 words were selected from the list of words arranged in descending order of erroneous production by 30 subjects tested in the age range of 3.0 - 3.6 years. For these 20 words, 3 varied production patterns for each word were selected for the software development. Table 17 shows the list of these words along with the three varied patterns for each test word selected. The same list is provided in Appendix C.

SL. No	Correct Production	1	2	3
1	dōktəR	dōtəR	dōkt̪̪əR	dōt̪̪əR
2	nəkʂət̠Rəm	nəʃət̪̪əRəm	nəktʃət̪̪Rəm	nətʃət̪̪əRəm
3	sImhəm	sImgəm	tʃIməm	tʃImgəm
4	bRəʂ̣ə	bətʃə	bRəʃə	bəʃə
5	pust̪̪əkəm	put̪̪əkəm	puʃt̪̪əkəm	putʃəkəm
6	bIskətə	bIkətə	bIʃkətə	
7	vəst̺̪Rəm	vəst̪̪əRəm	vət̺̪Rəm	vət̺̪əRəm
8	ʂ̣əRtə	tʃəRtə	ʃəRtə	t̪̪əRtə
9	pat̪̪Rəm	pat̪̪əRəm	pat̺̪əm	-
10	tʃ ə̃d̺̪r̠ən	tʃ ə̃d̺̪ər̠ən	tʃə̃d̺̪ən	-
11	skutəR	kutəR	tʃutəR	-
12	pRāvə	pāvə	paRvə	-
13	tʃəkRəm	tʃəkəRəm	tʃəkəm	kəkəRəm
14	bəsə	bəʃə	bətʃə	bət̪̪ə
15	kəsɛra	kəʃɛra	kətʃɛra	kət̪̪ɛra
16	sə̃dʒi	t̪̪ə̃dʒi	t̪̪ə̃di	-
17	ʃə̃gʰə	tʃə̃gʰə	t̪̪ə̃gʰə	-
18	mɛʃa	mɛtʃa	mɛt̪̪a	-
19	surjen	ʃurjen	t̪̪urjen	tʃurjen
20	ɛʃu	ɛtʃu	ɛt̪̪u	-

Table 17: Selected words with their most frequent forms of production for 3.0-3.6 years (Merin, 2010)

Thus most erroneous words along with its most commonly occurring patterns were ready for the software making. This material was provided to a software professional at Bangalore (ENFIN Technologies India Pvt Ltd), for the development of the assessment software.

With the list of words provided, the software was developed and is named as Computerized Assessment of Phonological Processes in Malayalam (CAPP-M). This tool assesses the phonological processes in the age range of 2 – 3.6 years. Material for 2-3 years is developed in the present project and material for 3- 3.6 years was developed by Merin (2010). In the final product the two data were appended to cover an age range of 2-3.6 years. The test stimuli are represented in colour picture form. The installation and working of the software (CAPP-M) is described below.

Framework: To run the software, it is mandatory to install Adobe AIR in the system. Adobe AIR enables developers to use HTML, JavaScript, Adobe Flash® and Flex technologies, and ActionScript® to build web applications that run as standalone client applications without the constraints of a browser. So as the first step, Adobe AIR framework was downloaded from Adobe AIR from Google (link for the download is http://get.adobe.com/air/) and installed. The software (CAPP-M) can be run in any computer provided the framework Adobe AIR is installed in the system intended for the assessment procedure.

Working: After the installation of the framework, the software program (CAPP-M) file can be opened. In the first page of the tool, the name of the tool along with the name of the institute is displayed (Figure 1).

Figure 1: Shows the opening page of CAPP-M

There is an option 'start' which has the access to move to next page of the tool. Following the first page are the 2 pages for users to familiarize with the tool. There is a brief introduction about the test and instructions for the users in the following pages. Next page is for selecting the age range. The clinician, based on the language age of the child will select the age range for running the tool. There are 3 options available for selection (2.0 - 2.6, 2.6 - 3.0 and 3.0 - 3.6 years). Once the age range is selected, it automatically starts the test. The screen contains the picture of the intended target word to be tested on the left corner. Below the picture its correct production is shown in IPA symbols. At the bottom of the page, five options are provided towards the left side, i.e. the 4 most possible patterns of the intended target word along with an option called "Any other". This "Any other" option is meant for any other production by the subject which does not fall under the common patterns of production. The right side top portion of the screen contains the analysis report. Towards the bottom of the page, there are 3 blocks which shows the options, ‘Back’, ‘Report’ and ‘Next’. The option ‘Back’ aids in returning to the previous stimuli, the option ‘Report’ helps in display of the phonological processes identified in the children and the option ‘Next’ is to select the next stimulus in the tool.

The steps for using CAPP-M are elaborated below.

Step1

Installation of framework: Download Adobe AIR. Install the framework. This is mandatory as the application software requires this frame work for the working in any computer system. Inter net access is required only for the installation of the frame work Adobe AIR in the working system. CAPP-M is available in a CD format. After the installation of the framework, CAPP-M is compatible for use with any computer system.

Step 2: After installation of the framework, open the file named CAPP-M. First page is the title page consisting of the title of the software and the contact information. There is a block named ‘Start’ at the bottom right corner of this page. Selection of ‘Next’ will enable the user to go to the next page which has a brief note about the test and instructions to the user.

Figure 2: Shows the 'Next' option

Step 3: The user can get a brief introduction regarding the tool from the 2nd and the 3rd pages (See Appendix D and E). It gives a comprehensive and brief introduction regarding the use of CAPP-M.

Step 4: The clinician has to assess the language age of the child to be tested. Language age of the child can be determined by administering any of the language assessment tools such as Receptive Expressive Emergent Language skills (REELS, Bzoch & League, 1991) or 3 Dimensional Language Acquisition Test (3D LAT, Geetha Harlekhkar, 1986) or Scales for Early Communication Skills for Hearing Impaired children (SECS, Moog and Geers, 1975). Once the language age of the child is determined, the clinician can select the age range to be tested from the three options for the age range (ie., 2.0 - 2.6 years, 2.6 - 3.0 years and 3.0 - 3.6 years) as shown in Figure (3). Here the user needs to keep in mind that this tool can be used only with children who fall in the language age of 2 – 3.6 years.

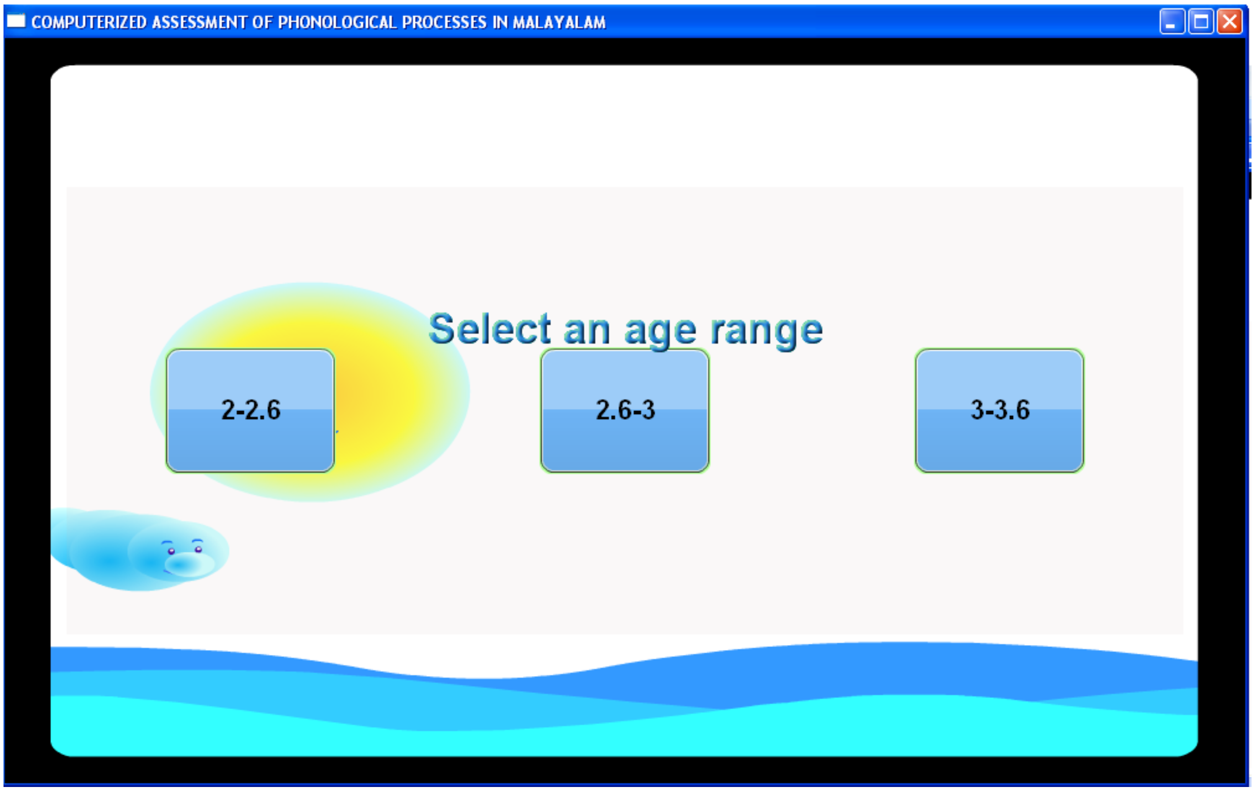


Figure 3: Shows the option for selecting the age range

Step 5: Once the clinician selects the age range, the first target word in the tool is displayed automatically in picture form along with its various possible production patterns as shown in Figure 4.

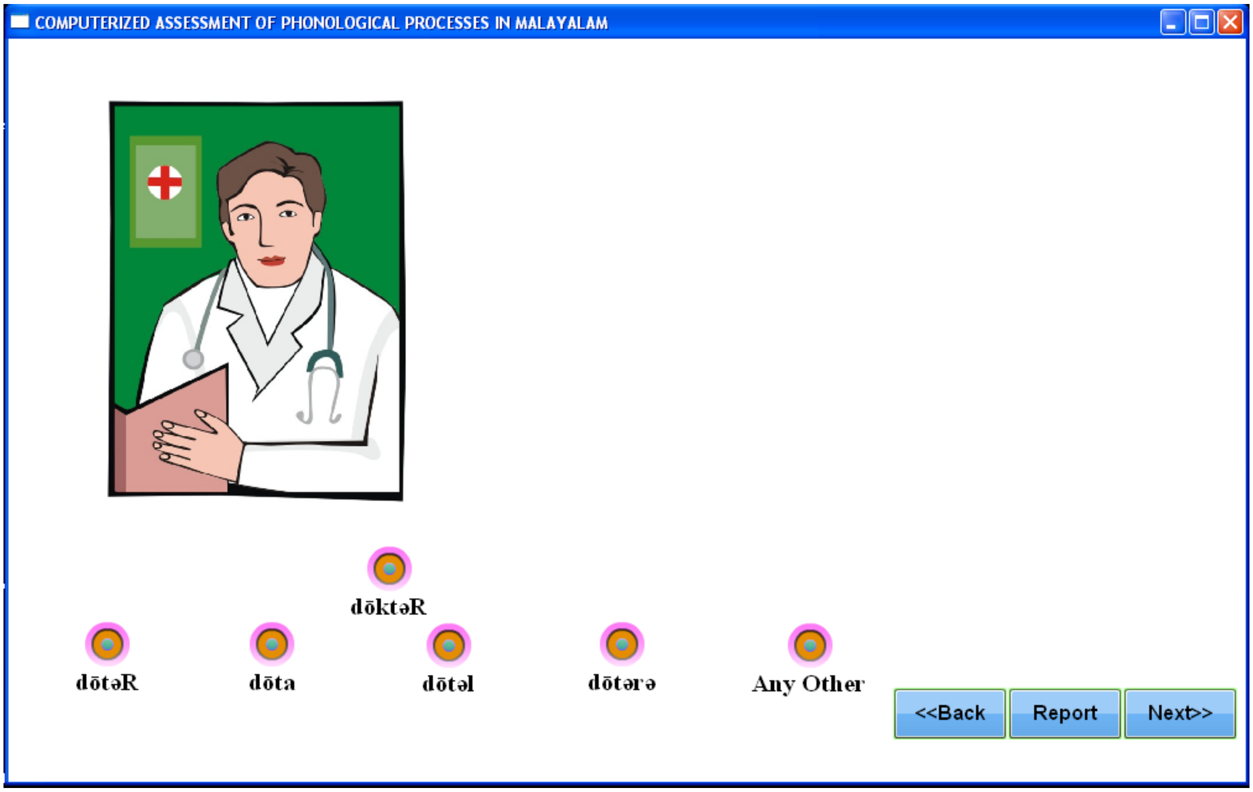


Figure 4: Shows the first target word and its various patterns of productions

The child to be tested is asked to name the picture stimulus. The clinician has to listen to the child's production of the target word carefully and based on the response obtained, the clinician is expected to click on the various options available to indicate whether the response was a correct production or was one among the possible error productions displayed on the screen. If the child produces an utterance which is not an option, the clinician can select the option; "Any other". Like this the clinician can test all the test words present in CAPP-M. On clicking the option for each test word, the phonological process operating in that particular word is identified and counted by the software itself and the information is displayed on the right hand corner of the same page. If "Any other" option is clicked, then the process counted would be under the idiosyncratic process.

Step 6: Once the selection of patterns for the first word is completed, move on further by clicking “Next” on the display page as shown in Figure 5. Similarly all the words in CAPP-M can be tested one after another. If the tester needs to go back, there is an option of “Back” for selecting the previous test word (Figure 5)

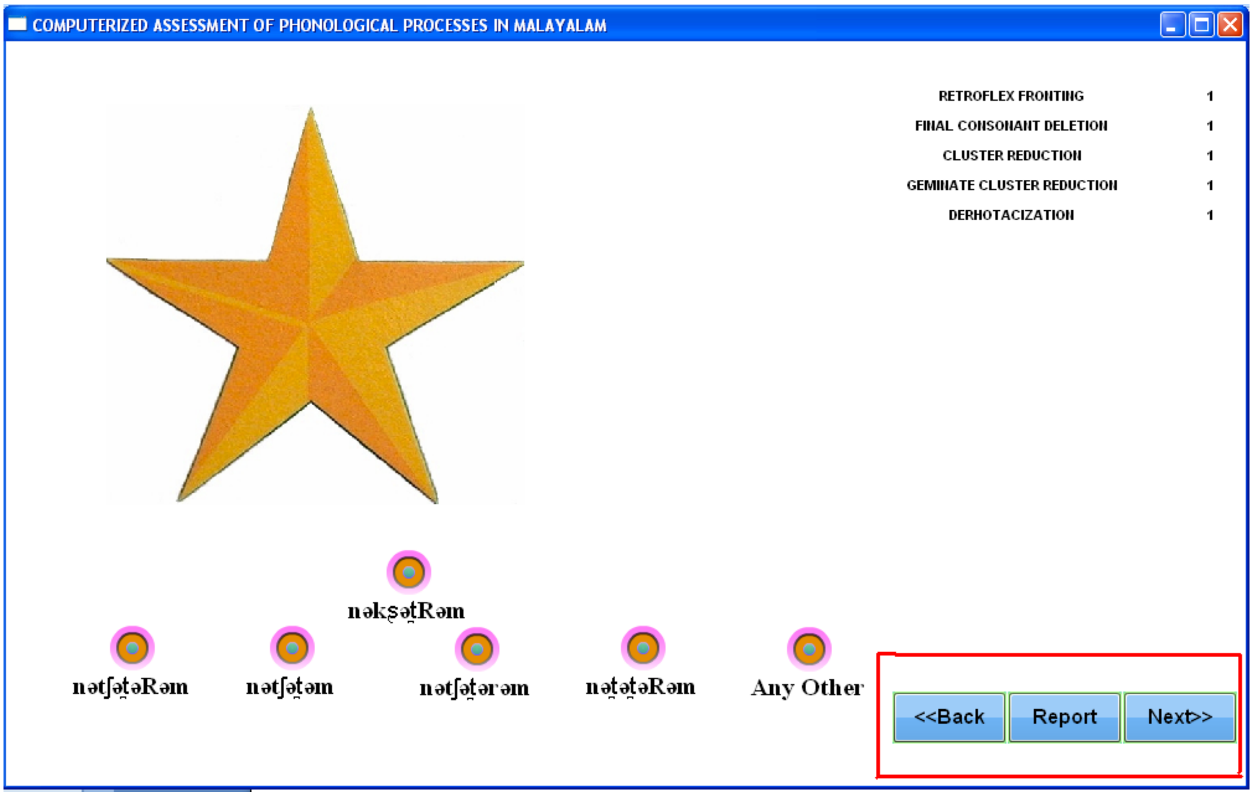


Figure 5: Shows the option ‘Back’, ‘Report’ and ‘Next’.

Step 7: Once the entire test words are administered, selection of the option ‘Next’ will open into another page highlighted as ‘Finished’ (Figure 6).

Figure 6: Depicts the ‘Finished’ page.

This page has three options. ‘Start again’ option will help the clinician to go back to the page which displayed the age ranges for selection. The option ‘Report’ gives access to the list of phonological processes with the frequency with which each process occurred. The next option is ‘Print’ which aids in taking a print out.

Step 8: When the ‘Print’ option is selected, a page is accessed in which the clinician needs to enter the details of the child (Figure 7). The details include child’s name, case number, telephone number, child’s provisional diagnosis, age and gender along with name of the child’s home town in Kerala to know about the dialect of the child.

Figure 7: Shows the page for entering the details of the subject tested.

Once the clinician fills in these details and clicks on the 'Print Preview' option, the page for print out will be displayed. This page contains all the demographic information along with the list of phonological processes the child exhibited arranged in descending order of its occurrence. Clinician can obtain the print out by selecting the block 'Print' on the top right hand corner of the page (Figure 8).

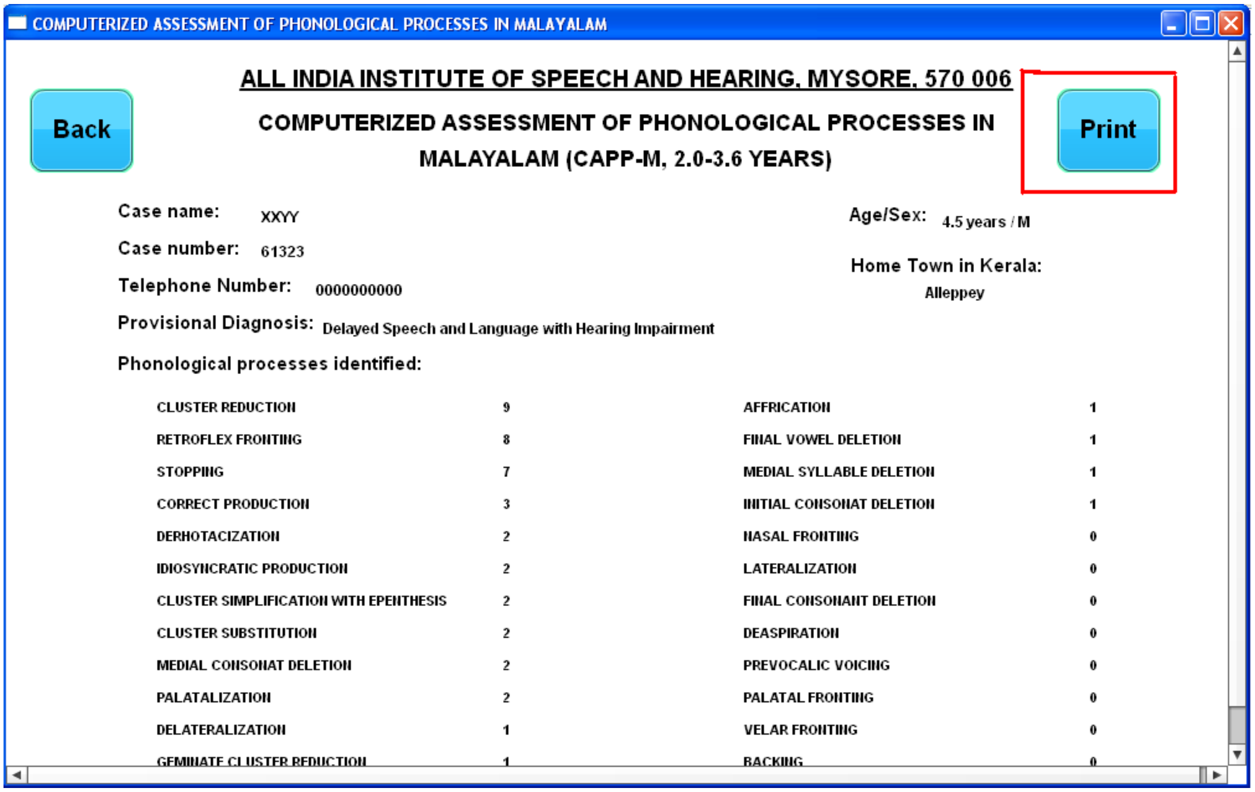


Figure 8: Shows the option 'Print' in the report page.

Step 9: After the evaluation of one child, the clinician can continue the testing with another child by selecting the 'Back' option in the same page with the print command. This will give access to the 'Finished Page' and the clinician can easily select 'Start again' option to restart the test again.

Phase III: Sensitivity evaluation of CAPP-M

The tool developed named Computerized Assessment of Phonological Processes in Malayalam (CAPP-M) was verified for its sensitivity. The sensitivity evaluation of CAPP-M was administered in children with communication disorders. Children with mental retardation and hearing impairment were selected as the target groups. The administration reveled that CAPP-M was sensitive to the various patterns of productions of children with hearing impairment as well as that of children with mental retardation. That is to say that CAPP-M can identify the most commonly occurring phonological processes in these children also.

CAPP-M in children with Hearing impairment

Aim of this phase was to see how many of the productions of children with hearing impairment and mental retardation matched with the various production patterns included in CAPP-M. CAPP-M assesses phonological processes in children in the age range of 2.0 - 3.6 years. In this age range, the part of the tool that assesses 3.0 - 3.6 years was already developed and verified for sensitivity by Merin (2010). Hence in this phase only children in the age range of 2.0 - 3.0 years were selected and tested for sensitivity.

Initially the examiner selected a list of children with hearing impairment and children with mental retardation who were attending speech and language therapy or attending special school. Receptive Expressive Emergent Language Scale (REELS; Bzoch & League, 1991) was done in these children. Based on this, children who had language age between 2.0 - 2.6 and 2.6 - 3.0 years were selected for the administration of CAPP-M. 10 children each in both the age ranges ie., 2.0 - 2.6 years and 2.6 - 3.0 years from both the categories i.e., children with hearing impairment and children with mental retardation were selected. CAPP-M was administered to these children to see how many of their productions matched with those of the various patterns accommodated in CAPP-M. For each subject tested, the number of child’s production that matched with the templates in the software is counted. Once the number of productions that matched with the templates in the software is obtained, their percentage score for each subject is calculated. This percentage score is the percentage of child’s production matching with the various patterns in the new tool developed. Again mean percentage score was calculated for each age range. Higher the percentage score, higher will be the correlation between the child's production and the templates in the software. The details of how many productions of these children matched with the patterns provided in the software are shown in Table 18 (a), (b), (c) and (d).

Subject No.	Age (in years)	Duration of Speech and Language therapy attended	Degree of Hearing loss	No of productions which matched with the templates in CAPP-M	Percentage of matching
Subject 1	3.4	8 months	B/L Severe HL	27	77
Subject 2	4.0	1.6 years	R: Severe HL L: Moderately Severe HL	29	82
Subject 3	3.8	1.4 years	B/L Moderately Severe HL	30	85
Subject 4	3.9	9 months	B/L Severe Hearing loss	27	77
Subject 5	4.6	9 months	R: Severe HL L: Moderately Severe HL	29	82
Subject 6	4.2	1.0 year	R: Moderately Severe HL L: Severe HL	31	88
Subject 7	3.7	10 months	R: Moderately Severe HL L: Severe HL	30	85
Subject 8	4.0	6 months	B/L Moderately Severe HL	28	80
Subject 9	4.1	7 months	B/L Severe HL	29	82
Subject 10	3.7	10 months	B/L Severe HL	29	82

Table 18a: Shows number of productions matching with the templates in the software for children with **hearing impairment** in the ***language age*** of 2.0 - 2.6 years

In an attempt to see to what extent the child's production matched with the patterns in the software, clinician administered CAPP-M to children with communication disorders and calculated the percentage of the child's production that matched the templates in the tool as shown in Table 18a. The results show that the mean percentage score for all the participants considered for the study was 82%. All subjects except 1 and 4 had a correlation of above 80%, which means all the participants except these two subjects had their productions similar to the patterns in CAPP-M to more than 80%. This study is in consonance with the findings of Gordon-Brannan, Weiss (2007) who reported a direct correlation between hearing loss and articulatory skills of the hearing impaired. Subject 1 and 4 have severe hearing loss and attended speech and language therapy for only 8 and 9 months respectively. Here both the factors, i.e., the degree of hearing loss and the duration of speech and language therapy attended contribute to the lesser percentage of correlation between the child's production and the templates in the software.

Subject No.	Age (in years)	Duration of Speech and Language therapy attended	Degree of Hearing loss	No of productions which matched with templates in CAPP-M	Percentage of matching
Subject 1	4.9	6 months	B/L Moderately Severe HL	20	80
Subject 2	4	7 months	R: Moderately Severe HL L: Severe HL	21	84
Subject 3	5.0	3 months	B/L Severe HL	19	76
Subject 4	4.0	5 months	B/L Severe HL	20	80
Subject 5	3.10	1 year	B/L Moderately Severe HL	22	88
Subject 6	4.6	1.2 years	R: Severe HL L: Moderately Severe HL	21	84
Subject 7	4.8	6 months	R: Moderately Severe HL L: Severe HL	20	80
Subject 8	4.3	4 months	B/L Severe HL	19	76
Subject 9	4.9	1 year	R: Severe HL L: Moderately Severe HL	21	84
Subject 10	5.0	9 months	B/L Moderately Severe HL	20	80

Table 18b: Shows number of productions matching with the templates in the software for children with **hearing impairment** in the ***language age*** of 2.6 - 3.0 years

Table 18b, suggests that Subject 3 and Subject 8 had a correlation of less than 80%. All the other subjects in the language age of 2.6 – 3.0 years had a correlation greater than 80%. This category includes children who attended therapy from 3 months to 1.2 years and the degree of hearing loss varied among the subjects. As shown in Table 18b, subject 3 and subject 8 were found to have lesser correlation (below 80%) between the production of the child and the templates in the software. These two children were found to have shorter duration of speech and language therapy (3 months and 4 months respectively), and greater degree of hearing loss (bilateral severe hearing loss). More the duration of therapy attended, better would be the articulatory skills and also, more the degree of hearing loss, articulatory skills are found to be poorer. Here in subjects 3 and 8, both the factors are found to be negatively affecting. Hence their productions had less similarity with the normal children's productions on which this new assessment tool is based.

CAPP-M in children with Mental retardation

Children with mental retardation in the language age range between 2.0 - 2.6 years, had a mean correlation of 80% between the children's production and the templates in the tool. Subject 1 had the highest correlation of 88% between the patterns in the tool and the child's productions. It is evident from Table 18c that, Subject 1 has moderate mental retardation and attended speech and language therapy for one year duration. These factors have contributed for the better performance on CAPP-M. Whereas Subject 3 had the lowest correlation of 71% between the templates and the child's production of the target picture stimuli. Subject 3 attended speech and language therapy for 7 months and had moderate level of mental retardation. This factor might have contributed for obtaining lower correlation in this particular subject. The results show that there is a good correlation between the production patterns of children with mental retardation and the production patterns in CAPP-M.

Subject No.	Age (in years)	Duration of Speech and Language therapy attended	Level of Mental Retardation	No of productions which matched with templates in CAPP-M	Percentage of matching
Subject 1	4.6	1 year	Mild	31	88
Subject 2	5.3	10 months	Mild	29	82
Subject 3	4.0	7 months	Moderate	25	71
Subject 4	6.2	1.1 years	Moderate	26	74
Subject 5	7.2	11 months	Mild	28	80
Subject 6	7.0	7 months	Mild	30	85
Subject 7	6.0	8 months	Mild	30	85
Subject 8	4.3	1.8 years	Moderate	29	82
Subject 9	5.2	7 months	Moderate	27	77
Subject 10	5.5	1.4 years	Mild	29	82

Table 18c: Shows number of productions matching with the templates in the software for children with **mental retardation** in the ***language age*** of 2.0 - 2.6 years

Table 18d reveals that children with mental retardation in the language age of 2.6 - 3.0 years obtained a mean percentage correlation of only 67% between the children's productions and the templates in the tool. In this age range, Subjects 3 and 7 had a correlation of 80%. Subject 3 attended speech and language therapy for 1.6 years and have mild mental retardation. Subject 7 attended speech and language therapy for 1.5 years and has moderate level of mental retardation. However all the other subjects had less than 80% correlation. The results indicate that the correlation between the children's productions and the patterns in the tool was poorer for the children with mental retardation in the age range of 2.6 - 3.0 years (67% only). However as the correlation is above chance factor, the tool can be used to assess children with mental retardation also. Also the present finding is based on the performance of only 10 subjects with mental retardation. The correlation scores can possibly improved by administering on a larger population.

Subject No.	Age (in years)	Duration of Speech and Language therapy attended	Level of Mental Retardation	No of productions which matched with templates in CAPP-M	Percentage of matching
Subject 1	5.3	10 months	Moderate	19	76
Subject 2	7.4	1 year	Severe	17	68
Subject 3	5.9	1.6 years	Mild	20	80
Subject 4	6.5	1.8 years	Moderate	19	76
Subject 5	6.0	1.2 years	Severe	18	72
Subject 6	5.9	1.1 year	Moderate	18	72
Subject 7	6.1	1.5 years	Moderate	20	80
Subject 8	6.2	9 months	Mild	19	76
Subject 9	7.0	1.6 years	Moderate	19	76
Subject 10	7.2	1.4 years	Moderate	18	72

Table 18d: Shows number of productions matching with the templates in the software for children with **mental retardation** in the ***language age*** of 2.6 - 3.0 years

SUMMARY AND CONCLUSIONS

The present study aimed to develop an indigenous software which assess phonological processes in the age range of 2.0 - 3.0 years in Malayalam speaking children. After the tool was developed, the existing similar software (Computer based Assessment of Phonological Processes in Malayalam for 3 – 3.6 years; Merin, 2010 as part of dissertation) was appended to this newly developed tool. Thus CAPP-M assesses phonological processes in the age range of 2.0-3.6 years.

Present study was conducted in three phases. Literature reports of several studies to identify the phonological processes in English and in various Indian languages. In Phase I, normative data was collected from 120 subjects (60 subjects each in 2.0 - 2.6 and 2.6 - 3.0 years) by administering the Malayalam Diagnostic Articulation Test (MAT; Maya, 1990). The recorded samples were transcribed and analyzed and phonological processes were identified. Results showed that out of the 71 words tested, children errored on 62 test words in the 2.0 - 2.6 years group and on 55 words in the 2.6 - 3.0 years group. A total of 29 phonological processes were prevalent in the lower age group and 24 phonological processes were operational in the higher age group.

There are a number of computer based assessment materials like Computerized Articulation and Phonology Evaluation System (CAPES; Masterson & Bernhardt, 2001), Hodson Computerized Analysis of Phonological Patterns (HCAPP; Hodson, 2003) etc in the western context. In Indian languages first attempt has been made in Kannada language, but was limited to only the computerized presentation of the test stimuli. Merin (2010) developed ‘Computer based Assessment of Phonological Processes in Malayalam’ which automatically assess phonological process from 20 target words. However, the test is for the children in the age range of 3.0 - 3.6

years only. However this tool made the assessment of phonological processes to be quick and less laborious.

Phase II aimed at the development of the software which is named as Computerized Assessment of Phonological Processes in Malayalam (CAPP-M) with age range o 2.0 - 3.0 years. Based on the normative data obtained, CAPP-M has 35 test words for the age range of 2.0 - 2.6, 25 test words for 2.6 - 3.0 and 20 test stimuli for 3.0 - 3.6 years. On presentation of the picture stimuli on a laptop computer, the child had to name the stimuli and the clinician had to listen to the child's production carefully and select one of the six options provided in the tool (the number of options will reduce with increase in age). The six options include IPA representations of the correct production of the test stimuli, four varied erroneous production patterns based on the normative data collected and lastly an option 'Any other' which corresponds to idiosyncratic productions. Once the clinician selects any of these options, the type of phonological processes based on the child's utterance is automatically accounted by the assessment software. The clinician can obtain the report by selecting the option 'Report' and obtain the hard copy by selecting the option 'Print'.

Phase III was carried out on children with communication disorders to check the sensitivity of the newly developed computerized assessment software CAPP-M. The testing can be completed with in duration of 10 minutes for each subject. CAPP-M was administered on 10 children each with mental retardation and hearing impairment in the age range 2.0 - 2.6 years and 2.6 - 3.0 years. Hence totally 40 children were included for the sensitivity evaluation. Results showed that a mean correlation of 82% in children with hearing impairment and 80% in children with mental retardation in the age range of 2.0 – 2.6 years. In the 2.6 - 3.0 years group, children with hearing impairment had a mean correlation of 81%, while children with mental retardation had a correlation of 67% only between the children's production of the target stimuli and the templates in the tool developed. However the tool can be tested on a larger clinical population to establish its clinical validity. Phase III was helpful in testing the sensitivity of various patterns of productions considered in the assessment software on children with hearing impairement and mental retardation.

REFERENCES

Bharathy, R. (2001). Development of phonological processes of 3-4 years old normal Tamil speaking children. Research at A.I.I.S.H, IV, 130-131.

Bortolini, U., & Leonard, L. B. (1991). The speech of phonologically disordered children acquiring Italian. *Clinical Linguistics and Phonetics*, (8), 283–93.

Bzoch, K. R., League, R (1991). Receptive Expressive Emergent Language Scales (2nd Edn). Austin, TX: PRO-ED.

Dean, E.C., Howell, J., Hill, A., & Waters, D. (1990). Metaphon resource pack. Windsor, Berks, Nfer Nelson.

Divya, P., & Sreedevi, N. (2010). Articulatory Acquisition in Typically Developing Malayalam Speaking Children: 2 – 3 years. Student Research at A.I.I.S.H. Mysore (Articles based on dissertation done at AIISH), Vol VIII:2009-10.

Dodd, J.B., & Hua, Z. (2000). The Phonological Acquisition of Putonghua (Modern Standard Chinese). *Journal of Child Language*, 27, 3-42.

Dyson, A., & Paden, E., (1983). Some Phonological Acquisition Strategies used by two years olds. *Journal of Childhood Communication Disorders,* 7(1),

Dyson, A.T., & Amayrey, M.M. (1998). The Acquisition of Arabic Consonants. *Journal of Speech, Language, and Hearing Research*, 41, 642-653.

Edward, M.L., & Shriberg, L.D. (1983). Phonology: Application in communication disorders. San Diego: College-Hill press.

Edwards, M.L. (1992). Clinical forum: Phonological assessment and treatment. In support of phonological processes. *Language Speech and Hearing Services in Schools, 23*, 233-240.

Geetha, H. (1986). 3- Dimensional Language Acquisition Test. Research at A.I.I.S.H, Dissertation Abstracts: Vol II, 87-88.

Goldstein,B., & Washington, S.P. (2001). An Initial Investigation of Phonological Patterns in typically developing 4-Year old Spanish- English Bilingual Children. *Language, Speech and Hearing Services in Schools*, 32, 153-164.

Gordon-Brannan, M.E., & Weiss, C.E. (2007). Clinical Management of Articulatory and Phonologic Disorders (3rd eds.). Baltomore: Lippincott Williams and Wilkins.

Grunwell, P. (1981). The Development of Phonology: A description profile. *First Language*, 3, 161-191.

Grunwell, P. (1985). *Phonological Assessment of Child Speech (PACS).* Windsor, Berks: NFER-Nelson.

Grunwell, P. (1987). Clinical Phonology (2nd ed). Baltimore, Williams & Wilkins.

Haelsig, P.C., & Madison, C.L. (1986). A Study of Phonological Processes Exhibited by 3-, 4-, and 5- Year- Old Children. *Language, Speech and Hearing Services in Schools*, 17, 107-114.

Hodson, B. (1980). *The Assessment of Phonological Processes*. Danville, Illinois: Interstate.

Hodson, B. W. (1985). Computerized Assessment of Phonological Processes: Version 1.0 (Apple II series Computer Program). Danville III, Interstate.

Hodson, B.W. (2003). Hodson computerized analysis of phonological pattern. Wichita, KS: PhonoComp software.

Hodson, B.W. (2004). Hodson assessment of phonological patterns (34d ed). Austin, TX, Pro-Ed.

Hodson, B.W., & Paden, E. (1981). Phonological processes which characterize unintelligible and intelligible speech in early childhood. *Journal of Speech and Hearing Disorders,* 46, 369-373

Hodson, B.W., & Paden, E. (1983). Targeting intelligible speech. San Diego, College-Hill press.

Hodson, B., & Paden, E. (1991). Targeting intelligible speech: A phonological approach to remediation. (2nd ed.). Texas: Pro-Ed.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: Relation to language input and gender. Developmental Psychology, 27, 236-248.

Ingram, D. (1976). Phonological disability in children. London, UK: Edward Arnold.

Ingram, D. (1981). Procedure for the phonological analysis of children's language. Baltimore, University Park Press.

Ingram, D. (1989). Phonological Disability in Children (2nd ed.). San Diego: Singualr Publishing Group, Inc.

Ingram, D. (1997) The categorization of phonological impairment. In B. W. Hodson and M. L. Edwards (eds.), *Perspectives in Applied Phonology* (pp. 19–42). Gaithersburg, MD: Aspen

Ingram, K., & Ingram, D. (2002). Comentary on Evaluating Articulation and Phonological Disorders when the clock is running. American Journal of Speech- Language Pathology, 11,257-258.

James, D. G.H. (2001). Use of phonological processes in Australian children ages 2 to 7;11 years. *Advances in Speech- Language Pathology*. Vol:3, No:2, pp:109-127.

Jayashree, U.P. (1999). The Devlopment of Phonological Processes in 4-5 years old children in Kannada speaking population. Unpublished Masters Dissertation submitted to he University of Mangalore.

Locke, J.L. (1983). Clinical Phonology: The Explanation and Treatment of Speech Sound Disorders. *Journal of Speech and Hearing Disorders*, 48, 339-341.

Long, S., & Fey. M. (1988). Computerized Profiling (Apple II Series Computer Program). Department of Speech Pathology and Audiology, Ithara College, Ithara, New York.

Long, S., Fey, M., & Channell, R. (2002). Computerized Profiling, Version 9.4.1, www.computerizedprofiling.org.

Louko, L., & Edwards, M. (2001). Collecting and transcribing speech samples: Enhancing phonological analysis. *Topics in Language Disorders*, 21:4.

Lowe, R.J. (1986). Assessment Link between Phonology and Articulation (ALPHA). Moline, IL:Linguasystems, Inc.

Lowe, R.J. (1986). Phonological process analysis using three position tests. *Language, Speech and Hearing Disorders*, 46, 197-204.

Lowe, R.J. (1994). Phonology: Assessment and intervention applications in speech pathology. Baltimore: Williams & Wilkins.

Lowe, R.J. (1996). Workbook for the Identification of Phonological Processes (2^{nd} ed.). Austin, TX: PRO-ED.

Mackay, L., & Hodson, B. (1982). Phonological process identification of misarticulations of mentally retarded children. Journal of Communication Disorders, 15;3, 1982.

Masterson, H. (1999). Technological applications for speech and language assessments. *Seminars in Speech and Language*, 20.

Masterson, J., & Bernhardt, B. (2001). Computerized Articulation and Phonology Evaluations System. San Antonio. TX: The Psychological Corporation.

Masterson, J., & Long, S. (2004). Computerized Phonological Analysis. Cited in Bernthal, J., & Bankson, N. Articulation and Phonological Disorders. NY: Pearson Education, Inc.

Maya (1990): 'An articulation test battery in Malayalam'. Research at A.I.I.S.H, II, 179-180.

Mc Reynolds, L.V., & Elbert, M. (1981). Criteria for Phonological Process analyais. *Journal of Speech and Hearing Disorders*, 46, 197-204.

Merin, J. (2010). Computer Based Assessment of Phonological Processes (CAPP-M) in Malayalam- A Preliminary Attempt. Student Research at A.I.I.S.H. Mysore (Articles based on dissertation done at AIISH), Vol VIII:2009-10.

Moog, J.S., Geers, A.E. (1975). Scales for Early Communication Skills for Hearing Impaired children. St Louis, Central Institute for the Deaf.

Oller, D.K. (1975). Simplification as the goal of phonological processes in child speech. *Language Learning*, 24, 299-303.

Oller, D.K., Jensen, H.T., & Lafayette, R.H. (1978). The Relatedness of Phonological Processes of Hearing Impaired Child. *Journal of Communication Disorders*, 11, 97-105.

Oller, K., & Delgado. R. (1990). Logical International Phonetic Programs: Version 1.03 (MS-DOS Computer Program). Miami, Intelligent Hearing System.

Pena-Brooks, A., & Hedge, M. N. (2007). Assessment and treatment of articulation and phonological disorders in children: A dual-level text (2nd Ed.). Austin, TX: Pro-E.

Pye, C. (1987). Pye Analysis of Language: Version 2.0 (MS- DOS Computer Program. Lawrence, Kan: 200 Arrowhead.

Pye, C., Ingram, D., and List, H. (1987). A comparison of initial consonant acquisition in English and Quiche. Cited in Nelson, K., & Van Kleeck. A. *Children's Language*, (vol. 6) (pp. 175–90). Hillsdale, NJ: Erlbaum.

Rahul, B., & Sreedevi, N. (2006). Study of Phonological Processes of 2-3 years old Hindi Speaking Normal Children. Student research at A.I.I.S.H. Mysore, VII.

Ramadevi, K.J.S., & Prema, K.S (2002). Phonological process in hearing impaired children. A paper submitted at the 4th International conerence on Sounth Asian Languages held at Annamalai University, Chidambaram, Tamil Nadu, India.

Ramadevi. (2006). Phonological Profile in Kannada, A study on Hearing Impaired. Ph D Thesis submitted to the University of Mysore.

Ranjan, R. (1999). Development of phonological processes of 3-4 years old children in Hindi speaking population. Unpublished Master`s Dissertation submitted to the University of Mangalore.

Ranjan, R. (2009). Phonological processes in English speaking Indian children. *Languages in India*, 9.

Roberts, J. E., Burchinal, M.R., & Footo, M.M. (1990). Cited in Lowe, J.R. (1994). Phonology: Assessment and Intervention Applications in Speech Pathology. Baltimore: Williams & Wilkins.

Sameer, P. (1998). Development o phonological processes of 3-4 years old children in Malayalam speaking population. Unpublished Masters Dissertation submitted to the University of Mangalore.

Santhosh, M. (2001). Development of phonological processes in normal Hindi speaking children in the 3-4 years age group. Unpublished Masters Dissertation submitted to the University of Mangalore.

Shriberg, L., & Kwiatkowski, J. (1980). Natural process analysis (NPA). New York, Academic Press.

Shriberg, L. D. (1986). PEPPER: Programs to examine phonetic and phonologic evaluation records. Hillsdale, NJ: Lawrence Erlbaum.

Smit, A.B. (1993a). Phonologic error distribution in the IOWA- Nebraska articulation norms project: Consonant singleton. *Journal of Speech & Hearing Research*, 366, 533-547.

Smit, A.B. (1993b). Phonologic error distribution in the IOWA- Nebraska articulation norms project: Word- Initial Consonant clusters. Journal of Speech and Hearing Research, 366, 931-947.

Smit, A.B. (2004). Articulation and Phonology resource guide for school age children and adults. Clifton part, NY, Thomson Delmar Learning.

So, L. K. H., & Dodd, B. (1994). Phonologically disordered Cantonese-speaking children. *Clinical Linguistics and Phonetics*, (8), 235–55.

Sreedevi, N., Shilpashree, & Jayaram, M. (2005). Development of phonological processes in 2-3 year old children in Kannada. In proceedings of the *6th ICOSAL*, Osmania University, Hyderabad.

Stampe, D. (1969). Cited in Gordan- Brannan, M.E., & Weiss, C.E. (2007). Clinical Management of Articulatory and Phonologic Disorders. Lippincott Williams & Wilkins.

Stampe, D. (1979). Cited in Ball, M.J., Perkins, M.R., Muller, N., & Howard, S. (2008). The handbook of clinical linguistics. Retrieved from http://www.blackwellreference.com/public/tocnode?id=g9781405135221_chunk_g978140513522127

Stoel- Gammon, C., & Dunn, C. (1985). Normal and Disordered Phonology in Children. Baltimore: University Park Press.

Sunil, T.J. (1998). Cited in, Ramadevi, *Phonological profile in Kannada, A study on hearing impaired.* Ph D Thesis submitted to the University of Mysore, 2006.

Templin, M.C. (1957). Certain language skills in children (Monograph series No. 26). Minneapolis: University of Minnesota, The institute of child welfare.

Topbas, S. (1997). Phonological acquisition of Turkish children: Implications for Phonological disorders. *Journal of Communication Disorders*. *32*, 377-396.

Vasanta, D. (1990). Maximizing phonological information from picture word articulation test. In S. V. Kacker and V. Basavaraj (Eds.). The ISHA test battery, Indian Speech Language and Hearing Association.

Vekatesh, L., Ramsankar, S.A., Nagaraja, M.N., & Pushpa, S. (2010). Phonological processes in typically developing Tamil speaking children and Tamil- Telugu bilingual children. *Journal of Indian Speech and Hearing Association*, *24 (2)*, 121-133.

Velleman, S.L. (1998). Making Phonology Functional. Boston: Butterworth-Heinemann

Vihman, M. M., & Velleman, S. L. (2000). Phonetics and the origins of phonology. In N. Burton-Roberts, P. Carr, and G. Docherty (eds.), *Phonological Knowledge: Its Nature and Status* (pp. 305–39). Oxford: Oxford University Press.

Weiner, F. (1986). Process Analysis: Version 2.0 (Apple II series computer program). State College, Pa: Parrot Software.

Wellman, B. L., Case, M., Mengert, G., & Bradbury, D. E. (1931). Speech sounds of young children. University of Iowa studies in Child Welfare, Vol 5, No. 2

Wolk, L., Edward, M.L. (1993). The emerging phonological system of an autistic child. *Journal of Communication Disorders*, *26 (3)*, 161-177.

Usha. R. K., & Sreedevi, N. (2010). Articulatory Acquisition in Typically Developing Telugu Speaking Children: 2 – 3 years. Student Research at A.I.I.S.H. Mysore (Articles based on dissertation done at AIISH), Vol VIII:2009-10.

Yavas, M., & Lamprecht, R. (1988). Processes and intelligibility in disordered phonology. *Clinical Linguistics and Linguistics*, (*2*), 329–45.

==========================

Appendix A

(The test stimuli for the age range of 2.0 – 2.6 years)

SL NO	CORRECT PRODUCTION	PATTERN 1	PATTERN 2	PATTERN 3	PATTERN 4
1	dōktəR	dōtəR	dōta	dōtəl	dōtərə
2.	Rōdə	rōdə	dōdə	d̪ōdə	
3.	kIɳəʀ	kIɳəl	kIɳə	kIɳəɳ	kIɳərə
4.	məd̪d̪aḷəm	məd̪aḷəm	məd̪aləm	məd̪d̪aləm	
5	nəkʂət̪Rəm	nətʃət̪əRəm	nətʃət̪əm	nətʃət̪ərəm	nət̪ət̪əRəm
6.	udupə	upə			
7.	bəsə	bətʃə	bət̪ə	bəʃə	
8.	RIbəɳ	rIbən	rIbəɳ	rIbə	rIbəm
9.	jɛʃu	ɛtʃu	ɛt̪u		
10.	lōRI	lōrI	d̪ōrI	lōlI	
11.	ələmarI	əmarI	əlarI	əjəmarI	ələmajI
12	tʃevI	t̪evI	tʃebI	t̪ebI	evI
13.	sImhəm	tʃIməm	t̪Imgəm	t̪Imbəm	sImgəm
14.	sə̃dʒi	t̪ə̃dʒi	ʃə̃dʒi	tʃə̃dʒi	ə̃dʒi
15.	surjen	t̪urjen	tʃurjen	ʃurjen	tʃujen

Appendix A (Continued)

(The test stimuli for the age range of 2.0 – 2.6 years)

16.	kəsɛra	kətʃɛra	kət̪ɛra	kəʃɛra	kət̪ɛla
17.	pʰəlam	pəlam	bəlam	pənam	
18.	radʒavə	rad̪avə	radavə	d̪adʒavə	
19.	tʃerupə	tʃepə	tʃeupə	t̪erupə	t̪epə
20.	ʃə̃kʰə	t̪ə̃kʰə	tʃə̃kʰə	t̪ə̃t̪ə	
21.	mɛʃa	mɛtʃa	mɛt̪a	mɛsa	
22.	koɻi	koi	koḷi	koli	
23.	Redlo	redlo	redl	dedlo	reo
24.	uRũbə	ũbə	urũbə	udũbə	
25	kāR	kār ə	kāl ə	kāj ə	
26.	tʃəd̪ rən	tʃəd̪ ərən	tʃəd̪ən	tʃəd̪ ənən	
27	pRāvə	pāvə	pābə	pRābə	
28.	tʃəkRəm	tʃəkəRəm	tʃəkəm	tʃəkrəm	kəkRəm
29.	pat̪Rəm	pat̪əRəm	pat̪əm	pat̪ərəm	
30	ṣəRtə	t̪ətə	tʃətə	t̪əRtə	ʃəRtə
31	bRəṣə	bətʃə	bət̪ə	bəʃə	bRəʃə
32.	pust̪əkəm	put̪əkəm	putʃəkəm	puʃəkəm	put̪əm
33.	skutəR	kutəR	kutəl	kutərə	tʃutəl
34.	bIskətə	bIkətə	bIʃkətə	bItʃkətə	
35.	vəst̪ Rəm	vəst̪əRəm	vəst̪ əm	vəst̪ ərəm	vəst̪ əm

Appendix B

(Test stimuli for the age range of 2.6 – 3.0 years)

SL. NO	CORRECT PRODUCTION	PATTERN 1	PATTERN 2	PATTERN 3	PATTERN 4
1	dōktəR	dōtəR	dōta	dōtəl	
2	məd̪d̪aḷəm	məd̪aḷəm	məd̪aləm		
3	nəkʂət̪Rəm	nətʃət̪əRəm	nətʃət̪əm	nəʃət̪əRəm	nətʃət̪ərəm
4	bəsə	bətʃə	bət̪ə	bəʃə	
5	RIbəɳ	rIbən	rIbəɳ	rIbə	rIbəm
6	jɛʃu	ɛtʃu	ɛt̪u		
7	lōRI	lōrI	lōlI	lōdI	t̪ōrI
8	sImhəm	tʃIməm	t̪Imgəm	sIməm	sImgəm
9	sə̃dʒi	t̪ə̃dʒi	ʃə̃dʒi	tʃə̃dʒi	
10	surjen	t̪urjen	tʃurjen	ʃurjen	tʃujen
11	kəsɛra	kətʃɛra	kət̪ɛra	kəʃɛra	
12	ʃə̃kʰə	t̪ə̃kʰə	tʃə̃kʰə	sə̃t̪ə	
13	mɛʃa	mɛtʃa	mɛt̪a		
14	RedIo	redIo	edIo	dedIo	

Appendix B (Continued)

(Test stimuli for the age range of 2.6 – 3.0 years)

15	uRũbə	ũbə	urũbə	udũbə	ujũbə
16	tʃəd̪ɾ̠ən	tʃəd̪əɾ̠ən	tʃəd̪ən	tʃəd̪əjən	
17	pRāvə	pāvə	pābə		
18	tʃəkRəm	tʃəkəRəm	tʃəkəm	tʃəkrəm	tʃəkəjəm
19	pat̪Rəm	pat̪əRəm	pat̪əm	pat̪ərəm	pat̪əjəm
20	ʂəRtə	t̪ətə	tʃəRtə	t̪əRtə	ʃəRtə
21	bRəʂə	bətʃə	bət̪ə	bəʃə	bRəʃə
22	pust̪əkəm	put̪əkəm	putʃəkəm	puʃt̪əkəm	putʃəm
23	skutəR	kutəR	sutəR	t̪utəR	tʃutəR
24	bIskətə	bIkətə	bIʃkətə	bItʃətə	
25	vəst̪Rəm	vəst̪əRəm	vət̪Rəm	vət̪əRəm	vət̪əm

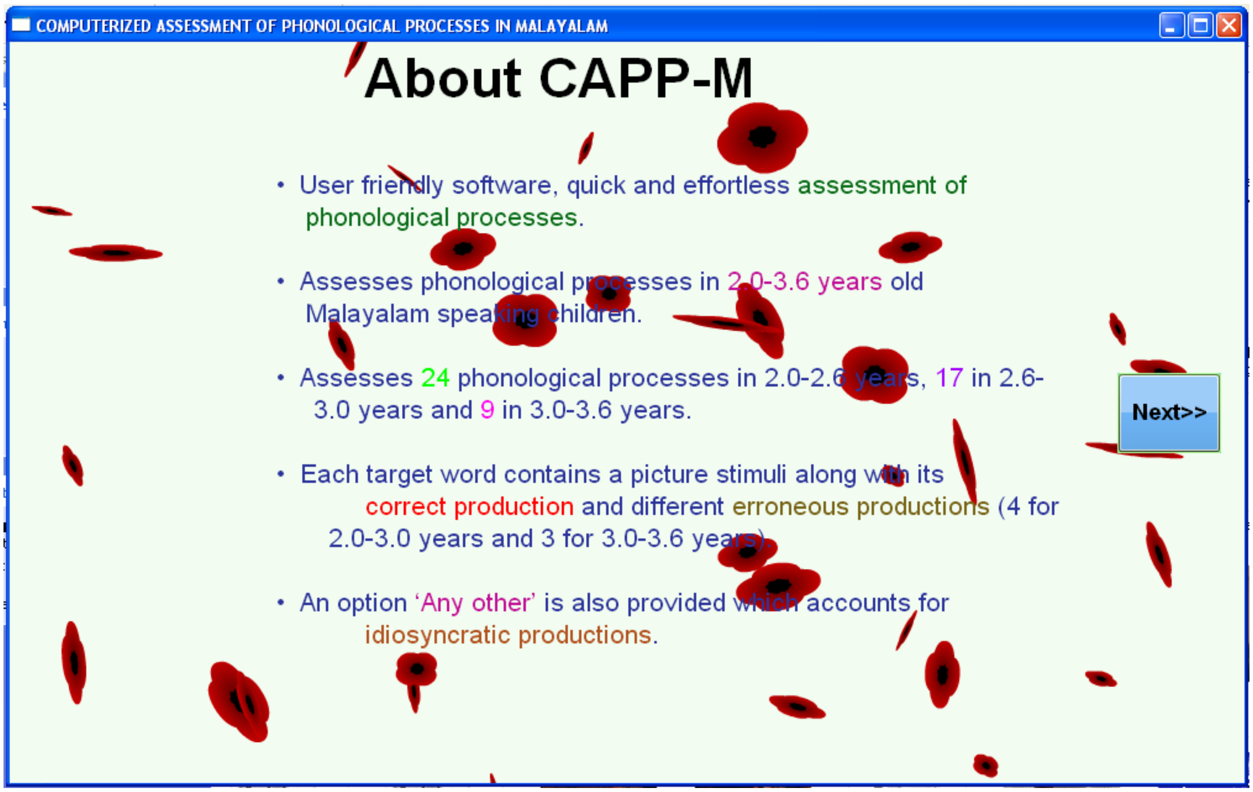
Appendix C

(The test stimuli for the age range of 3.0 – 3.6 years)

SL. No	Correct Production	1	2	3
1	dōktəR	dōtəR	dōkt̪əR	dōt̪əR
2	nəkʂət̠Rəm	nəʃət̪əRəm	nəktʃət̪Rəm	nətʃət̪əRəm
3	sImhəm	sImgəm	tʃIməm	tʃImgəm
4	bRəṣə	bətʃə	bRəʃə	bəʃə
5	pust̪əkəm	put̪əkəm	puʃt̪əkəm	putʃəkəm
6	bIskətə	bIkətə	bIʃkətə	
7	vəst̪ Rəm	vəst̪əRəm	vət̪ Rəm	vət̪ əRəm
8	ṣəRtə	tʃəRtə	ʃəRtə	t̪əRtə
9	pat̪Rəm	pat̪əRəm	pat̪ əm	-
10	tʃ ə̃d̪ r̠ən	tʃ ə̃d̪ ər̠ən	tʃə̃d̪ ən	-
11	skutəR	kutəR	tʃutəR	-
12	pRāvə	pāvə	paRvə	-
13	tʃəkRəm	tʃəkəRəm	tʃəkəm	kəkəRəm
14	bəsə	bəʃə	bətʃə	bət̪ə
15	kəsɛra	kəʃɛra	kətʃɛra	kət̪ɛra
16	sə̃dʒi	t̪ə̃dʒi	t̪ə̃di	-
17	ʃə̃gʰə	tʃə̃gʰə	t̪ə̃gʰə	-
18	mɛʃa	mɛtʃa	mɛt̪a	-
19	surjen	ʃurjen	t̪urjen	tʃurjen
20	ɛʃu	ɛtʃu	ɛt̪u	-

Appendix D

(Brief Introduction on CAPP-M)



Appendix E

(Instructions to the users)