COMPUTER BASED ASSESSMENT OF PHONOLOGICAL PROCESSES IN KANNADA (CAPP-K)

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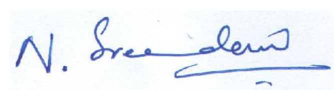

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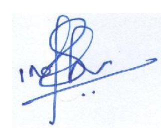

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CHAPTER I

INTRODUCTION

Typically developing children during their speech language acquisition, progress from the basic repertoire and learn to produce a wider range of features of their language. By the end of first-word stage, speech language development is signaled by a rapid increase in vocabulary size, an expansion of the repertoire of segments and syllable shapes, and the onset of two-word utterances. By two years, the typically developing child acquires a productive vocabulary of 300 words for American children (Fenson, Marchman, Thal, Dale, Reznick & Bates, 2007), 550 words for children acquiring Mandarin (Tardif, Fletcher, Liang & Kaciroti, 2009), 260 words for Australian children (Bavin, Prior, Reilly, Bretherton, Williams, Eadie, Barrett, & Ukoumunne, 2008) etc. At this period, a childŏs early word productions are marked by extensive individual differences in pronunciation patterns. Their phonological organization can be explained in two ways: independent analysis which focuses on the childŏs productions without reference to the adult model, or relational analysis that compares the childŏs production to the adult model.

Pattern-based analysis to phonological disorders emerged in the 1970s and 1980s after researchers realized that phonological rules can used to describe speech patterns of children. One of the pattern-based approaches to assessment and treatment of phonological disorders is phonological process analysis based Stampeŏs natural phonology theory (Stampe, 1969, 1973). According to Stampe, comparisons of adult targets with child productions revealed that childŏs productions are systematic and have been described in terms of rules, also called as phonological processes. These rules modify the target by modifying sounds or syllables, or substituting one sound class for another or influence neighboring sounds. Stampeŏs natural phonology theory was best applied to speech productions of children to identify phonological patterns/ processes easily and quickly. By using the notion of universal simplifying phonological processes to the childös word productions, speech language pathologists (SLPs) was able to examine both childös phonological system (contrastive segments in speech production) as well as phonological structure (combined segments to form words in terms of syllable and word shapes). In addition, it was possible to consider how consistent or variable the childös speech output was. Phonological process analysis was recognised and popularly used method by all SLPs compared to place-manner-voicing and distinctive feature analysis that consider childös error in relation to phonetic features and distinctive features respectively. Thus, by classifying the childös utterances from adult target productions, PPA offers a more economical framework for assessment and intervention in children with communication disorders.

Speech sound production disorders is one of the most prevalent communication disorders in paediatric communication disorders (Gierut, 1998) with an incidence as high as 10%- 14%, and 80% of which warrant speech language therapy. Clients with speech sound errors are highly prevalent in Indian SLPsô caseloads. According to 2011 Indian census, 1.62% of the disabilities are speech disorders in children below four years. According to a preliminary unpublished data in 2012 at the Department of Prevention of Communication Disorders at the All India Institute of Speech and Hearing, Mysore, 0.26% of school going children below 15 years of age in Mysore district was found to have speech language disorder based on screening programs. Children with communication disorders like hearing impairment, mental retardation, cleft lip and palate, autism, misarticulation etc present with difficulty in producing certain speech sounds or group of speech sound. They were found to simply words which are delayed or deviant compared to typical speech productions.

Assessment being a very significant stage while dealing with children with communication disorders for SLPs, a systematic and detailed assessment is a prerequisite for accurate diagnosis, identification of etiology and providing a concrete foundation for intervention. Since 1980s, phonological process analysis was an essential tool in the field of ñclinical phonologyò but as a task by itself is laborious and time consuming. Researchers in the area therefore put forth innovative thoughts of the applicability of computers for phonological process analysis. Hence, began the development of computerized phonological assessment procedures/ tools. Various computer based phonological analysis tools in English are the following:

1. Computer analysis of phonological data (Faircloth & Dickerson, 1970)
2. Computer Analysis of Phonological Processes (CAPP) version 1.0 (Hudson, 1985)
3. Programs to Examine Phonetic and Phonologic Evaluation Records Version 4.0 (PEPPER) (Shriberg, 1986)
4. Computer Profiling (CP) (Long & Fey, 1988)
5. Logical International Phonetic Programs Version 1.03 (LIPP) (Oller & Delgado, 1990)
6. Computerized Articulation and Phonology Evaluation System (CAPES) (Masterson & Bernhardt (2001)
7. Profile in Phonology (PROPH) (Long, Fey & Channell, 2002) etc.

Though there are many such computerized tests published in English, an attempt to develop computer software for phonological analysis is in the initial stages in India considering its wide linguistic diversity. One such tool in India was initially attempted by Ramadevi (2006). The tool profiled the phonological productions of children with hearing impairment. However, except for the presentation of stimuli, all the other tasks of scoring were to be completed by the clinician. Merin and Sreedevi (2010) developed a computerized assessment tool óComputer based Assessment of Phonological Processes in Malayalamô. This was a user friendly software program developed to automatically assess the phonological processes in native Malayalam speaking children of 3.0 -3.6 years. But the tool did not assess processes in the younger age group i.e; below 3 years of age when there is drastic growth in childôs phonological development. Hence, Sreedevi and Merin (2012) studied phonological processes in younger group of 2.0-3.0 years and a software application was developed for wider language age groups of 2.0-3.6 years. The new test tool óComputerized Assessment of Phonological Processes in Malayalam (CAPP-M)ô assessed 24 processes in 2.0-2.6 years, 17 in 2.6-3.0 years and 9 in 3.0-3.6 years. The sensitivity of the tool was also checked for in children with communication disorders and revealed that the tool was sensitive to the patterns of their production. This test software was an important milestone in the field of computer based assessment of phonological processes in India which could present the stimuli, analyse the childôs utterance, provide the count of frequency of phonological processes and document phonological process report. The CAPP-M test tool set a landmark in developing indigenous computerized assessment tools helped the tester in achieving the goal in a short time. The present study attempts to develop similar software tool in native Kannada speaking children in the age group of 2.0-3.6 years. This will minimise the laborious repetitive manual work and time involved in the traditional phonological analysis used in the routine busy clinical set up.

Need for the study

Clients with speech sound errors are highly prevalent in Indian SLPsô caseloads. In spite of this, there is limited documented data which are not sufficient to describe the phonological patterns of native Kannada speaking children. In India, linguistic diversity is a fundamental characteristic and hence assessment tools need to be language sensitive. The present study is conducted in Kannada which is spoken by 3.7% of Indian population according to India demographics profile, 2013 and is the 32nd most spoken languages in the world (http://en.wikipedia.org/wiki/).

Several earlier researchers have studied phonological processes in children above 3.0 years. Few researchers have attempted to analyse and profile phonological development in children as young as two year olds in India. In this computerized era, most of the assessment tools to evaluate the phonological processes in English are software modules for easy, simpler and accurate evaluation. Such an assessment tool is available only in Malayalam among the Indian languages till date and hence the present project was taken up to develop a similar assessment tool in Kannada which is very essential in day to day clinical activities of an SLP. This provides the clinician with appropriate guidelines for choosing remediation targets and evaluating progress in speech language therapy. The dearth in availability of a computerized tool to assess phonological processes in children with communication disorders was the motivating factor to develop a test tool in Kannada for 2.0-3.6 year old children.

Aim of the study

To develop an indigenous computer based software to evaluate the phonological processes in native Kannada language speaking children.

Objectives

1. To obtain the phonological developmental norms in native Kannada speaking children in the age range of 2.0-3.6 years.
2. Based on the normative data obtained to develop a computer based software for phonological process analysis
3. To evaluate sensitivity of the developed tool by administering the tool on children with communication impairment.

Implications of the study

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

2. The tool assesses the presence of phonological processes in children as young as 2.0 to 3.6 years of age. Thus CAPP-K encompasses phonological process assessment for the age range where dynamic and drastic phonological development takes place. It provides a quick computer based assessment of phonological processes compared to the manual, tedious and time consuming traditional assessment.
3. The tool tests for 35 different processes under the categories syllable structure, substitution, assimilation, vowel processes. The processes that are unusual or deviant from typical productions are classified under idiosyncratic processes.
4. This is a highly user friendly assessment software with only minimal training required on the part of the clinician to operate the tool.
5. 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 for children with communication disorders.
6. The study can be extended in various dimensions with regard to age range and different dialects of Kannada and in other Indian languages also.

Limitations of the study

1. The options in the test tool contain closed set of patterns including idiosyncratic process. The idiosyncratic pattern does not describe the phonological process present.
2. Various studies have revealed early emergence of certain consonant clusters in typically developing children by two years of age. The test software which was constructed based on normative children included only 4 test words with clusters to assess the process cluster reduction.

CHAPTER II

REVIEW OF LITERATURE

Phonology is the component of language concerned with the rules governing the structure, distribution and sequencing of speech sounds and the shape of syllables (Owens, 2007). It is considered as one of the chief components of language, along with morphology, syntax, semantics and pragmatics. Acquisition of phonological organisation in typically developing children entails both phonetic and phonological features of language. The phonological development is a significant milestone in a childös speech language development. As the phonetic mastery to articulate individual sounds and sequence the sounds develop, the child learns to use these sounds according to the rules governed in that particular language. In order to produce meaningful speech, children must learn the movements (articulatory and phonatory) necessary to produce words in an adult-like manner, and must have knowledge of the phonological forms of words of their native language. Thus, phonological development according to Stoel-Gammon and Sosa (2007) consists of two fundamental components: (1) a biologically based component associated with the development of the speechï motor skills needed for the adult-like pronunciation of words; and (2) a cognitiveï linguistic component associated with learning the phonological system of the ambient language; this component includes processes of memory and pattern recognition associated with the storage and retrieval of words in a childös ómental lexiconö.

Phonological Acquisition

According to Stoel-Gammon (2010), phonological development begins from infant cries, gestures and vocalizations which are non-meaningful to the emergence of adult target words. Early research on phonological development emphasized acquisition of phoneme using a segmental approach. This approach deals with the analysis of speech into phonemes (or segmental phonemes). The focus of these studies was to establish norms for the order and age of speech sound acquisition of typically developing English speaking children. SLPs have extensively used this speech normative data in their practice to evaluate children with articulation and phonological disorders. This was essential to understand the development of speech sounds which could help determine whether a childøs speech is typical or not.

A typically developing two year old child acquires a productive vocabulary of 300 words for American children (Fenson et al, 2007), 550 words for children acquiring Mandarin (Tardif et al, 2009), 260 words for Australian children (Bavin et al, 2008). Thus by age of two years, about half of a childøs utterances are intelligible (i.e., can be understood by an adult who is not familiar with the child). By the age of three years, the level of intelligibility increases to 75% and by age four, it is 100% (Coplan & Gleason, 1988). This does not mean that the childøs productions are fully adult-like by age four, rather that the errors do not interfere with intelligibility. From two to four years, childøs productions bear resemblance to adult form and thus, intelligibility increases.

Theories of phonological development

Theories explaining phonological development are prerequisite in describing and understanding the structure of speech sound patterns in a particular language. Different theoretical frameworks and approaches were developed to analyze the phonological patterns in typical and atypical language development.

Stampe's theory of natural phonology

Out of the various theories, a shift in the description of childrenøs speech from a segmental approach to a phonological process approach was introduced by Stampe (1969) called the theory of natural phonology. Stampeøs theory has had a significant role in the development of phonology. Natural phonology clearly indicates what is considered to be innate, and by putting forth the universal existence of these natural processes that accounts for the structuralist observations of congruencies between child processes and phonological patterns in adults. Natural Phonology views the phonological system of each language as the output of a system of universal processes reflecting infant phonetic limitations and explaining the relationship between the phonetic capacities and the limitation of the child. ñThe phonological system of a language is largely the residue of an innate system of phonological processes, revised in certain ways by linguistic experienceò (Stampe 1969).

The original definition of this concept was: ñA phonological process merges a potential opposition into that member of the opposition which least tries the restrictions of the human speech capacityò. ñA 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 propertyò. According to Stampe (1979), natural processes reflect the natural and automatic responses of children to the articulatory and perceptual difficulties which speech sounds or sound sequences present. All individual show responds to the difficulties of speech by applying these processes. Hence the theory proposes that phonology is based on a set of universal phonological processes.

When children learn to produce adult target words, they simplify the words in such a way that is manifested by an innate universal system of phonological processes regardless of any language of the world. During the phonological development, these processes will develop certain pronunciation patterns. These are considered as provisional simplification before the articulation of mature adult productions. These processes interact with each another and the child gradually learns to suppress these natural responses to acquire language-specific phonology. They master through a gradual process of constraining the "non-adult-like" patterns. For example, a child learning Hawaiian or Kannada language does not have to suppress the process of final consonant deletion as there are no word-final consonants in that language, whereas a child learning English must learn to produce final consonants. Thus, studying and analyzing the natural phonological processes in childôs speech have received considerable attention in the domain of Natural Phonology. Stampeôs theory has been highly influential in studies of phonological acquisition and phonological disorders. Ever since the study and analysis of natural phonological processes, various definitions of phonological processes has been proposed as shown in Table 2.1.

Table 2.1:

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.	Hodson & Paden (1983)	Phonological processes are regularly occurring deviations from standard adult speech patterns that may occur across a class of sounds, a syllable shape or syllable sequence.
4.	Lowe (1996)	A systematic sound change or simplification that affects a class of sounds, or a particular sequence of sounds.

Systematic nature of Phonological Processes

Speech language pathologists and researchers working in the field agree on the fact that childôs simplification of adult target words is systematic in nature (Creaghead, 1989; Bernthal & Bankson, 2004). Phonological substitutions are found to show great regularity in the language of children. According to Oller (1975), ñthe sorts of substitutions, deletions and additions occurring in child language are not merely random errors of the child, while they are rather resulting of a set of systematic tendenciesò. They are the rules which describe errors of substitution, omission or addition. Stampe (1969) and Edwards (1979) has also reported that children typically do not make these substitutions randomly or irregularly; but advocated that children can perceive phonemic distinctions long before they can produce them. It is thus believed that children know what the typical sounds are or what they should be like and hence their internal representations of words correspond to the adult target forms. This assumption was confirmed by Stampe by stating that when a child acquires sounds which he had previously been unable to produce, thus substituting them, he does not have to rehear all the words that he had been mispronouncing in order to correct them. Instead the child normally changes the pronunciation of the relevant sounds in all the words where he had been simplifying in a way of avoiding that particular articulatory difficulty.

Ingram (1976) suggested two assumptions to explain their systematicity and patterns in misarticulated speech. Firstly phonological processes are correspondence rules which means there is one to one correspondence is observed between childọs error production and the adult target. This is because, the child is aware of the adult target form but simplify it. Secondly phonological processes are rules set to simplify complex productions. The child applies phonological processes to simplify difficult to produce adult standard productions. These two assumptions not only describe the error production but also attempt to justify why the errors occur. Ingram explains the reason that child produce all the segments of the adult target as immature motor, cognitive, perceptual, or linguistic capabilities.

Explanation to occurrence of processes

Stoel-Gammon (2010) suggested that frequency of words, phonological similarities across words and age of acquisition of words influence phonological development in that particular language. High-frequency words are associated with faster word recognition and are produced more quickly and accurately (Ellis, 2002). High-density neighbourhood words are associated with inhibition in tasks of word recognition and production by adults, presumably due to competition effects among phonologically similar forms (Luce & Pisoni, 1998). Finally, studies indicate that the factor of age of acquisition affects word processing. With acquisition of speech sounds, children suppresses processes

Bernstein (1945) proposed a model to describe the development of articulatory skills in children. He suggested that articulatory skills are acquired on the basis of a functional cerebral system consisting of 5 hierarchical levels. Levels A and B are related to unconscious, involuntary operations like posture control, maintenance of muscle tension etc. These levels are developed in 8-9 months of life. Level C is related to special coordination and control of accuracy of a movement. Maturation of this level takes place at the end of 1 year and continues till 3 years of age. Level D is related to development of motor skills, also called ñtopological spaceò. This process lasts from the end of the second year to the sixth or seventh year. From three years, the child masters the aggregation of syllables into single entities and is able to articulate these sequences fluently. During this stage the complexity of word length and of syllable structure increases. The phonetic repertoire becomes richer and the syllabic patterns of words are consolidated as whole units. And hence there is greater consistency in the phonetic characteristics of words. The most typical phonological errors in this period are word structure simplifications, syllabledeletions, word reductions, assimilations and reduplications. If the maturation of this subsystem is delayed we may continue to observe errors of this type even in the fifth or sixth year of life which is seen in children with communication disorders. Level E is responsible for producing schemes of symbolic action. This level begins to mature approximately in the 13th month. This sub-system has the most complex cerebral organization. Its period of development is the longest, lasting upto five years to 12 years. This stage plays a crucial role in the organization of the language system at phonological, morphological and syntactic levels. The phonological signs of Level E development include the acquisition of the most complex consonants, the regularity of sound substitutions, the disappearance of assimilations, reduplications and the decrease of phonological, contextual dependency.

Phonological processes in English

A wide variety of researches are conducted in the phonological development in English. Classifications of various authors have been tabulated in Table 2.2 (a) and 2.2 (b). Literature reports that there are over 40 different processes operating during children's phonological development (Hodson, 1980) and they are present in certain age of child's speech language development and suppressed at a certain age. Process such as denasalization is suppressed as early as by 2 years of age whereas epenthesis and cluster reduction prevail even after 7 years of age (Smit, 1973; Lowe, 1996).

Various classification systems of phonological processes have been developed (Hodson, 1980; Ingram, 1981; Shriberg & Kwiatkowski, 1980; Stoel- Gammon & Dunn, 1985; Weiner, 1979). Table 2.2 (a) and (b) shows classification by Weiner (1979) who mentioned 16 process, Shriberg & Kwiatkowski (1980) who used 8 processes, Hodson (1980) who described 40 processes, Ingram (1981) who used 27 processes, Grunwell (1985) who used 10 processes, Dean et al.(1990) who mentioned 12 processes and Toblin (2009) who reported 12 processes. Table 2.2 (c) shows profile of phonological development given by Grunwell (1987).

Table 2.2 (a):

Classification of phonological processes by various authors

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

Table 2.2 (b):

Classification of phonological processes by various authors

Ingram (1981)	Grunwell (1985)	Dean et al. (1990)	Toblin (2009)
1. Deletion of Final Consonant ▪ Nasals ▪ Voiced stops ▪ Voiceless stops ▪ Voiced fricatives ▪ Voiceless fricatives 2. Reduction of Consonant Cluster ▪ Liquid ▪ Nasals ▪ /s/ Clusters 3. Syllable deletion and reduplication ▪ Reduction of disyllables ▪ Unstressed syllable deletion ▪ Reduplication ▪ Fronting ▪ Of palatal ▪ Of velars ▪ Stopping ▪ of initial voiceless fricatives ▪ Of initial voiced fricatives ▪ Of initial affricates ▪ Simplification of Liquids and Nasals ▪ Liquid gliding ▪ Vocalization ▪ Denasalization 4. Other substitution processes ▪ Deaffrication ▪ Deletion of initial consonants ▪ Apocalizattion ▪ Labialization 5. Assimilation Processes ▪ Velar assimilation ▪ Labial assimilation ▪ Prevocalic voicing ▪ Devoicing of final consonant	1. Structure simplifications ▪ Weak syllable deletion a. Pretonic b. Postonic ▪ Final Consonant Deletion ▪ Nasals ▪ Plosives ▪ Fricatives ▪ Affricatives ▪ Clusters-1 -2+ Vocalization /l/ other C Reduplication ▪ Complete ▪ Partial 2. Consonant Harmony ▪ Velar ▪ Alveolar ▪ Labial ▪ Manner 3. Other S.L Cluster Reduction ▪ Plosives+ approximants ▪ Fricatives + approximants ▪ /s/ + plosive ▪ /s/ + nasal ▪ /s/ + approximants ▪ /s/ + plosive + approximants 4. Systematic Simplifications Fronting ▪ Velars ▪ Palato- Alveolars Stopping ▪ /f/ /v/ ▪ / ɗ/ /ð/ ▪ /s/ /z/ ▪ /t/ /ʤ/ ▪ /l/ /r/ Gliding: ▪ /r/, /l/ ▪ Fricatives Context Sensitive Voicing Glottal replacement Glottal Insertion	1. 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) 2. Structure processes ▪ Final consonant deletion ▪ Initial consonant deletion ▪ (unusual / atypical processes) ▪ Initial Cluster Reduction/ deletion	1. Functional processes influencing syllable structure: ▪ Final consonant deletion: CVC Ÿ CV (chronology: 2:0 Ÿ 3:2) ▪ Deletion of unstressed syllables (chronology: 2:0 Ÿ 4:0) ▪ Consonant cluster reduction: CC Ÿ C (chronology: 2:0 Ÿ 3:6-8) ▪ Reduplication (chronology: 2:0 Ÿ 2.5) ▪ Epenthesis: addition of segments (usually an unstressed vowel) 2. Assimilation processes (consonant/consonantï vowel harmony) ▪ Velar or nasal or labial, etc. assimilation (chronology: 2:0 Ÿ 2:8) ▪ Prevocalic voicing of consonants (chronology: 2:0 Ÿ 3:5) ▪ Devoicing of final consonants (chronology: 2:0 Ÿ 3:1) 3. Substitution processes: ▪ Processes reflecting the substitution of active articulators: a. Fronting (chronology: 2:0 Ÿ 3:5) b. Backing ▪ Processes reflecting the substitution of turbulence and/or airflow: a. Stopping: variable chronology depending on sounds and language (chronology 2:0 Ÿ 5:0+) b. Gliding of liquids: (variable chronology 2:0 Ÿ 5:0+) c. Glottal replacement.

Table 2.2 (c):

Profile for Phonological Development (Grunwell, 1987)

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 and 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, Ǽ, p, b, t, d k, g, w and h.	Final consonant deletion Cluster reduction	Stopping Fronting Gliding /r/→[w] Context sensitive voicing
Stage IV (2;6-3;0)	m, n, Ǽ p, b, t, d, k, g, f, s, j, h, and w.	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 + approximents used; /s/ clusters may occur	Stopping /v ð/ (/z/) /ɗ/→ [f] Fronting of / tʃ dʒ ʃ/ Gliding /r/→ [w]
Stage VI (3;6-4;0) (4;0-4;6)	Ǽ m, t, d, tʃ, dʒ, k, g, p, b, s, z, ʃ, h, f, v, l(r), j and w.	Clusters established: Obs+approximants /s/ clusters: /s/→fricative Obs+ approx. acceptable /s/ clusters: /s/→type fricative	(/ɗ/→[Ǽ]) (/ð/→[d] or [v]) Palatalization of / tʃ dʒ ʃ/ Gliding /r/ →[w]
Stage VII (4;6<)	m, n, Ǽ p, b, t, d, tʃ dʒ, k, g, f, v, ɗ, ð, s, z, ʃ, ʒ, h, w, l, r, j	/ ɗ / → [Ǽ] / ð / → [d] or [v] /r/ → [w] or []	

With development in speech-language skills, production abilities and perception skills in children improve and they gradually eliminate these simplification rules one by one using suppression rule. Much of the developmental information were studied from Ingram (1989), Prater and Swift (1982) and Haeslig and Madison (1986). Different processes have different age of permanence and disappearance. Processes such as denasalization are suppressed as early as by 2 years of age whereas epenthesis and cluster reduction prevail even after 7 years of age (Smit, 1993; Lowe, 1996). In general, phonological processes can be divided into three categories: i) syllable structure, ii) substitution and iii) assimilation or harmony phonological processes (Grunwell, 1985).

Syllable structure processes

Syllable structure processes are the processes that change the constitution/ structure of the syllables of adult standard productions. Phonotactic constituency may affect the distribution of segments within the phonological word. In most cases, the effect of syllable processes is to achieve a simplified syllable structure. According to Prater and Swift (1982), these processes are frequently seen in younger children with MLU between 1 and 4 morphemes. Different syllable processes are discussed in Table 2.3.

Table: 2.3.

Definitions, studies and examples for different syllable structure processes

Sl. N	Syllable structure processes	Definition	Developmental research	Example
1	Initial vowel deletion (IVD)	Deletion of a vowel in a word		[pal] for apple [dő̃dő̃i] for adő̃dő̃i *(in Kannada)*
2	Initial consonant deletion (ICD)	Deletion of initial consonant in a word	ICD was very commonly seen in children between the ages 1.6-2.6 years (Hua & Dodd, 2006). According to Lowe (2000), by the age of 4, 90% of the children suppress the process of consonant deletion.	[æbal] for table [aı̋ı̋ari] for kaı̋ı̋ari *(in Kannada)*
3	Medial consonant deletion (MCD)	Deletion of medial consonant in a word		[beewin] for between [kuuræ] for kuduræ *(in Kannada)*
4	Initial syllable deletion (ISD)	Deletion of initial syllable (CV) in a word	Ingram (1981) studied that word initial weak syllable deletion persisted in 2 years old typically developing children. Williamson (2008) studied that syllable deletions was common in 2 to 4 years of age. According to Lowe (2000), by the	[tas] for lotus [gemanæ] for adigemanæ *(in Kannada)*
5	Medial syllable deletion	Deletion of medial syllable in a		[æplane] for aeroplane

	(MSD)	word	age of 5, 90% of the children suppress the process of syllable deletion.	[kiki] for kitaki *(in Kannada)*
6	Final syllable deletion (FSD)	Deletion of final syllable in a word		[kabæ] for cabbage [gadi] for gadijara *(in Kannada)*
7	Epenthesis (Epn)	Epn is resulted in insertion of a schwa between two consonants (Khan, 1985).	Smit (1993) and Lowe (1996) that suggested that epenthesis continued to prevail at older age ranges, even in 7 years.	[bɒlu] for blue [bigɒ] for big [bɒledu] for bledu *(in Kannada)*
8	Reduplication (Red)	Repetition/ doubling of a CV syllable in a word.	Red is an early seen process in first 50 words stage (Ingram, 1989) and disappears after first 50 words stage, but reappears in about 3 years of age (Lleo, 1990). Stoel- Gammon and Dunn (1985) report that the process disappeared before 3 years of age. Grunwell (1981) reported the process existing in the childȏs repertoire till 2.6 years.	[baba] for ball [dada] for /dara/ *(in Kannada)*
9	Metathesis (Met)	Alteration in phonemes or syllable order in a word.	Steol-Gammon & Dunn (1985) suggested that occurrence of this process was rare in childȏs phonology and was termed as idiosyncratic process. Hodson and Paden (1983) suggested the process to be occurring in 4 to 5 year old children.	[aks] for ask [vinama] for vimana *(in Kannada)*
10	Cluster simplification (CSim)	Simplification of a consonant cluster by replacing difficult cluster with a single consonant.	Watson and Scukanec (1997) indicated that cluster simplification was present in 2.9 years, that later reduced to 20% presence in 3 years of age. CSim is often observed in children between 2;00 and 3;06 years of age (Williamson, 2008). According to Lowe (2000), by the age of 6, 90% of the children suppress this process.	[twi:] for tree [jaŞaga:na] for jakŰaga:na *(in Kannada)*
11	Cluster deletion (CD)	Deletion of a consonant cluster in a word.	Williamson (2008) studied that this process was common in 2 to 3.6 years of age.	[i:n] for green [jana] for jantra *(in Kannada)*
12	Geminate cluster	Deletion of a geminate	Phonetic gemination occurs marginally in English phonology.	[drakkŰi] for drasi *(in Kannada)*

	reduction (GCR)	consonant cluster in a word.	The consonant length is not distinctive within root words. For instance, 'baggage' is pronounced /˜ˈbæʊ̃idʒ̃Ą/, not /bæʊ̃ˊEdʒ̃Ą/.	
13	Cluster substitution (CSub)	Substitution of a consonant cluster in a word for a simpler consonant cluster.		[blæd] for bread [jandra] for jantra *(in Kannada)*
14	Cluster reduction (CR)	Simplification of a consonant cluster by reducing it to one sound (or two sounds if the target cluster consists of three consonants).	CRs are mastered after 3 years of age (Smit, Hand, Freilinger, Bernthal, & Bird, 1990). Common CRs is seen in clusters with /s/ and /z/, liquids or stridents (Dyson & Paden, 1983). CRs are suppressed late compared to other processes. It occurs beyond 4 years of age (Haelsing & Madison, 1986). Grunwell (1997) and Brown (1998) studied that the process is eliminated by 4 years of age. According to Lowe (2000), by the age of 6, 90% of the children suppress this process.	[ti:t] for street [tǓka] for tǓkra *(in Kannada)*

The acquisition of consonant clusters is relatively difficult sound to acquire, hence requires long duration, and process of acquisition is gradual (McLeod, Doorn & Reed, 2001 & Ben-David 2001). Children progress through a number of stages for their mastery in consonant clusters. These stages in the acquisition of clusters were first reported by Greenlee (1974) and Ingram (1989). In stage 1, the entire cluster is deleted, for example, [e] for tree. In second stage, the cluster is reduced to a single consonant, for example, [te] for tree is common and often persists for several months or more. In third stage, the number of elements in the cluster is preserved but with substitution of one or more of the consonants in the cluster, for example, [twe] for tree. Finally, in stage 4, children achieve full accuracy in production of clusters. Children tend to move through similar progression when acquiring consonant clusters, but slight variations are noted in few children.

Substitution processes

Substitution processes involve replacement of one sound by another sound without being influenced by the surrounding phonemes. Weiner (1979) entitled these set of processes as feature contrast process before Steol-Gammom and Dunn (1985) named them as substitution processes. Examples of substitution processes are discussed in Table 2.4.

Table: 2.4.

Definitions, studies and examples for different substitution processes

Sl. No	Substitution processes	Definition	Research	Example
1	Stopping (Stp)	Substitution of a stop for a fricative or an affricate (Dyson & Paden, 1983).	More active in children with MLU between 1 and 4.99 (Prater & Swift, 1982). Hua and Dodd (2006) reported that Stp was common in 1.6-3.0 years, while Bankson and Bernthal (1990) and Robert et al (1990) suggested that stopping persisted in older childhood years. Williamson (2008) studied that this process was common in 2 to 4.6 years of age. According to Lowe (2000), by the age of 6, 90% of the children suppress this process.	[tiÁ] for sing [baŞu] for basu *(in Kannada)*
2	Nasal fronting (NF)	Substitution of an alveolar or dental for a nasal consonant.	Fronting process was present in 2 years in English speaking (Dyson & Paden, 1983 and 3 years Spanish speaking children (Martinez, 1986). Williamson (2008) studied that fronting was widespread from 2.0 to 4.6 years in children.	[dajiu] for naji *(in Kannada)*
3	Dental fronting (DF)	Substitution of a labial or labiodental for a dental consonant.	PF occurred after 42 months of age (Lowe, Knutson & Monson, 1985). Fronting was was used by higher percentage of children (87%) from 1.6-4.6 years, where in retroflex fronting was higher compared to velar fronting in Putonghua.	[aivappu] for aivaŞŞu *(in Kannada)*
4	Palatal fronting (PF)	Substitution of an alveolar or dental for a palatal consonant.	Grunwell (1987) and Steol-Gammon and Dunn (1985) that pointed that velar fronting was suppressed by 3 years. Robert et al (1990), Dodd (2003) and James (2001) study indicated that fronting errors persisted in later childhood years.	[loŞa] for lota *(in Kannada)*
5	Retroflex fronting (RF)	Substitution of an alveolar or dental for a retroflex consonant.	Grunwell (1997) and Bowen (1998) studied that fronting is eliminated by 3.6 years of age. According to Lowe (2000), by the age of 5, 90% of the children suppress the fronting process.	[tain] for rain [pud i] for puri *(in Kannada)*
6	Velar fronting (VF)	Substitution of an alveolar and dental for a velar consonant.		[tau] for cow [land a] for langa

				(in Kannada)
7	Backing (Bak)	According to Williamson (2008), ñBacking occurs whenever a non-velar or non-glottal consonant (i.e., a bilabial, labio-dental, dental, alveolar, post-alveolar or palatal consonant) is substituted with a velar /k ŭ Æ or glottal /h ῃ/consonant.	Dodd (1994) reported that backing was unusual phonological process. Williamson (2008) studied that this process was a typical process from 2 to 3 years of age. According to Lowe (2000), by the age of 3, 90% of the children suppress the process.	[Boop] for book [kagge] for kappe *(in Kannada)*
8	Affrication (Aff)	The use of affricate to replace fricative.	Children use Aff when they are learning to differentiate between stops and continuants (Hodson, 1980). According to Lowe (2000), by the age of 3, 90% of the children suppress the process.	[dʒu] for zoo [mi:tᶩé] for mi:se *(in Kannada)*
9	Palatalisation (PL)	Replacement of a palatal fricative for a non palatal sound (Lowe, Knutson & Monson, 1985).		[ʃop] for soap [mi:tᶩé] for mi:se *(in kannada)*
10	Depalatalisation (DPal)	Substitution of alveolar fricative for a palatal fricative or alveolar affricate for a palatal affricate (Steol-Gammon & Dunn, 1985).	Bankson and Bernthal (1990) suggested that the process was present in <3 years old children.	[seep] for sheep [sanka] for Ɩánka *(in Kannada)*
11	Gliding (Gldg)	Substitution of glide for a prevocalic liquid; /r/ and /l/ are usually replaced by either [w] or [j].	Gliding is mostly seen in 3.0-3.6 years of age. Dyson and Paden (1983) and Ingram (1981) suggested most frequent use of gliding in 2 year old children. It was observed in 4.6-5.0 year old children with reduced frequency (Haelsig & Madison, 1986). Gliding was very commonly seen in children with deviant phonology (Weiner, 1979; Hodson & Paden, 1981). Grunwell (1997) and Bowen (1998) studied that gliding is eliminated by 5 years of age. According to Lowe (2000), by the age of 6, 90% of the children suppress this process.	[wi] for ring [o:je] for o:le *(in Kannada)*
12	Vowelisation (Vlz)	Substitution of a vowel for a consonant in a word.	Vlz is commonly occurring process during development. It was observed in children with <5 morphemes MLU and 6.90 morphemes MLU (Prater & Swift, 1982). Watson and Scukanec (1997) indicated that the process occurred commonly in 2 to 3 years. According to Lowe (2000), by the age of 6, 90% of the children suppress this process.	[papo] for paper [æ:u] for ærad u *(in Kannada)*
13	Denasalisation (Dnas)	Nasal sounds are replaced by homorganic (same place) stops.	According to Hua and Dodd (2006), /n/ deletion was a frequent deletion strategy used by children from 1.6-4.6 years. 57% of children used /n/ deletion in Putonghua.	[du:n] for noon [dibu] for

				dimbu *(in Kannada)*
14	Lateralisation (Lat)	Non lateral sound in a word replaced by lateral sound (l, r).		[label] for table [male] for mane *(in Kannada)*
15	Delateralisation (DLat)	Lateral sound in a word replaced by non lateral sound.		[pu:Ş] for pool [haŞŞu] for hallu *(in Kannada)*
16	Monophthongisation (Mon)	Simplification of a diphthong n a word to vowel.		[Ǘ:n] for shine [ad u] for aid u *(in Kannada)*
17	Labialization (Lab)	Replacing consonants made with the tongue tip with labial or labiodentals consonants.	According to Lowe (2000), by the age of 6, 90% of the children suppressed labialization.	[fon] for thorn [beppu] for bekku *(in Kannada)*

Assimilation

Assimilation or harmony processes are the process that occur when an earlier sound influences a later one or vice versa (Khan, 1982). In assimilatory processes a segment takes on features from a neighbouring segment. A consonant may pick up features from a vowel, a vowel may take on features of a consonant, one consonant may influence another, or one vowel may have an effect on another (Steol-Gammon and Dunn, 1985). The processes within this category discussed in Table 2.5.

Table: 2.5

Definitions, studies and examples for different assimilation processes

Sl. No	Syllable structure processes	Definition	Research	Example
1	Progressive assimilation (Pass)	The affected segment follows the one that influences it.	Grunwell (1987), Lowe (1995) and Smit (1993, 2004) put forth that assimilations disappeared by 3 years of age. Grunwell (1997) and Brown (1998) studied that consonant harmony is eliminated by 3.8 years of age.	[kok] for coat [mu:mu] for mu:gu *(in Kannada)*
2	Regressive assimilation (Rass)	The affected segment precedes the one that influences it.		[gok] for rock [bimbu] for d imbu *(in Kannada)*
3	Prevocalic devoicing (PreVD)	Devoicing of a voiced consonant when preceding a vowel within the same word.	Haelsig and Madison (1986) and James (2001) found the presence of the PreVD in 3 years of age. Toblin (2009) suggested the presence of the prevocalic devoicing in 2.0-3.6 years.	[pag] for bag [beppu] for bekku *(in Kannada)*
4	Post vocalic devoicing (PostVD)	Devoicing of a voiced consonant when following a vowel within the same word.	Haelsig and Madison (1986) and James (2001) suggested the presence of the process in 3 years and 4 years of age respectively. Toblin (2009) suggested the presence of the postvocalic devoicing in 2.0-3.1 years. Grunwell (1997) and Brown (1998) studied that word final devoicing is eliminated by 3 years of age. According to Lowe (2000), by the age of 3, 90% of the children suppress the process of voicing change.	[bj̧ t] for bed [go:t i] for go:d i *(in Kannada)*

Idiosyncratic processes

Idiosyncratic processes are the processes that occur rarely or occur unusually or never occur in typical child phonology (Steol-Gammon & Dunn, 1985). Studies have reported that processes like initial consonant deletion, medial consonant deletion, backing, apicalization (apical consonant replacing a labial), glottal replacement, medial consonant substitution, denasalisation, devoicing stop, metathesis, migration, sound preference substitution (replacement of group of consonants by one or two particular consonants) and articulatory shifts were idiosyncratic patterns (Steol-Gammon & Dunn, 1985; Dodd, 1989; Robert et al., 1990; Leonard & Mc Gregor, 1991). Robert, Burchinal and Footo (1990) reported that deletion of medial consonant and deaffrication were uncommon processes, while reduplication and syllable deletion were labelled common.

Phonological processes in other languages

Becker (1982) studied 10 Spanish speaking children of four years age range and found that de-affrication, /r/ deficiencies, cluster reduction, epenthesis, weak syllable deletion and alveolar assimilation were frequently occurring processes in these children. Another study carried out in Spanish children was by Martinez (1986) in three year old children that revealed tap/trill deficiencies, consonant sequencing reduction, deaffrication, stopping, affrication, fronting, assimilation and sibilant distortion.

Topbas (1997) studied the phonological acquisition in Turkish children and reported that Turkish /l/ was substituted by /r/, i.e. liquid realization of another liquid whereas, in English /r/ is usually replaced by /w/ or /j/ a gliding process. According to the author, the phonological patterns exhibited coincide broadly with universal tendencies, although some language specific patterns were also evident. Same finding was also reported in the study by Bonoleni and Leonard (1991) in Italian language.

Amayreh and Dyson (1998) studied 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 parallel to those for English but with notable exceptions. The ages of acquisition of Arabic consonants were classified into into three development periods: early, intermediate, and late. During the early period, children acquired at least 10 standard consonants or half of the 28 consonants of Arabic language. The intermediate period (4.0 to 6.4 years) more or less matched 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 2.0-3.0 years of age. The late period proposed for the children were comparable to Ingramǿs stages of morphophonemic development and spelling. Those consonants not acquired by 6.4 year old children in the study were expected to be acquired later in their life.

Paulson (1991) studied 30 normal developing children of Mexican language in the age range of 2.0-5.0 years. The findings of the study were that the 2 year olds used phonological processes syllable reduction, consonant sequence reduction, prevocalic singleton omission, strident deficiencies, and /r/deficiencies most frequently and the 4 year olds least often. And miscellaneous error patterns were stopping, gliding, vowel deviation, epenthesis, substitution of /l/ for /r/ and sibilant distortions.

Dodd and Hua (2000) studied the phonological developmental aspects in 129 monolingual Putonghua (Modern Standard Chinese) speaking children of the age range 1.6 to 4.6 years. Syllables of Putonghua are characterized by four possible elements: tone, syllable-initial consonant, vowel, and syllabic-final consonants. The results suggested that Putonghua-speaking children mastered these elements in the following order: tones were acquired first; followed by syllable final consonants and vowels; and later syllable-initial consonants were acquired. Simple vowels emerged early in development; while triphthongs and diphthongs were prone to systematic errors. The acquisition of ǳweak stressǴ and ǳrhotacized featureǴ was incomplete in the oldest children assessed.

Other relevant factors that contribute to phonological acquisition were functional load and frequency of occurrence (Pye, Ingram, & List, 1987; Vihman & Velleman, 2000). Pye and colleagues argued 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

The literature on phonological processes and their development are abundant in English, Spanish and other languages; but are limited in India considering the enormous linguistic and cultural diversity. India is one of the most linguistically diverse countries of the world. According to the 2001 Indian census, there are 122 languages and 234 mother tongues. 22 languages have been recognized by the Constitution of India (http://www.censusindia.gov.in/Census_Data_2001/Census_Data_Online/Language).

Relatively little is known about the phonological development in Indian languages in comparison to the vast diversity of languages in India. 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 2.6.

Table: 2.6.

Different Indian studies on phonological processes

Author	Language	Age group	Common processes observed
Sunil (1998)	Kannada	3.0-4.0 years	*Commonly occurring processes:* Fronting and cluster reduction *Least occurring processes:* medial consonant deletion, final consonant deletion and affrication
Sameer (1998)	Malayalam	3.0-4.0 years	*Commonly occurring processes:* Cluster reduction, final consonant deletion, epenthesis, affrication, apicalization, de-affrication etc. *Least occurring processes:* deaffrication, strident deletion, stopping, fronting, reduplication, palatalization, medial consonant deletion, fricative backing and denasalized articulatory chifts.
Jayashree (1999)	Kannada	4.0-5.0 years	*Commonly occurring processes:* Fronting, cluster reduction, and stopping *Least occurring processes:* metathesis, epenthesis, prevocalic voicing and palatalization.
Ranjan (1999)	Hindi	4.0-5.0 years	Cluster reduction, partial reduplication and aspiration

Bharathy (2001)	Tamil	3.0-4.0 years	Epenthesis, cluster reduction, gliding, nasal assimilation, voicing, de-affrication, stopping and fronting
Ramadevi et al (2006)	Kannada	5.0-6.0 years	Stridency deletion, de-aspiration, and retroflex deletion
Santhosh (2001)	Hindi	3.0-4.0 years	Cluster reduction, partial reduplication and aspiration
Sreedevi, Jayaram & Shilpashree (2005)	Kannada	2.0-3.0 years	Retroflex fronting, trill deletion, depalatalization, de-affrication, stopping, cluster reduction etc.
Rahul & Sreedevi (2006)	Hindi	2.0-2.6 years	Retroflex fronting, Deaspiration, /h/ deletion, Gliding, Initial consonant deletion etc
		2.6-3.0 years	Affrication, Denasalization, Monothongisation, Devoicing etc.
Sreedevi (2008)	Kannada	1.6-2.0 years	Retroflex fronting, Initial Consonant deletion, Vowel lowering, Trill deletion, Cluster reduction etc
Sreedevi & Shilpashree (2008)	Kannada	2.0-3.0 years	Final vowel deletion, retroflex fronting, /h/ deletion etc.
Ranjan (2009)	English speaking Indian children	3.0-4.0 years	*Commonly occurring processes:* cluster reduction, final consonant deletion, strident deletion and assimilation *Least occurring processes:* diphthong reduction, vocalization, initial consonant deletion, backing of vowel, de-affrication, and gliding
		4.0-5.0 years	*Commonly occurring processes:* cluster reduction, final consonant deletion, and strident deletion *Least occurring processes:* diphthong reduction, vowelization, initial consonant deletion, backing of vowel, de-affrication and assimilation
Merin & Sreedevi (2010)	Malayalam	3-3.6 years	Cluster reduction, epenthesis, stopping, fronting, palatalization, affrication
Venkatesh, Ramsankar, Nagaraja & Srinivasan (2010)	Tamil	4.6-5.0 years	Initial consonant deletion, final consonant deletion, syllable deletion, cluster reduction, affrication, gliding of liquids, fronting, deaffrication, vowel assimilation, nasal assimilation.
		5.0-6.6 years	Gliding of liquids and cluster reduction

These studies demonstrate the presence of the universal tendencies in the phonological acquisition of typically developing children. The phonotactic rules underlying in each language also determines the presence of phonological process in that particular language. For example, final consonant deletion (deletion of final consonant in a word, for example, [bo] for boat) is not present in Kannada, a south Indian language spoken in Karnataka because of its phonotactic structure. Kannada being a syllabic language restricts a word to end with a consonant. Hence FCD was irrelevant and not applicable in the present study and hence not included in the table. Thus, the language specific features play an important role in determining the phonological development of the children of a given language.

The frequency of words and age of acquisition of words influence phonological development in that particular language (Stoel-Gammon, 2010). When certain phonemes occur more frequently in a particular language regardless of its complexity, children attempt to produce the sound. The produced sound will be simplified to match the adult productions. Vikas and Sreedevi (2012) studied the frequency of occurrence of phonemes in Kannada. According to them in decending order of occurrence of phonemes in Kannada were /a/ (14.57%), /n/ (7.59%), /i/ (6.70%), /a:/ (5.66%), /r/ (5.53%), /d/ (5.35%), /e/ (5.27%), /l/ (4.98%), /t/ (4.54%), /u/ (4.32%) and other phonemes occurred in negligible proportion. The age of acquisition of a speech sound in a language is another important factor that affects the suppression of the processes. Table 2.7 shows acquisition of different speech sounds in Indian context. Once a sound is acquired by the child and masters it at word level, the word is no longer a simplified version of adult pattern.

Table: 2.7.

Age of acquisition of speech sounds in years in Indian context

Speech sounds	Usha, 1986 (Tamil)	Padmaja, 1988 (Bengali)	Arun Banik, 1988 (Bengali)	Maya, 1990 (Malayalam)	Tasneem Banu, 1977 (Kannada)	Prathima, 2009 (Kannada)	Deepa & Savithri, 2010 (Kannada)
m	3	2.6	2.5	3-3.6	3	3-3.6	2
n	3	2.6	2.5	3-3.6	3	3-3.6	2
وُ	-	-	2.5	3-3.6	-	3-3.6	4.6
p	3	2.6	2.5	3-3.6	3	3-3.6	2
f	-	2.9	-	3-3.6	-	-	-
h	-	2.6	3	3-3.6	-	-	>6
k	3	2.6	2.7	3-3.6	3	3-3.6	2
b	3	2.6	2.5	3-3.6	3	3-3.6	2
d	3	2.6	3	3-3.6	3.6	3-3.6	3.6
g	3	2.6	3	3-3.6	3	3-3.6	2
r	-	3.9	4	3.7-4	4.6	-	5
s	3	3.3	-	3.6-4	3	3-3.6	4.6
ώ	6	3.6	3	5-5.6	5.1	3.6-4	4
tώ	3	2.6	3	3-3.6	3.7	3-3.6	3.6
t	3	2.6	3	3-3.6	-	3-3.6	3.6
v	3	2.6	-	3-3.6	-	3-3.6	2.6
l	3	2.6	3	3-3.6	3	3-3.6	3
j	3	2.6	3	3-3.6	3	3-3.6	2

Phonological processes in children with communication disorders

When a child does not develop the ability to produce some or all sounds necessary for speech that are normally used at his or her age, phonological disorder occurs. Phonological disorder is one of the most prevalent communication disorders diagnosed in the preschool and school age populations, affecting approximately 10% of children (NIDCD, 2000). Approximately 7-8% of children aged between 3 and 11 years old are diagnosed with articulation disorders and males are affected two to four times more often than their female peers (Encyclopedia of Mental Disorders, 2007). Approximately 90% of school speech-language pathologists (SLPs) treated children with articulation disorders in 2006 (ASHA, 2008). Approximately 32% of all communication disorders are articulation and phonological disorders (Slater, 1992). 10ï 15% of preschoolers and 6% of school-age children are reported to have an articulation and phonological disorders (Office of Scientific and Health Reports, 1988). Approximately 75% to 85% of preschoolers with articulation and phonological disorders also experience disorders in language (Shriberg & Kwiatkowski, 1988; Paul & Shriberg, 1982). Approximately 92% of clinicians have clients with articulation and phonological disorders on their caseloads (Shewan, 1988).

SLPs are concerned of normal phonological development for the purpose of differentiating normal and disordered children and for effective planning of intervention programmes. Geirut (1998) observed an association between early phonological disorders and subsequent abilities in reading, writing, mathematical abilities and spelling. Crompton (1970) and Oller (1973) reported that children with speech sound disorders have structured and regular phonological systems as those of typically developing children.

Phonological process analysis offered the possibility of classifying childrenôs speech output within a developmental framework. Grunwell (1982) classified children with speech sound disorders as normal development (the presence of phonological processes typical for a childôs chronological age) and phonological disability. Phonological disability was further divided as ñPersisting Normal Processes,ò where children continue to use the phonological processes more appropriate to a younger child (equivalent to Ingramôs (1976) category of ñphonological delayò), ñChronological Mismatch,ò where a childôs speech evidences a combination of phonological patterns, some characteristic of early child speech and some reflecting more advanced phonological development, and ñUnusual and Idiosyncratic Processes,ò where children use processes not found in typical speech development (Ingramôs (1976) ñphonological devianceò).

Dodd (1995) and Dodd et al. (2006) also proposed a four-category system: Articulatory Disorder, Phonological Delay, Consistent Phonological Disorder, and

Inconsistent Phonological Disorder, encompassing both a developmental perspective (with delay being by far the most common speech difficulty encountered). Articulation impairment is characterised by the inability to produce a perceptually acceptable form of particular phonemes, either in isolation or in any phonetic context. Delayed phonological skills in speech are characterized by the use of regular error patterns that occur in normal development but at a chronological age when the patterns are not evident. Consistent deviant disorder is the systematic use of atypical (non-developmental) phonological patterns (e.g. deleting all syllable initial consonants) (Leonard 1985, Ingram 1989). These children have poor understanding of the phonemic rules of the (Dodd et al., 1989). Inconsistent speech disorder in speech is characterized by variable productions of the same lexical items or phonological features not only from context to context, but also within the same context. Broomfield and Dodd (2004) reported prevalence rates for the subgroups as 12.5% articulation impairment, 57.5% delayed phonological skills, 20.6% consistent deviant phonological disorder and 9.4% inconsistent phonological disorder.

Phonological process in children with hearing impairment (HI)

Speech production and intelligibility in the children with HI are affected by the degree of hearing loss. According to Osberger and McGarr (1982) the greater the hearing loss, the more likely errors will extend from consonant and vowel productions to errors in stress, pitch and voicing. Consonant production in hearing impaired children is generally characterized by deletions and substitutions. Final consonant deletions are more prevalent followed by initial consonant deletions (Abraham, 1989). Levitt and Stromberg (1983) revealed frequently occurring substitutions include confusion of voiced and voiceless cognates, substitution of stops for fricatives and liquids, and confusion between oral and nasal consonants. Markides (1970) and Smith (1975) studied and reported that consonants produced with the blade of tongue (/t, d, s, z, f z, y, z) are more likely to be misarticulated in children with HI. The affricates were ranked as most erroneous in this group of communication disorders.

Children with HI use partially rule governed phonological systems (Abraham, 1989, Dodd, 1976). The uses of phonological processes were found to be higher as well as they parallel with those of typically developing children. The overall intelligibility of speech reduced with increase in linguistic complexity (Radziewicz & Antonellis, 1997). Vowels tend to be neutralized; the front and back vowels were perceived like central vowels (Ling 1976). Other vowel errors include tense for lax and viseversa substitutions, especially the front vowels due to poor control of timing diphthongs are often produced as monophthongs and vice versa (Levitt & Stromberg, 1983).

Hudgnis and Numbers (1942) studied 192 children with HI of the age range between 8.0 ï 20.0 years. Consonant errors were described as voicing confusions, substitutions, added nasality, misarticulations of adjacent consonants, omission of word initial or final consonants, misarticulations of consonant blends and devoicing. The consonant errors were seen frequently in initial position. The children were reported to either add an additional vowel, usually /ɒ/, between the 2 elements of the blend or eliminate one of the elements. The authors also classified vowel and diphthong errors involved in these children as substitution of one vowel for another, distortion of diphthongs, neutralization, diphthongization, and nasalization of vowels.

Several researchers have reported that omission of the intended consonant is a frequent error type in children with hearing loss (Hudgins & Numbers, 1942, Markides, 1970, Smith, 1972, Mc Garr & Osberger, 1978). Mangan (1961) reported that devoicing of final voiced consonants is the common error that is found in speech of individuals with hearing loss. Smith (1972) also stated that voicing errors were more frequent and consonant errors were high in final position than medial position in children with HI. Markides (1970) described diphthongs errors in children with HI as prolongation of phoneme parts, elimination of the second element, omission of the first element, or substitution of neutral schwa vowel for the intended diphthong. Oller, Jensen, and Lafayette (1978) reported errors in six year old child with HI like omission of final voiced consonants, devoicing or added a /e/ after them, reduce words to the CV level by omitting parts of clusters or final sounds. But the phonological processes paralleled studies of younger normal children and in studies of normally hearing, language ï delayed children.

A single case study performed by Oller and Kelly (1974) on a six year old child with moderately severe, stable, bilateral sensoryneural hearing loss revealed the presence of liquid and glide processes, voicing avoidance, final obstruent devoicing and fronting of consonants. Consonant cluster reduction, assimilation of both vowels and consonants, stopping of certain fricatives, fricativization of certain stops and vowel substitutions were noted occasionally. The patterns did not parallel with the patterns in typically developing children.

Dodd (1994) studied phonological abilities of Cantonese-speaking children with HI (ages 4:2 to 6:11 years). Their speech characterized presence of cluster reduction, stopping, and deaspiration which were seen in the speech of younger hearing children acquiring Cantonese. However, most children also used at least one unusual phonological patterns frication, addition, initial consonant deletion, and/or backing.

Meline (1997) described phonological patterns for nineteen elementary-age children with HI between 5.0 and 12.0 years. The processes prevalent in these children were final consonant deletion and cluster reduction. The most prevalent deficiencies included /r/ and /l/ phonemes. Subjects with profound HI frequently deleted entire consonant clusters, whereas subjects with Moderate to Severe HI did not.

Huttunen (2001) studied phonological development in 15 Finnish speaking children (five normally hearing 3 year olds and ten moderately HI 4-6 year olds children and revealed that frequent phonetic errors, normal (but delayed) and deviant phonological processes were seen in children with HI.

All these studies revealed occurrence of phonological problems in children with HI. These studies demonstrate the universal tendencies in childrenôs phonological acquisition. However, language specific features play an important role in determining the phonological development of the children of a given language.

Phonological process in children with mental retardation (MR)

Literature has reported that over 50% of the subjects with MR evidenced speech problems. Bodline (1974) and Smith (1974) investigated phonological patterns in speech of Down syndrome and identified that cluster reduction, assimilation, fronting, final consonant deletion, stopping, vowelization, liquid deletion and gliding were frequently seen.

Mackay and Hodson (1982) studied phonological processes in 20 children with mental retardation of the ages of 6 years 4 months and 15 years. The processes liquid deviations and cluster reductions were most common phonological processes seen in their speech sample. The processes postvocalic obstruent omissions, deviations of other sonorants (glides and nasals), velar deviations, stridency deletion, stopping, and /ɗ, ð/ deviations were noted least.

Smith and Steol-Gammon (1983) explored the rate of suppression of phonological processes in children with Down syndrome through a longitudinal study. The results of the study revealed that four phonological processes declined from 63% at 18-24 months to 25% at 30-36 months in typically developing children. While the same processes were suppressed to 61% when the children with Down syndrome were 3 years old declining to 40% at 6 years old. Even at the mental age of 7.0-8.0 years, error characteristics of younger children persisted.

Dodd (1976) compared phonological patterns in typically developing children, children with severe learning disabilities and children with Down syndrome, all matched for mental age. He found that the number and type of phonological errors in children with severe learning disabilities were not significantly different when compared to typically developing children; while children with Down syndrome exhibited several differences. The children with Down syndrome made greater number of phonological errors in their productions, their error were inconsistent and greater set of the error were uncommon phonological processes. Steol-Gammon (1981) reported greater variability of errors and more substitution types of errors in children with Down syndrome.

Phonological process in children with HI and children with MR in the Indian context

Jasmine (2001) studied ten subjects each in the age range of 3.0-5.0 years and 5.0-7.0 years Malayalam speaking children with moderately severe HI and typically developing children. In 3.0-5.0 years, 13 phonological processes were demonstrated typically developing children whereas the hearing impaired children exhibited 25 phonological processes. Comparing both 3.0-5.0 years and 5.0-7.0 years age groups of children with HI, 25 phonological processes were seen in the former group and 15 in the latter group. This indicates phonological processes decrease with age.

Vardi (1991) developed a manual, phonological profile for the children with HI. The author illustrated processes in normal children and in deaf children arranged developmentally in different stages. She studied this in 4 stages in normal children. They are stage 1 (2.06 years), stage 2 (3.06 years), stage 3 (4.06 years) and stage 4 (>4.06 years). She profiled the phonological processes in hearing impaired children. This profile is comprehensive and less time consuming but is applicable only for English speakers.

Ramadevi (2006) profiled the phonological processes in Kannada speaking normal children and also in Kannada children with HI. The phonological profile developed incorporated three elicitation tasks: picture naming, words having clusters, and spontaneous speech. It was administered on 30 normal children (Group -1) and 30 hard of hearing children (Group ï 2) of age range 5+, 6+, 7+, 8+ and 9+ years. Findings revealed percentage of children using 29 processes in both the groups seen in Table 2.8.

Table: 2.8.

Percentage of typically developing children and children with HI using 29 phonological processes (Ramadevi, 2006)

Sl no	Phonological processes	% of normal	% of HI
1	Affrication	3.33	50.00
2	Alveolar assimilation	10.00	33.33
3	Backing of alveolars	6.67	23.33
4	Cluster reduction	30.00	90.00
5	Deaspiration	93.33	90.00
6	denasalisation	3.33	86.67
7	Devoicing of consonant	6.67	73.33
8	Double C > Single C	33.33	60.00
9	Epenthesis	30.00	6.67
10	Fronting of palatals	16.66	70.00
11	Fronting of retroflexes	20.00	96.67
12	Final vowel deletion	3.33	53.33
13	Gliding of liquids	6.67	13.33
14	H deletion	80.00	93.33
15	Lateral replacing flap	13.33	56.67
16	Monophthongization	13.33	36.67
17	Medial vowel deletion	6.67	6.67
18	Nasal deletion	36.67	83.33
19	Stopping of glides	10.00	36.67
20	Stopping of liquids	13.33	23.33
21	Single c > double c	6.67	63.33
22	Stridency deletion	13.33	93.33
23	Voicing	10.00	46.67
24	Vowel backing	13.33	53.33
25	Vowel fronting	13.33	60.00
26	Vowel lowering	13.33	76.67
27	Vowel lengthening	26.67	56.67
28	Vowel raising	16.67	46.67
29	Vowel shortening	13.33	40.00

Assessment of phonological systems

In describing the phonological systems of children, two procedures are commonly used: independent analyses and relational analyses (Stoel-Gammon & Dunn, 1985). An independent analysis describes the childôs individual system while a relational analysis compares the childôs system with the adult system.

Independent analyses focuses on the childôs production by itself, not considering the relationship to the adult model. Studies that employ independent analyses discuss phonetic inventories of early meaningful speech as well as speech behaviours preceding the onset of meaningful speech such as vocalization and babbling. For instance, Stoel-Gammon (1987) provided a profile of the phonological skills of 2 year old children by studying the word and syllable shapes produced and the inventories of consonants; Robb and Bleile (1994) studied the number and types of consonants occurring in the childrenôs inventories and the relative frequency of occurrence of sound classes of glossable and non-glossable utterances produced by seven children between the ages of 8 and 25 months. These studies are crucial in the account of childrenôs phonological development as they provide data on the early period of meaningful speech development and can be used to establish preliminary norms regarding the emergence and use of early speech sounds. However, an independent analysis has been predominately longitudinal in nature and has been based on small samples of participants under 3 years old. This makes it difficult to use them clinically as valid normative data.

Relational analyses compare the childôs correct and incorrect productions of a word with the standard adult form. The analysis of correct pronunciations is commonly used to establish norms of speech sound acquisition (Dodd, Holm, Hua, & Crosbie, 2003; Moyle, 2005; Porter & Hodson, 2001; Smit, Hand, Bernthal, Freilinger, & Bird, 1990). The incorrect productions of children are compared with the adult forms in terms of phonological processes (Dodd, et al., 2003; Dyson & Paden, 1983; Grunwell, 1981; Haelsig & Madison, 1986;

Hodson & Paden, 1981; James, McCormack, & Butcher, 1999; James, 2001; Prater & Swift, 1982; Preisser, Hodson, & Paden, 1988; Roberts et al., 1990).

The age of acquisition of phonemes derived using relational analysis is one of the important benchmarks regularly used to determine the status of childrenö speech. This includes the traditional sound analysis (SODA errors) and pattern based analysis. In pattern based analysis, three analyses are performeb namely, the place, voicing and manner (PVM) analysis, distinctive feature analysis and phonological process analysis. Place, manner voicing analysis is a basic type of pattern analysis that considers childö misarticulations in relation to the phonetic features of place, manner and voicing. This can be done on single word elicitation as well as connected speech sample and is done relatively quickly. The distinctive feature analysis refers to the unique sound which distinguishes one sound from the other, e.g; +_ voicing, +_ strident, +_ rounding, +_ nasals. This method is not frequently adapted in the assessment and treatment of phonological disorders due to its complex method and a questionable clinical relevance. While phonological process analysis is a commonly used method for identifying error patterns exhibited by children. Here the childö sound errors are classified according to the phonological process and analyzed in terms of frequency of occurrence of phonological processes and percent of occurrence of phonological processes.

Clinicians used standardized articulation tests for assessment that do not differentiate among error types. With the development of a number of phonological process analysis procedures, it has been 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).

Phonological process analysis

Phonological process analysis is based on the assumption that childrenö speech sound errors are not random, but represent systematic variations from the adult standard. Clinicians compare the childös 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 childös 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 clientös 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 Childrenös 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 ñopen endedò and can continue ñuntil all the substitutions in a childös speech have been explainedò.

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

The criteria for phonological process analysis should be clearly defined. The majority of the early studies used surface analysis procedures with no quantitative criteria to demonstrate the presence of processes, for example, Hodson & Paden (1981) and Preisser et al. (1988).

Non- quantitative criteria

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 process of Final Consonant Deletion is present in the child. 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 childȇs 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 process is said be present in non quantitative criteria.

Quantitative criteria

Quantitative criteria were used in recent studies with different thresholds. Different researchers set 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 (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. This criterion was 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 sound change must occur in at least 40% of the time for qualifying a sound change as a phonological processes. Another criterion for use of phonological process occurrence was more 20% of the time in Haelsig and Madison (1986) and Roberts et al. (1990) and 10% of the time in Dodd et al. (2003). With different criteria set to identify phonological process to be persisting in the particular age groups, the age of suppression of the processes were different in different studies as seen in Table 2.9.

Table 2.9:

Age of suppression of different processes by various authors (NR=Not reported)

Authors Phonological processes	Grunwell (1981)	Haelsig & Madison (1986)	Roberts et al. (1990)	Bankson & Bernthal (1990)	James (2001)	Dodd et al. (2003)
Age	0;09- 4;06	2;10- 5;02	2;06- 8;11	3;00- 6;11	2;00-7;11	3;00-6;11
Liquid gliding	< 4;00	< 4;06	5;00	5;00	5;00*	6;00
Fronting	3;03	3;00	3;06	< 3;00	> 6;00	4;00
Stopping	3;00	3;00	3;00	5;00	4;00	3;06
Unstressed syllable deletion	4;00	5;00	< 2;06	4;00	4;00	4;00
Final consonant deletion	3;03	3;06	< 2;06	4;00	4;00	NR
Deaffrication	NR	NR	3;06	< 3;00	4;00	5;00
Affrication	NR	3;00	NR	NR	3;00	NR
Alveolar assimilation	NR	3;00	NR	NR	4;00	NR
Velar assimilation	NR	3;00	NR	NR	> 6;00	NR
Prevocalic devoicing	NR	3;00	NR	NR	3;00	NR
Postvocalic devoicing	NR	3;00	NR	NR	4;00	NR
Glottal replacement	NR	4;00	NR	NR	5;00	NR
Consonant harmony	2;06	NR	NR	< 3;00	NR	NR
Depalatalization	NR	NR	NR	< 3;00	5;00	NR
Context sensitive voicing	2;06	NR	NR	NR	NR	NR
Reduplication	2;06	NR	NR	NR	NR	NR
Labial assimilation	NR	3;06	NR	NR	NR	NR
Denasalization	NR	3;00	NR	NR	NR	NR
Fricatives gliding	NR	3;00	NR	NR	NR	NR
Vocalization	NR	NR	NR	5;00	NR	NR
Backing	NR	NR	NR	NR	4;00	NR
Metathesis	NR	NR	NR	NR	6;00	NR
Initial consonant deletion	NR	NR	NR	NR	4;00	NR
Palatalisation	NR	NR	NR	NR	4;00	NR

The age when cluster reduction was suppressed was reported in large scale cross-sectional studies such as Grunwell (1981), Haelsig and Madison (1986), Roberts et al. (1990), Bankson and Bernthal (1990), James (2001) and Dodd et al. (2003). The age when cluster reduction was suppressed varied greatly from one study to another, ranging from 3 to 7 years. Cluster reduction was suppressed as early as 3 years in Grunwell, but as late as 7 years in Roberts et al. (1990).

According to McReynolds and Elbert (1981), if a phonological process analysis is conducted within the framework of natural phonology (Stampe, 1969), the conditions set forth within the theory should be satisfied. When they employed non-quantitative and quantitative phonological process analysis on 13 children with functional articulation problems, there was a great difference in terms of the number of phonological patterns identified with and without quantitative criteria imposed. Thus, a standardized quantitative and qualitative criterion for phonological process identification is an important parameter to consider.

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.

Clinical application of phonological processes

Examination of the types of error that occur in childrenös phonological development showed that childrenös productions were related to the adult forms in systematic ways. The use of phonological process analysis provides a simple and economical way of describing the differences in the structural and segmental aspects of a childös phonology (Stoel-Gammon & Dunn, 1985). This phonological process approach, therefore, became the most common procedure in describing childrenös phonological acquisition, and phonological rules were derived to describe the relationships (Smith, 1974). Ever since, many researchers have used phonological process analysis to describe the speech pattern of both normal and disordered children (Grunwell, 1985; Hodson, 1980; Ingram, 1981; Shriberg & Kwiatkowski, 1980; Stoel- Gammon & Dunn, 1985; Weiner, 1979). Two methods are usually employed in the studies of phonological processes: longitudinal and cross-sectional. Both methods have their strengths and limitations and are able to complement each other in providing rich and valuable information about childrenös phonological development.

Issues in clinical application of phonological processes

Even though phonological processes analysis has been widely recognized and accepted, there are a few concerns pertaining to the procedure. Some of the issues are as follows.

1. Lack of agreement on what constitutes a process

Natural phonology theory is based on observations of ónormalô 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 ótapô and [ti] for ókeyô 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 óseaô 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 /ď/ as in ósinkô and óthinkô and the contrast between /z/ and /Ö/. Ignoring this distinction prevents the understanding of what a child is doing. To produce ósinkô as óthinkô is not the same process as producing ósinkô as órinkô. 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.

Gender differences in phonological processes

Girls in general are thought to perform better in speech and language functions that boys eventually catch up. Various studies have been conducted to reveal gender differences in speech language skills. Many studies have revealed a significant and an accelerated (Templin, 1963) articulatory acquisition in girls. Moore (1967) performed a longitudinal study in the language development during their first 8 years. The only significant gender difference was seen in higher speech quotient in girls at 18 months of age. McCormack and Knighton (1996) reported that 2.5-year-old girls had more accurate phonological output than boys. Hyde and Linn (1988) and Fenson, Reznick, Bates, Thal and Pethick (1994) found that gender accounted for only 1% and 1-2% of the variance in language acquisition. Females were observed to perform better than males in the area of speech production.

Wellman, Case, Mengert and Bradbury (1931) found that 3 and 4 year old girls achieved statistically significant better consonant accuracy scores than boys but no significant difference was observed between 5 and 6 year old girls and boys. Smit et al. (1990) found that although girls appeared to acquire sounds earlier compared to boys, statistically significant data was found in older ages: 4;0, 4;6 and 6;0 years. Kenny and Prather (1986) found more consistent performance in girls than boys between 3 to 5 years of age. However, studies like Holm and Doddôs (1999) and Dodd, Holm, Hua and Crossbie (2003) have revealed no gender differences.

A number of potential explanations have been posited regarding the basis of gender differences in speech development like differences in brain maturation rates (Hyde & Linn, 1988); earlier maturation of the speech organs (Templin, 1957; Darley & Winitz, 1961); differences in socialization (Moore, 1967) etc.

Sample size of studies of phonological processes

With limited number of children included in studying phonological acquisition, immense individual variation was noted and it is hard to generalize the findings to the general population like in the study done by Grunwell (1981) and James (2001). Grunwell (1981) had compiled data from case studies by Ingram (1976) and presented a profile of phonological development in 9 to 18 months to 4 years old children including the chronology of the suppression of the processes. Due to the inadequate number of children in the study, great individual variation was noted and it was difficult to generalize the findings to the general population. Similarly James (2001) recruited only 50 children aged 2 to 7 years old while establishing the phonological process developmental data for normal children and found increased variability. Thus, more larger-scale studies are required to authenticate the findings of previous smaller-scale studies.

Test items

The studies in this area also need to bring into consideration about the stimuli. The test items should reflect an appropriate proportion of monosyllabic (MSWs), disyllabic (DSWs) and polysyllabic words (PSWs) (James et al., 1999). Klein (1981) found that childrenǿs lexicons contain approximately 20% of PSWs. Therefore,

PSWs should be included in phonological process analysis to ensure valid and reliable testing of childrenǿs speech skills. Klein (1985) noted that childrenǿs approach to the production of PSWs was suggestive of their later production skills for continuous speech, especially with schwa in unstressed syllables in DSWs and PSWs. Vowel errors in weak syllable in PSWs were also reported by Allen and Hawkins (1980) and Young (1991). Young (1991) found that there was an interaction between the number of syllables and syllable deletion in young children. Much of the literature indicated that vowel errors are apparent only in DSWs and PSWs.

Children at age 3 years had difficulty producing weak syllables, and tended to substitute a full vowel for schwa. James (2001), who studied the vowel production of 354 children aged 3 to 7 years old across MSWs, DSWs and PSWs, discovered a similar finding, where many vowel errors were associated with the production of schwa in weak syllables in PSWs.

There is also a need that number of children considered for the developmental phonological research to be large enough to reflect the actual population. This aid in examining the phonological processes to be present, persisting or suppressed, a wider age range should be included. James (2001) considered only 50 children aged 2 to 7 years of age group to establish the phonological process developmental data for normal children and there was increased variability in the findings. Thus, studies with increased sample sizes validate the findings of previous smaller-scale studies. Dodd et al. (2003) obtained a large representative sample of British childrenô phonological processes to establish reliable and representative normative data for clinical use. Thus developmental data on phonological processes should represent a specific population for the purpose of validity and reliability.

Research in younger children

Numerous investigators have examined phonological systems of children in English , out of which only hanfull studies are conducted under the age of 3 (Edwards, 1973; Ferguson & Farwell, 1975; Ingram, 1974; Leonard, Newhoff, & Mesalam, 1980; Macken & Barton, 1980; Menn, 1971; Moskowitz, 1970; Schwartz, Leonard, Wilcox, & Folger, 1980; Smith, 1973). Preisser et al. (1988) inferred that studies in younger groups of children reveal trends that are not evident in older groups. Watson and Scukanec (1997) attempted to profile the phonological abilities in 12 young children of the age group 2.0-3.0 years. The authors indicated that the variability in the production patterns were greater in the younger children. At age 2;9, liquid simplification was no longer used. However, cluster simplification, cluster reduction, vowelization, and later stopping were used by most subjects. Finally, at the age of 3;0, only the phonological processes of later stopping and cluster simplification was used at least 20 per cent of the time by the group of subjects. The studies in younger ages below 3 years revealed significant details of phonological acquisition.

Computerized Assessment of Phonological Processes

Speech-language therapists rely on normal developmental patterns of phonological process and their ages of suppression derived from normative phonological developmental studies. Research revealed that targeting error patterns could facilitate greater change than treating phonemes one by one. When errors pattern were targeted, improvement occurred not just in specific targets but also in related patterns. Thus began the development of computerized based phonological assessment procedures/ tools.

Much of the analysis work in phonological analysis is laborious and repetitive. The amount of time required to analyze phonological samples became a major practical consideration. 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 clientôs 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 ñby handò seemed to be tailor-made for computer analysis. 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. The nature of these tasks is ideally suited to computer analysis. The computer can take a corpus of language and generate more accurate information than analysis done by a clinician.

A phonological analysis that might take a clinicianős several hours to accomplish can actually be completed in less than a few minutes by most programs and are user friendly. These applications 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 and the sample can be copied to a CD-ROM for storage and later comparisons. Masterson and Long (2004) also indicated advantages of 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

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

Various computer based analysis have been developed in English. Computer analysis of phonological data (Faircloth & Dickerson, 1970) was the first computer based phonological analysis developed. Masterson and Bernhardt (2002) developed the computerized Articulation and Phonology Evaluation System (CAPES) to elicit and analyze phonological productions in children from 2 years to adulthood using single words, sentences and connected speech. The computer program also scored and provided treatment recommendations. Other computerized analysis programs are tabulated in Table 2.10.

Table 2.10:

List of computerized analysis programs in English

Sl.no	Author	Computerised tool
1	Hodson, 1985	Computer Analysis of Phonological Processes (CAPP)
2	Shriberg, 1986	Programs to Examine Phonetic and Phonologic Evaluation Records Version 4.0 (PEPPER)
3	Long & Fey, 1988	Computer Profiling (CP)
4	Oller & Delgado, 1990	Logical International Phonetic Programs (LIPP)
5	Weiner, 1986	Process Analyses (PAC)
6	Pye, 1987	Pye Analysis of Language (PAL)
7	Masterson & Bernhardt, 2001	The Computerized Articulation and Phonology Evaluation System (CAPES)
8.	Hodson, 2003	The Hodson Computerized Analysis of Phonological Patterns (HCAPP)

Each of these programs listed in Table 2.10 has its own strengths and limitations. 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 doesnȇt ñdo it allò. 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 consumerǿs 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 (CAPP; Hodson, 1985) CAPP is easy to use program. Clinicians with little or no experience with microcomputers should readily able to use this software. The description of CAPP is given in Table 2.11.

Table 2.11:

Description about CAPP

About CAPP	Output of the program
CAPP runs in any of the Apple II series computers. Includes a closed set of 50 words stimuli. 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. 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 clientǿs transcription form. The space bar is denoted to indicate deletions. The 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.	• 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.

It takes less than 10 minutes to enter the clientǿs responses. It uses closed set and spontaneous speech data cannot be analyzed. However, 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. 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.

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. The description of CP is given in Table 2.12.

Table 2.12:

Description about CP

About CP	Output of the program
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 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 program accessible, simple and save time. CP also includes modules for semantic, syntactic, pragmatic, and prosodic analyses. The users need to enter a sample only once to obtain results. 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 (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. The description of LIPP is given in Table 2.13.

Table 2.13:

Description about LIPP

About LIPP	Output of the program
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 clientôs 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: • An inventory analyses, which compares the target and transcription lines; and • Rule driven analyses, which counts sounds, calculates percentage of correctness, evaluates structural characteristics of the sample, performs phonological process analysis etc.

LIPP is avalable 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. LIPP is an expensive product but a unique program because of the amount of flexibility it offers. It has well designed 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 (PAC; Weiner, 1986)

Table 2.14:

Description about PAC

About PAC	Output of the program
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 clientôs 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: Output reveals percentages for approximately 15 phonological processes. Analysis results can be viewed on the screen and/ or printed. The analyses performed are completed rapidly, so little time is lost in repeating the analysis of a previously saved file.

PAC has few disadvantages: the stimulus set includes monosyllabic words only, so word-medial consonant production is not considered, the program does not list the words in which specific phones or phonological processes were found and it does not allow the results of an analysis to be saved to a disk.

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

PAL 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). The description of PAL is given in Table 2.15.

Table 2.15:

Description about PAL

About PAL	Output of the program
Analysis of a sample occurs in five steps. 1. A transcript is created and saved in text (ASCII) format. This file is input to the FORMIX module of PAL and checked for format errors. 2. If errors are found, they are edited with a word processor. 3. Input the file to the PHONIX module of PAL and create a phonological lexican file and is edited with a word processor so that it contains only the data that user wishes to analyze. 4. Run this edited file through a phonetic dictionary, which automatically finds the target form for each of the words in the sample. 5. Finally, the file containing the lexical, target, and production forms is submitted for phonological analysis by the program.	PALọs phonological analysis consists of a phonetic inventory and a substitution analysis. The program calculates 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 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. The strengths of PAL are its ability to analyze any set of words, including connected speech data; analyzes vowels; it is fast; and it handles very large data sets.

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

PEPPER is a comprehensive approach to the analysis and interpretation of phonological data. The description of PEPPER is given in Table 2.16.

Table 2.16:

Description about PEPPER

About PEPPER	Output of the program
The software provides assesses an individualôs phonetic abilities and the phonological simplifications. PEPPER employs a graphics mode which allows data for the target and transcription lines to be entered in IPA symbols and diacritics. 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.	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 vowel. ▪ Percentage consonants correct ▪ Phonetic inventories for word-initial and ï final phones.

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

Table 2.17:

Description about CAPES

About CAPES	Output of the program
The stimuli consists of photographs of 46 words with various word lengths, structures and stress patterns in the single- word tasks that are displayed on the computer screen. The testee names the items, the computer audio records the responses (which can be played back later), and the clinician transcribes the clientôs words directly into the computer as the test is being administered. 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 clientôs 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 clientôs productions using the IPA.	Independent and relational analysis can be done. 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. 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, ñuser friendlyò method, was designed for preschool and school-age children with highly unintelligible speech. The description of HCAPP is given in Table 2.18.

Table 2.18:

Description about HCAPP

About HCAPP	Output of the program
This program compares the clientǿs phoneme by phoneme productions to the adult standard production. The program works on IBM- compatible and Macintosh computers. Phonetic symbols representing the childǿs productions of 50 words are required to be entered into the computer in approximately 5 minutes [depending on oneǿs typing skills and the individual clientǿs level of severity]. The utterances are analyzed for phonological deviations as soon as the ñResultsò key is ñclicked.ò Client data can be stored on the hard drive [or on a floppy or CD or flash drive] for future retrieval.	Analysis by the HCAPP provides the following: ▪ Percentage-of-Occurrence scores for Major Phonological Deviations, ▪ Severity Rating specification [Mild, Moderate, Severe, Profound] for the childǿs 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 and Sreedevi (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 as described in Table 2.19. The assessment tool uses 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. This module elicits phonological profile in Kannada in children with hearing impairment.

Table 2.19:

Description about computerised module developed by Ramadevi (2006)

About Phonological profile in Kannada	Output of the program
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 ñEnterò button thrice. If the correct response is not obtained for the picture, ñEnterò button is pressed once, and then the written word is displayed. The data of child is entered in the color coded phonological profile (Table 2.22) developed in the study.	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.

Table 2.22:

Phonological profile developed by Ramadevi (2006)

PROCESSSES AFFECTING VOWELS & DIPHTHONGS	VOWEL & DIPHTHONG INVENTORY					SUBSTITUTION PROCESSES		I	M		SYLLABLE STRUCTURE PROCESSES
			I	M	F		m			STAGE 1	INITIAL CONS. DELETION:
	FRONT	i					n			STAGE 1	
	FRONT	ii			-		p			STAGE 1	
	FRONT	e					b			STAGE 1	
	FRONT	ee			-		t			STAGE 1	MEDIAL CONS. DELETION:
	CENT-RAL	a					d			STAGE 1	
	CENT-RAL	aa			-		y			STAGE 2	
	BACK	o					v,w			STAGE 2	
	BACK	oo			-		k			STAGE 2	FINAL SYL. DELETION:
	BACK	u					g			STAGE 2	
	BACK	uu			-		l			STAGE 2	
	DIPH-THONG	ai					s			STAGE 3	
	DIPH-THONG	au					h			STAGE 3	CLUSTER REDUCTION:
							c			STAGE 3	
INTELLIGIBILITY RATING SCALE	ASSIMILATION						T			STAGE 3	
							D			STAGE 3	
	ALVEOLAR ASSIMILATION:						L	-		STAGE 3	STRIDENCY DELETION:
100%							N	-		STAGE 3	
							j			STAGE 3	
							r			STAGE 3	
80%	NASAL ASSIMILATION:						sh			STAGE 4	NASAL DELETION:
							S			STAGE 4	
60%							ph			STAGE 4	
							bh			STAGE 4	
	OTHERS:						th			STAGE 4	LIQUID DELETION:
40%							dh			STAGE 4	
							kh			STAGE 4	
							gh			STAGE 4	GLIDE DELETION:
20%							ch		-	STAGE 4	
							jh		-	STAGE 4	
0%							Th			STAGE 4	OTHERS:
							Dh		-	STAGE 4	
STOP ï S	NASAL ï N	GLIDE ï G				FRICATIVE ï F	AFFRICATE ï A	LIQUID ï L			
LABIAL	DENTAL	ALVEOLAR				RETROFLEX	PALATAL	VELAR			

Ramadevi 2006

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

CAPP-M is user friendly software used to assess native Malayalam speaking children of 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 childôs utterance and clicks on the correct production or any of the three possible patterns of that word or the option ñany otherò 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 ñreportò to obtain a summary of the processes exhibited by the child along with its frequency in descending order. The test yields the common phonological processes in each childôs utterance, the frequency of their occurrence and 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.

3. Computerized Assessment of Phonological Processes in Malayalam (CAPP-M; Sreedevi & Merin, 2012)

CAPP-M was developed with the aim to prepare an indigenous computer based software to assess the phonological processes in 2.0-3.6 year old native speakers of Malayalam language speaking children. 120 native Malayalam speaking children in the age range 2.0-3.0 years were administered the Malayalam Diagnostic Articulation Test. The most common phonological processes were obtained. The data of selected words with their frequent utterance patterns were used to prepare the software tool. The data of 3.0- 3.6 years was appended to this study prepare ñComputer based Assessment of Phonological Processes in Malayalamò (CAPP-M) to assess phonological processes in 2.0-3.6 years old children. The tool was considered sensitive when subjected to sensitivity evaluation on 10 children with communication disorders.

The test tool assessed 24 processes in 2.0-2.6 years, 17 in 2.6-3.0 years and 9 in 3.0-3.6 years. 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 years or 2.6 - 3.0 years or 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. Below the picture its correct production and five options is shown in IPA symbols. The 4 most possible patterns of the intended target word along with an option called ñAny otherò. This ñAny otherò option is meant for any other production by the subject which does not fall under the common patterns of production. The output provides the list of phonological processes with the frequency with which each process is occurring in descending order of its occurrence.

CAPP-M is the first indigenous software for the assessment of phonological processes in Malayalam. The approximate duration of testing was 8-10 minutes. It is a quick screening tool for automatic and easy analysis of the phonological processes. This tool can be used for evaluation and post therapy assessment of children with communication disorders of age range 2.0 to 3.6 years in Malayalam. CAPP- M can be used as an index of phonological development there by aiding early intervention and remediation.

Thus CAPP-M software was an important milestone in the field of computer based assessment of phonological processes in India which could present the stimuli, analyse the childôs utterance, provide the count of frequency of phonological processes and document phonological process report. The CAPP-M test tool set a landmark in developing indigenous computerized assessment tools. The present study attempts to develop similar software tool in native Kannada speaking children of the age group 2.0-3.6 years. This will minimize the laborious repetitive manual work and time involved in traditional phonological analysis used in the routine busy clinical set up.

CHAPTER III

METHOD

The primary objective of the present study was to develop a user friendly indigenous computerized assessment tool which automatically evaluates the phonological processes in native Kannada speaking children. The study was carried out in 3 phases.

- **Phase I** was to obtain the normative data of phonological processes prevalent in native Kannada speaking children in the age range of 2.0-3.6 years.
- **Phase II** was to develop a computerized tool which assesses phonological processes using the normative data collected in phase I.
- **Phase III** was to evaluate the sensitivity of the tool developed in children with hearing impairment and mental retardation.

Phase I: To obtain norms

Participants: Native Kannada speaking children of age group 2.0 - 3.6 years were considered for the present study. A total of 180 subjects of this age group were enrolled in the study. Out of the 180 subjects, 60 participants each in the age ranges of 2.0-2.6 years, 2.6 to 3.0 years and 3.0-3.6 years were considered. Each of the age groups consisted of 30 males and females.

All subjects had Kannada as their native language and were selected from different localities of Mysore city which is the second largest city in the state of Karnataka. It is the 32nd most spoken languages in the world, one of the scheduled languages in India and official language of the state (http://en.wikipedia.org/wiki/). The participants of the age group 2.0-2.6 years were selected from day care centers and homes, and participants of the age group 2.5-3.0 and 3.0-3.6 years were selected from play homes and preschools. All the participants enrolled in the study were subjected to an informal screening and the inclusion criteria were;

- Native speakers of Kannada, 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 were tested with the Kannada Diagnostic photo Articulation Test (KDPAT; Deepa & Savithri, 2010). This test was outcome of standardization on 240 typically developing children in the age range of 2.0-6.0 years. The KDPAT consists of 114 test words including part I and II; 20 words assess vowels, 3 words assess diphthongs, 80 words assess consonants and 11 test words for clusters. Out of 114 test words, only certain words were considered in the present study based on the age at which each phoneme is acquired (ie in the order of difficulty). These word stimuli are depicted in color pictures. The details of the test words in each age group from 2.0-2.6 years, 2.6 to 3.0 years and 3.0-3.6 years are depicted in Table 3.1.

Table 3.1:

Number of stimuli from KDPAT considered for the present study

Age groups	Test words from KDAT test tool		Total words (Total=114)
	Part I (Total=52)	Part II (Total=62)	
2.0-2.6 years	30	29	59
2.6-3.0 years	34	33	67
3.0-3.6 years	34	33	67

Test environment: Consent from the parent/ care giver/ principal of the day care or preschool was obtained prior to data collection. All the children were individually tested in a quiet environment. The participant was seated beside the examiner to best view the display of test stimuli pictures on a laptop computer.

Procedure: The researcher established rapport with the child before administration of KDPAT. The participants were asked to name the stimuli pictures one after the other. If they failed to identify a target word, additional cues (semantic and phonemic) were presented by the examiner. If the child failed to name the target picture in spite of additional cues, repetition was used for elicitation of the target word. Child was asked to repeat the target word at least twice and the response that best matched with the target word was considered for analysis. The responses obtained were audio recorded using a digital voice recorder (Sony Olympus WS-100). The test administration for each child was carried out in 20-30 minutes. Analysis of the recorded audio samples involved the following steps.

1. Transcription: The recorded speech samples of all the 180 subjects were thoroughly listened to individually and transcribed using broad and narrow transcription (IPA, 2005).

2. Identification of the Phonological Processes: The phonological processes were 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, 35 phonological processes operating were identified and classified under major groups of processes as shown in Table 3.2.

Table 3.2:

Shows the phonological processes identified in the study

Syllable structure processes	Substitution processes	Assimilation processes
1. Initial vowel deletion	1. Stopping	1. Progressive assimilation
2. Initial consonant deletion	2. Nasal fronting	2. Regressive assimilation
3. Medial consonant deletion	3. Dental fronting	3. Prevocalic devoicing
4. Initial syllable deletion	4. Palatal fronting	4. Postvocalic devoicing
5. Medial syllable deletion	5. Retroflex fronting	
6. Final syllable deletion	6. Velar fronting	
7. Epenthesis	7. Backing	
8. Reduplication	8. Affrication	
9. Metathesis	9. Palatalisation	
10. Cluster simplification	10. Depalatalisation	
11. Cluster deletion	11. Gliding	
12. Geminate cluster deletion	12. Vowelisation	
13. Cluster substitution	13. Denasalisation	
14. Cluster reduction	14. Lateralisation	
	15. Delateralisation	
	16. Monophthongisation	
	17. Labialisation	

Each target response was analyzed for possible phonological processes. Certain children exhibited 2 or more processes in a single target word, for instance a child of 2.0-2.6 years produced the target word /a:spatre/ as /a:ate/. The processes identified were cluster deletion, cluster reduction. Similarly, another participant produced /adIju/ for /bagilu/, the processes identified were initial consonant deletion, velar fronting and gliding.

3. Calculation of percentage of subjects using the processes: The calculation of percentage of occurrence of each process and determining total opportunities for occurrence of a particular process is a very tedious task. 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 Kannada, and hence Kannada 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 findings which results in 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: Smith's Statistical Package was used to obtain significant differences across gender and age.

Phase II - Development of the phonological processes 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 /ga˺lIja:ra/ was produced incorrectly by 100% of the subjects in the younger age group 2.0-2.5 years.

The word /kaʈʈari/ was produced incorrectly by 98% of the subjects and word /auɖada/ was produced incorrectly by 95% of the subjects in the same age group. Hence while ordering; the target word /gaɭIja:ra/ was followed by the word /kaʈʈari/, /auɖada/ and so on.

2. Selection of words for the software: For all the target words, number of words errored was calculated as seen in Table 3.3.

Table 3.3:

Number of words incorrectly produced in each age range

Age groups	Total test words	Number of words errored
2.0-2.6 years	59	59
2.6-3.0 years	67	63
3.0-3.6 years	67	56

All error words in each of the age groups were listed in descending order from most erroneous words to the least erroneous words. The words that were produced erroneously by more than 20% of the children in each age group were the natural processes persisting in the typically developing child according to McReynolds and Elbert (1981) and Roberts et al (1990). The words produced erroneously by less than 20% of the typically developing children were considered as unusual or disordered phonological patterns in that age group. Hence the final list of words consisted for inclusion in the software tool were seven words in 2.0-2.6 years, 15 words in 2.6-3.0 years and 30 in 3.0-3.6 years of age. 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 all the selected seven target words in 2.0-2.6 years, 15 in 2.6-3.0 years and 30 in 3.0-3.6 years for software making, four to five different utterances of the same target word obtained from the sample were listed. The different productions of the same target word and their occurrence in the number of participants were listed. For example, the different production patterns of the target word /ʈʊnginakai / in 3.0 - 3.6 years age group children are shown in Table 3.4.

Table 3.4:

Shows an example of target word /t̠ɛnginakai/ and its different utterance patterns in 3.0 - 3.6 years old children (Numbers in the bracket indicate the number of subjects producing that particular pattern)

Target word	1	2	3	4	5
/ΐὺnginakai/	/ΐὺnginaΐai/ (2)	/ΐὺn˧ikai/ (1)	/ΐὺn˧inaΐai/ (1)	/ΐὺn˧iakai/ (1)	/ΐὺnakai/ (1)

Thus the various patterns obtained for each target word in the three age groups were listed. The list for software making consisted of 7 words in 2.0 - 2.6 years, 15 in 2.6 - 3.0 years and 30 in 3.0-3.6 years along with their four to five most commonly occurring patterns.

4. Collaboration with software professionals: The prepared material was provided to a software professional in Thiruvananthapuram (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 (HI) and 10 children with mental retardation (MR) each in 2.6-2.6 years, 2.6-3.6 years and 3.0-3.6 yearŝs age range for the sensitivity evaluation of the tool developed. Hence sensitivity evaluation involved a total number of 60 children with communication impairment as shown in Table 3.5.

Table 3.5:

Shows the number of participants included for sensitivity evaluation

Age groups	Children with communication disorders		Total
	Children with HI	Children with MR	
2.0-2.6 years	10	10	20
2.6-3.0 years	10	10	20
3.0-3.6 years	10	10	20
Total	30	30	60

Selection of participants: The children with HI and MR who were attending speech and language therapy at the Department of clinical services and Department of special education at the Institute were considered for the study. They were initially administered Computerized Linguistic Protocol for Screening (CLiPS) (Anitha & Prema, 2004) and Three Dimensional Language Acquisition Test (3D-LAT) Adapted version (Prema, Geetha & Mamtha, 2004) to assess their language age. The children whose language age was between 2.0- 2.6, 2.6- 3.0 and 3.0- 3.6 years were shortlisted. 10 children with HI and MR from each of the age ranges were selected for sensitivity evaluation of the developed tool CAPP-K. Hence the tool was administered on a total of 60 children with communication disorders (30 children with HI and 30 children with MR) for sensitivity evaluation.

Administration of CAPP-K: CAPP-K was administered on all 60 participants and the results were saved in the computer system. The productions of each child with HI or MR were matched with the pattern of productions provided in the software tool. 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 three age groups. Further a mean percentage of correlation was obtained for each group separately.

CHAPTER IV

RESULTS AND DISCUSSION

The aim of the study was to develop indigenous software to identify the phonological processes in 2.0-3.6 year old native Kannada speaking children. The study was carried out in 3 phases. Phase I was intended to identify the phonological processes in children in the age range of 2.0 - 3.6 years. Phase II involved making of the software CAPP-K with the data obtained. In phase III, sensitivity of the developed tool was evaluated in children with Hearing Impairment (HI) and Mental Retardation (MR).

Results of Phase I

KDPAT test tool was administered to 180 participants in three different age groups. As per KDPAT, 59 test words were administered in 2.0-2.6 year old children and 67 test words each were administered on 2.6-3.0 year old and 3.0-3.6 year old children. 35 phonological processes were identified by sound by sound analysis of target words in the three age groups.

The number of children exhibiting the phonological processes in the age groups 2.0-2.6, 2.6-3.0, and 3.0-3.6 years were established. The distribution of syllable structure, substitution and assimilation phonological processes in males and females are depicted for age 2.0-2.6 years in Table 4.1 (a), (b) and (c), for age 2.6-3.0 years in Table 4.2 (a), (b) and (c) and age 3.0-3.6 years in Table 4.3 (a), (b) and (c).

Table: 4.1 (a)

Distribution of syllable structure processes in male (M) and female (F) children in the age range of 2.0 – 2.6 years

SUB No.	IVD		ICD		MCD		ISD		MSD		FSD		Epn		Red		Met		CSim		CD		GCR		CSub		CR	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1			3	4	2	2	5		4	1		1			1				1				3	1			3	4
2	1		3	2	4		1		5	5									1	1	1			4			2	3
3			2	2		3	2	3	5	3	2					1			1	1			1	3			3	3
4	1		6	2	5	2	7	3	2	4	3										1		1	5			3	3
5	2		2	7	7	1	11	3	6	1	2	1		1									1	3			2	4
6			2	7	1	2	2	2	3	2	1	2					1		1	3			3	3			3	1
7			1	19	2	4	2	4	4	4		3							1					5			2	3
8	1		5	21	6	3	9	3	6	3	1	1	1								1		7	3			2	3
9			4	2		1	1		1	5		1							1				3	5			2	4
10			3		3	2	3	3	8	1	1				1				1	1			4	2			3	2
11			5	2	2	3	2	3	5	4	2		1					1		1			2	2			2	1
12			2		1	1	3		3	1	3		1						1					2			4	1
13			1			1	4	2	3	1	2	3	1														2	2
14	1	1	3	1	2	2	5	1	3	2	2		1	1					1			1	1	2	1		4	3
15			3	2	1			2	2	3			1				1			1			2	2			2	2
16			3	6	1	3	3	3	6	4	2								1				4				3	4
17			2	3	7	2	2	3		5			1				1		1	1			2	3			3	2
18			1		2		3	3	1	1	1	1							1				4				3	3
19			1		3	1	2		2		1		1				1						1	1		1	3	2
20				2	4		1	3	4	4			1										1				3	2
21				3	1		4	4	3	2	1	1	1	1						1			1				4	3
22			1		1	2	4	4	2	1	1	1	1	1						1			4				4	3
23		1		1		1		5		4		3								1			3				3	3
24			1		1	1	2		2	2		1															4	2
25				1	2	1	3	3	3	2	2	2	1							1			1	5			4	3
26	1		1	2	1		1	4	3	3		3		1						3			3	2			4	1
27				1	2	1	1		2	1	1	1							1				3	1			3	3
28			1	1	2		2	2	6	2	3		1	1									5	3			3	2
29			1	1	2	1		2	3	5	1	3	1										3	5			4	4
30		1		1		2	1	3	3	3								1									4	4

Syllable structure processes	Abb.
Initial vowel deletion	IVD
Initial consonant deletion	ICD
Medial consonant deletion	MCD
Initial syllable deletion	ISD
Medial syllable deletion	MSD
Final syllable deletion	FSD
Epenthesis	Epn
Reduplication	Red
Metathesis	Met
Cluster simplification	Csim
Cluster deletion	CD
Geminate cluster reduction	GCR
Cluster substitution	CSub
Cluster reduction	CR

Table: 4.1 (b)

Distribution of substitution processes in male (M) and female (F) children in the age range of 2.0 – 2.6 years

SUB No.	Stp		NF		DF		PF		RF		VF		Bak		Aff		Pal		Dpal		Gld		Vlz		Dnas		Lat		Dlat		Mon		Lab	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1	2	3					1	7	4	6	4	1	1		2		1			1	4	4	7	7	2			1			4	1		
2	1	2					6	5	4	5	1				1	1			1	1	2	2	12	6	1			2			4	3		
3	1	2	1				4	4	5	7		1		1				3			2	2	12	2							4	2		
4	2	1		1			4	4	3	4		1	1								3	3	19	7	1		1				4	3		
5	3			2			1	6	2	3	2	1						1			2	2	18	10		1					4	3		
6	1	2					6	5	9	3		1	1	1		1			1				2	16	5		1			1	2	4		
7	3	1		2			3	2	5	3	17	6		1	1						2	2	5	13				3			2	1		
8	1	2		1			3	2	4	6	3	10			2	2	1				1	1	19	14	1	1		1			4	1		
9	2	2					5	5	5	8	2	13		1						1	4	4	13	2		3					1	4		
10		2					7	4	4	3	3	4				1	2		1	1	1	1	14	9	3	2					4	2		
11	2						3	4	3	7	1	4		1		1			1		1	1	14	8		3					3	2		
12							5	2	8	1	2	1						1	1				7	2	1						3	2		1
13	2						4	6	4	8	2	1							1		1	1	14	6							3	2		
14	2	2					5	6	5	7					1				1	1	1	1	15	6							3	3		
15							4	5	9	9		2			1		1	1		1	1	1	6	7							4	3		
16	4						4	5	3	7	1				1				1	1	4	4	15	8							4	4		
17	3	2					5	2	7	4	3	13			1	5	1		1		1	1	9			3	1				4	3		
18	1						6	6	2	5	1	2			1					1			18	14		1					4	2		
19	2						5	5	6	4	2	1						1					10	7							2	2		
20	2						3	6	5	9	1	1									2	2	4	6		1	1					3		
21	1						5	6	3	5	1	2					1		1		3	3	13	3	1	1		1			3	3		
22		3					5	5	5	6	3					1	1		1		6	6	7	8		1	1				4	3		
23	1	5				1	8	8	6	10	1	2									7	7	4	8		2			2			4		
24	2						6	1	13	2					1			1	1				2	4	3		1				3			
25	1	1					5	6	7	10	1	13			1		1			1	1	1	11	3	1	3	1				3	4		
26	2	3					4	7	5	3											1	1	11	12							4	2	1	1
27	3						8	6	7	7	13				1					1	3	3	6	8				1			3	2		
28	3	1					7	6	3	10		3			2			1	1		1	1	16	1							4	2		
29	1						5	5	4	8	1	1	1						1	1	1	1	8	5							3	3		
30	2	2					3	5	6	6		4				2		1			1	1	7	8	1	2		1			2	3		

Substitution processes	Abb.
Stopping	Stp
Nasal fronting	NF
Dental fronting	DF
Retroflex fronting	PF
Palatal fronting	RF
Velar fronting	VF
Backing	Bak
Affrication	Aff
Palatalisation	Pal
Depalatalisation	Dpal
Gliding	Gld
Vowelisation	Vlz
Denasalisation	Dnas
Lateralization	Lat
Delateralization	Dlat
Monophthongization	Mon
Labialisation	Lab

Table: 4.1 (c)

Distribution of assimilation processes in male (M) and female (F) children in the age range of 2.0 – 2.6 years

SUB No.	PAss		RAss		PreVD		PostVD	
	M	F	M	F	M	F	M	F
1	3	1	4	1			2	1
2	1	2	1		1	1	4	1
3		1	4		1	1	4	4
4	5	1	1	2			2	3
5	2		1	3	1	3	2	4
6	2		1	1			1	1
7	4	1	1				1	2
8	2	1	1	1	1		2	2
9		1	1	2			3	
10	2	1	2	1			2	4
11	2	5		4		1	3	2
12			1	1	1		1	
13	2		1	1		1	1	2
14		1	2	1	3	1	5	4
15			1	1	1	1	2	3
16	1	1	1		1	1	4	5
17	2	4	2	1			2	1
18			1	1				
19	1		1	1				2
20	2		1	1		2		6
21		1	2	2		2	3	3
22		1	3	2	1	1	1	2
23			1	2	1		1	6
24			1	1			3	2
25	1	1		2			1	
26			1	5		2	4	3
27			3	1			1	1
28			1	4	2	1	2	5
29			1	2			3	2
30		3		2	1		6	3

Assimilation processes	Abb.
Progressive assimilation	PAss
Regressive assimilation	RAss
Prevocalic Devoicing	PreVD
Postvocalic Devoicing	PostVD

Table: 4.2 (a)

Distribution of syllable structure processes in male (M) and female (F) children in the age range of 2.6-3.0 years

SUB No.	IVD		ICD		MCD		ISD		MSD		FSD		Epn		Red		Met		CSim		CD		GCR		CSub		CR	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1			5		2		1												1				1				3	
2			2		1																		5				1	
3					1				1														2				2	
4	1				3																		1		1		3	
5			1		1																		1				1	
6			2				1		1				1										3				3	
7			2		1		3		2												1		2				2	
8			2		2		2		3				1										3				4	
9			5		2		3										1						6				4	
10			3		1						1								1				2				2	
11					1				2														1				1	
12					1		2		1		1												1				1	
13			2		2				1		1												1		1			
14			1																								3	
15					2		2																1				2	
16			3		2		2		4														1				4	
17			1				1		1		1				1								2				3	
18			1		1		1				1												3				3	
19			1				2																3				2	
20			4		1		1						1						1						1		1	
21			5				1		1										1								2	
22			2		2				2																2		2	
23	1		2		2		1												1								2	
24			1		2		4		4												1		2				3	
25			1		2		1														1						3	
26			4		2		2		4										2				1				2	
27	1		1		1		2		4														1				2	
28			3		1		2		2														3				3	
29			1				1																				2	
30	1		1																								2	

Syllable structure processes	Abb.
Initial vowel deletion	IVD
Initial consonant deletion	ICD
Medial consonant deletion	MCI
Initial syllable deletion	ISD
Medial syllable deletion	MSI
Final syllable deletion	FSD
Epenthesis	Epn
Reduplication	Red
Metathesis	Met
Cluster simplification	Csin
Cluster deletion	CD
Geminate cluster reduction	GCF
Cluster substitution	CSul
Cluster reduction	CR

Table: 4.2 (b)

Distribution of substitution processes in male (M) and female (F) children in the age range of 2.6-3.0 years

SUB	Stp		NF		DF		PF		RF		VF		Bak		Aff		Pal		Dpal		Gld		Vlz		Dnas		Lat		Dlat		Mon		Lab	
No.	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1	2						1	6	9	14	1										1	4	5	5	1						4	1	1	
2		2						3	4	8						1						1	3	7							1	2		
3							7	5	8	8	1	1					2					3	6	4							1	2		
4						1	2	6	6	10	1					1					4	1	7	3			1				1			
5		1					2	3	12	9		2									1	1	3	2			1					2		
6							2	4	8	11			1									1	1	2	1						2		2	
7							4	4	6	10											8	1	12	1							1	3		1
8	1						5	5	11	12	1					1	1	1			1		3	3			1				2	1	1	
9							5	5	5	8											2	2	11				1				2			1
10	2	3					3	6	5	10		2			1	3			1				4	5			1				2	4		
11							1	2	3	3													2											
12				1			2	5	5	5		1								1		3	8	5					1		3	1		1
13		1					6	1	5	5											2	1	10	2										
14							3	6	3	10							1	1					2	3										
15	1	1						4	4	12		1			1								1	6								2		
16	1						4	3	8	12						2	1	3	1		2		5	1							3	2	1	1
17	1	1					4	2	8	3	1				1						1		4	1							1			
18							2	4	2	6													6	2			1						2	
19							3		4	4	1							1				1	3	2		1			1		1			
20							5	1	12	8											2	1	7	5								1		
21	1						3	3	8	10					2						2	1	4	7				1			1	1		
22		2					4	6	9	9		2				1	1						8	2							1		1	
23	1	2					2	7	7	10	1	1			3							4	4	5						1	2		3	
24	1	2					2	2	7	8	2	1			1	1					1		7	6	3						1	1		1
25							6	4	11	9											1		4	2			1				2			
26		1					4	2	7	5	3				1		1				3	1	10	8							3	2		
27		1					5	4	6	7	1					2	1						4								1			
28							2	4	5	2		2					1				1	1	11	3			1				3	3	1	
29		1						6	8	13	1	1						1				1	1	3							1	2		
30							2	3	9	10	1					1		1					1	3	1						1			

Substitution processes	Al.
Stopping	St
Nasal fronting	NF
Dental fronting	DF
Retroflex fronting	PF
Palatal fronting	RF
Velar fronting	VF
Backing	Ba
Affrication	Af
Palatalisation	Pa
Depalatalisation	Dp
Gliding	Gl
Vowelisation	Vl
Denasalisation	Dn
Lateralization	La
Delateralization	Dl
Monophthongization	Mo
Labialisation	La

Table: 4.2 (c)

Distribution of assimilation processes in male (M) and female (F) children in the age range of 2.6-3.0 years

SUB No.	PAss		RAss		PreVD		PostVD	
	M	F	M	F	M	F	M	F
1			1	2				2
2				1	1	1	3	
3			1	3	1	1	2	
4	1		1	1	1		1	2
5		2		1	4	2	1	3
6			2	2	3		3	1
7			4	3	1	3	3	5
8				3	1		2	3
9			1	1				
10				3		4	1	2
11			1	1		1	2	
12			1	2	4	1	3	4
13						1	6	4
14				1			1	2
15		1	1	1	3	2	4	1
16	1		2		3	4	4	
17			1		1	1	1	5
18		1						
19					2	1	2	1
20	1		2	1	1	1	3	
21				1		1		1
22		1		2	3	1	3	5
23			1	2	3	1	1	2
24			1	3	3	1	3	
25			3	4	2	1	5	2
26	1	1	1		4	2	3	
27			1		2	1	7	2
28		1	2	1	2	3	4	5
29	1			2	2	2	1	2
30					1	3	2	1

Assimilation processes	Abb.
Progressive assimilation	PAss
Regressive assimilation	RAss
Prevocalic Devoicing	PreVD
Postvocalic Devoicing	PostVD

Table: 4.3 (a)

Distribution of syllable structure processes in male (M) and female (F) children in the age range of 3.0-3.6 years

SUB No.	IVD		ICD		MCD		ISD		MSD		FSD		Epn		Red		Met		CSim		CD		GCR		CSub		CR	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1								1																	1		1	3
2				1																								
3																												
4				1	1	1	1	1																			3	4
5			1		1	1	1																					2
6				1	1																						1	1
7																		1					1					2
8			1	1	1	1				1									1								2	2
9					1	1																						
10							1																				2	1
11																											3	3
12										1																	2	
13			1	1	1			1																			2	
14			1		1	1																						1
15																												2
16					1	1	1				1			1			1		1								3	1
17				1		1		2																			1	2
18																												1
19					1	1	2	1	1				1	1			1		1				1				2	
20					1	2		1		1																	1	3
21						1		1												1								2
22						1		1																				3
23											1		1														3	
24				1			2																		1		2	2
25					1	1	2	1																			2	4
26						1																					2	
27					1		1	1																			1	3
28						1	1	1																			1	2
29			1		1		1		1					1					1								3	2
30							1		1																		1	2

Syllable structure processes	Al
Initial vowel deletion	IV
Initial consonant deletion	IC
Medial consonant deletion	M
Initial syllable deletion	IS
Medial syllable deletion	M
Final syllable deletion	FS
Epenthesis	E
Reduplication	R
Metathesis	M
Cluster simplification	C
Cluster deletion	C
Geminate cluster reduction	G
Cluster substitution	CS
Cluster reduction	CI

Table: 4.3 (b)

Distribution of substitution processes in male (M) and female (F) children in the age range of 3.0-3.6 years

SUB	Stp		NF		DF		PF		RF		VF		Bak		Aff		Pal		Dpal		Gld		Vlz		Dnas		Lat		Dlat		Mon		Lab	
No.	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1							1	5	10	9	1	1												1								1		
2								1	1	2														2										
3							1		3	6													2											
4							1		1	7	1												8	1				1			1	2	1	
5								2	3	2														1										
6	1								3	4	1											1		3				1						
7	1						1	1	1	2							1						2											
8							1	1	6	4		1									1		3	1										1
9							3	1	3	1													3						1					1
10								1	6	1													2	1										
11							3	2	5	8											1		2											
12									3	7		1											2	1							1			
13							1		6	4														1										
14							1		9	4											3		3											1
15								2	1	6																								
16		1					1		6	4	1	1											4		1		1							1
17							1	5	6	12					3							1										1		
18								1	1	3											1	1										1		1
19	2	1					3		8	3													1	1							1	1		
20							1	2	5	7	1												2	2										
21		2					2	4	3	9														2										
22								1	2	10														2										
23									10			7									2		3	1			2		1					
24							1	1	6	2												1	1	1		1					1			
25							1	1	8	4	1												3	2			1							
26								1	12	1													1	1										
27		2						1	6	6		1											6	1										
28							3	3	2	2													1	1							1			
29	3						2		10	9		1							1		1		3								1			
30									5	1											2		1	2										

Substitution processes	A .
Stopping	S
Nasal fronting	N
Dental fronting	D
Retroflex fronting	P
Palatal fronting	R
Velar fronting	V
Backing	B
Affrication	A
Palatalisation	P
Depalatalisation	D
Gliding	G
Vowelisation	V
Denasalisation	D
Lateralization	L
Delateralization	D
Monophthongization	M
Labialisation	L

Table: 4.3 (c)

Distribution of assimilation processes in male (M) and female (F) children in the age range of 3.0-3.6 years

SUB No.	PAss		RAss		PreVD		PostVD	
	M	F	M	F	M	F	M	F
1				3	3			
2			1	1				
3						2		
4		1			5		1	
5								
6					3	1	3	1
7								1
8				1		1		3
9	2		1	2				
10								
11			1		2	4	1	2
12					1	1		
13								
14		1		1		1		
15				2				
16			2		1	2	5	
17		1	1	3		2	1	1
18					2	1	2	
19			2		2		1	
20					1	1		
21					2			
22							2	
23	1				2	1	3	
24			1		1	3	1	1
25			2					1
26							1	1
27				1				
28					1	2	2	
29						1	1	
30			1		2			

Assimilation processes	Abb.
Progressive assimilation	PAss
Regressive assimilation	RAss
Prevocalic Devoicing	PreVD
Postvocalic Devoicing	PostVD

Tables 4.1 (a), (b) and (c), 4.2 (a), (b) and (c) and 4.3 (a), (b) and (c) show that distribution of 35 phonological processes were marked in younger age group 2.0-2.6 years, marginally reduced in 2.5-3.0 years and sparsely distributed in 3.0-3.6 year old children. It can be evidently seen in Tables 4.1 (a, b and c) that distribution of the processes in 2.0-2.6 years were high in 15 processes like initial consonant deletion, medial consonant deletion, initial syllable deletion, medial syllable deletion, final syllable deletion, geminate cluster reduction, cluster reduction, stopping, palatal fronting, retroflex fronting, velar fronting, gliding, vowelization, monophthongisation and assimilation processes. The remaining 20 processes were sparsely distributed in few children in this age group. In 2.5-3.0 years, out of the above mentioned processes, final syllable deletion, stopping, velar fronting and progressive assimilation were sparsely distributed compared to children in 2.0-2.6 year age group as seen in Tables 4.2 (a, b and c). Further the distribution of phonological processes in 3.0-3.6 years in Tables 4.3 (a, b and c) shows that most of the processes did not operate except for initial syllable deletion, cluster reduction, palatal fronting, retroflex fronting, prevocalic and post vocalic devoicing.

Thus Tables 4.1, 4.2 and 4.3 implies that as age progressed, the distribution of process reduced since children used simplification rules lesser. The distribution of final syllable deletion, stopping, velar fronting and progressive assimilation were less frequently used in 2.6-3.0 years compared to 2.0-2.6 years. The processes initial consonant deletion, medial consonant deletion, medial syllable deletion, geminate cluster reduction, palatal fronting, gliding, monophthongisation and regressive assimilation were minimally used by children of 3.0-3.6 years compared to 2.6-3.0 years, implying that these processes are in the course of suppression. It can also be noted that processes cluster substitution, cluster deletion, metathesis, nasal fronting, dental fronting, backing and delateralisation showed negligible occurrence in all the children, suggesting that these processes are not operational in native Kannada speaking children. The number and percentage of children using a particular phonological process was calculated from the distribution of phonological processes in boys and girls as shown in Table 4.4, 4.5 and 4.6.

Table: 4.4

Number and percentage of children exhibiting different phonological processes in the age range of 2.0-2.6 years in both males and females

Sl.no	Phonological processes	No. of children exhibiting the process		Percentage of children exhibiting the process	
		Boys	Girls	Boys	Girls
1	Initial Vowel Deletion	6	3	20	10
2	Initial Consonant Deletion	24	24	80	80
3	Medial Consonant Deletion	25	23	83	77
4	Initial Syllable Deletion	27	23	90	77
5	Medial Syllable Deletion	28	29	93	97
6	Final Syllable Deletion	19	16	63	53
7	Epenthesis	14	6	47	20
8	Reduplication	2	1	7	3
9	Metathesis	4	2	13	7
10	Cluster Simplification	13	12	43	40
11	Cluster Deletion	3	1	10	3
12	Geminate Cluster Reduction	24	21	80	70
13	Cluster Substitution	1	1	3	3
14	Cluster Reduction	30	30	100	100
15	Stopping	26	17	87	57
16	Nasal Fronting	1	4	3	13
17	Dental Fronting	1	1	3	3
18	Palatal Fronting	30	30	100	100
19	Retroflex Fronting	30	30	100	100
20	Velar Fronting	21	23	70	77
21	Backing	4	5	13	17
22	Affrication	13	8	43	27
23	Palatalisation	7	7	23	23
24	Depalatalisation	14	11	47	37
25	Gliding	26	25	87	83
26	Vowelisation/ Neutralisation	30	30	100	100
27	Denasalisation	11	13	37	43
28	Lateralization	7	7	23	23
29	Delateralisation	1	1	3	3
30	Monophthongisation	28	29	93	97
31	Labialization	1	1	3	3
32	Progressive Assimilation	27	26	90	87
33	Regressive Assimilation	15	15	50	50
34	Prevocalic Devoicing	12	13	40	43
35	Postvocalic Devoicing	27	26	90	87

Table: 4.5

Number and percentage of children exhibiting different phonological processes in the age range of 2.6-3.0 years in both males and females

Sl.no	Phonological processes	No. of children exhibiting the process		Percentage of children exhibiting the process	
		Boys	Girls	Boys	Girls
1	Initial Vowel Deletion	4	1	13	3
2	Initial Consonant Deletion	25	22	83	73
3	Medial Consonant Deletion	23	20	77	67
4	Initial Syllable Deletion	20	17	67	57
5	Medial Syllable Deletion	15	10	50	33
6	Final Syllable Deletion	5	6	17	20
7	Epenthesis	3	1	10	3
8	Reduplication	1	0	3	0
9	Metathesis	1	1	3	3
10	Cluster Simplification	6	4	20	13
11	Cluster Deletion	3	0	10	0
12	Geminate Cluster Reduction	22	13	73	43
13	Cluster Substitution	4	1	13	3
14	Cluster Reduction	29	26	97	87
15	Stopping	9	12	30	40
16	Nasal Fronting	0	1	0	3
17	Dental Fronting	0	1	0	3
18	Palatal Fronting	27	29	90	97
19	Retroflex Fronting	30	30	100	100
20	Velar Fronting	12	10	40	33
21	Backing	1	0	3	0
22	Affrication	7	9	23	30
23	Palatalisation	8	6	27	20
24	Depalatalisation	2	1	7	3
25	Gliding	15	17	50	57
26	Vowelisation/ Neutralisation	30	28	100	93
27	Denasalisation	3	1	10	3
28	Lateralization	8	1	27	3
29	Delateralisation	2	1	7	3
30	Monophthongisation	23	16	77	53
31	Labialization	8	5	27	17
32	Progressive Assimilation	18	22	60	73
33	Regressive Assimilation	5	6	17	20
34	Prevocalic Devoicing	22	23	73	77
35	Postvocalic Devoicing	26	21	87	70

Table: 4.6

Number and percentage of children exhibiting different phonological processes in the age range of 3.0-3.6 years in both males and females

Sl.no	Phonological processes	No. of children exhibiting the process		Percentage of children exhibiting the process	
		Boys	Girls	Boys	Girls
1	Initial Consonant Deletion	5	7	17	23
2	Medial Consonant Deletion	13	14	43	47
3	Initial Syllable Deletion	11	11	37	37
4	Medial Syllable Deletion	3	3	10	10
5	Final Syllable Deletion	2	0	7	0
6	Epenthesis	2	3	7	10
7	Metathesis	2	1	7	3
8	Cluster Simplification	4	1	13	3
9	Geminate Cluster Reduction	2	0	7	0
10	Cluster Substitution	2	0	7	0
11	Cluster Reduction	20	21	67	70
12	Stopping	4	4	13	13
13	Palatal Fronting	18	19	60	63
14	Retroflex Fronting	30	29	100	97
15	Velar Fronting	6	7	20	23
16	Affrication	1	0	3	0
17	Palatalisation	1	0	3	0
18	Depalatalisation	1	0	3	0
19	Gliding	7	4	23	13
20	Vowelisation/ Neutralisation	20	20	67	67
21	Denasalisation	1	1	3	3
22	Lateralization	3	2	10	7
23	Delateralisation	2	0	7	0
24	Monophthongisation	6	5	20	17
25	Labialization	1	5	3	17
26	Progressive Assimilation	9	8	30	27
27	Regressive Assimilation	2	3	7	10
28	Prevocalic Devoicing	14	14	47	47
29	Postvocalic Devoicing	13	8	43	27

Table 4.4, 4.5 and 4.6 indicates that percentage of occurrence of processes varied across ages. In general all the processes were found to reduce as age increased, except for prevocalic devoicing, labialization which peaked at 2.6-3.0 years. Labialization occurred markedly in 2.6-3.0 year old children indicating the acquisition of labial sounds like /m/, /p/ and /b/ in this age group (Deepa & Savithri, 2010). It is presumed that children having acquired labial sounds tend to frequently labialize as part of learning and exploration; as in /onbu/ for /ondu/. The finding also indicated that children devoiced consonant preceding a vowel markedly in 2.6-3.0 years which were reduced in 2.0-2.6 years and 3.0-3.6 years. This is a strategy for easier articulation learnt only by 2.6-3.0 years and overcame prevocalic devoicing by 3.0-3.6 years supported by Toblin (2009) in English and Rahul (2006) in Hindi.

The processes that occurred 100% of 2.0-2.6 year old children were cluster reduction, palatal fronting, retroflex fronting, and vowelisation shown in Table 4.4. The finding implies that none of the children in this age group had acquired palatals /t≱, /d≱, /Ú and /z/, retroflexes /r/, /l≱, and /Æ and clusters /st/, /kÚ, /sp/, and /tr/. The palatals and retroflexes were substituted for simpler and earlier acquired sounds like dentals, labiodentals or labials. Deepa and Savithri (2010) suggested that dentals, labiodentals and labials were mastered by 90% of 2.0 to 2.6 year old children and the difficult sounds were mastered only by 3.6-4.0 years for palatals, after 4 years for retroflexes and clusters. Clusters were more often simplified with one consonant of the cluster in target word; for example children produced /devasa:na/ for /de:vasta:na/. Thus younger children substituted labials, dentals and labiodentals for difficult sounds. Hence retroflex fronting continued to operate on 100% of the children in 2.6-3.0 years. In 3.0-3.6 years, males demonstrated 100% occurrence of retroflex fronting compared to females indicating emergence of retroflexes in female subjects. Deepa and Savithri (2010) found that 90% of the girls mastered retroflexes by 4.0-4.6 years compared to 5 years in boys. Thus the findings suggest that acquisition retroflexes began in girls by 3.0-3.6 years.

35 processes were present in atleast 1% in younger age group indicating that 2.0-2.6 year old children simplified adult utterances most of the time. In 2.6-3.0 years, reduplication, backing, nasal fronting and dental fronting was seen in negligible percentages. Reduplication which is common in the first 50 word stage (Ingram, 1989) was not used in 2.6-3.0 years age children. Lowe (2000) reported that backing is suppressed by 3 years of age as seen in the present finding. Insignificant use of dental and nasal fronting implies that these children mastered the use of dental /t/ and /d/ and nasal sounds /m/ and /n/ appropriately by 2.6-3.0 years (Deepa & Savithri, 2010). By 3.0-3.6 years, initial vowel deletion and cluster deletion was not used indicating that children mastered vowels by 3 years (Deepa & Savithri, 2010) and they began to acquire cluster by either substituting it with simpler non clusters or reduced a consonant of the target cluster. Phonological processes identified in children from 2.0 to 3.6 years are graphically depicted in Fig 4.1 - 4.8. The results describe the trend of processes from 2.0 to 3.6 years.

1. Initial vowel deletion (IVD)

*Example of **IVD**:* /næ/ for /a:næ/

Fig 4.1. shows the percentage of children using ***IVD*** with age. It can be evidently noted that only 15% of the 2.0-2.6 year old children used it, which further reduced to 8% in 2.6-3.0 years and finally none of the children of 3.0-3.6 years used ***IVD***. The results indicate that ***IVD*** is a less frequently occurring process in 2.0 to 3.0 years, disappearing by 3.0-3.6 years. The present finding shows that ***IVD*** was minimally used by children above 3 years, indicating early vowel acquisition. Deepa and Savithri (2010) found that all vowels were mastered by 90% of the 2.6-3.0 year old typical Kannada speaking children resulting in insignificant percent of 2.0-3.0 year old children deleting vowels in the initial position; and children beyond 3 years of age no longer used this simplification process.

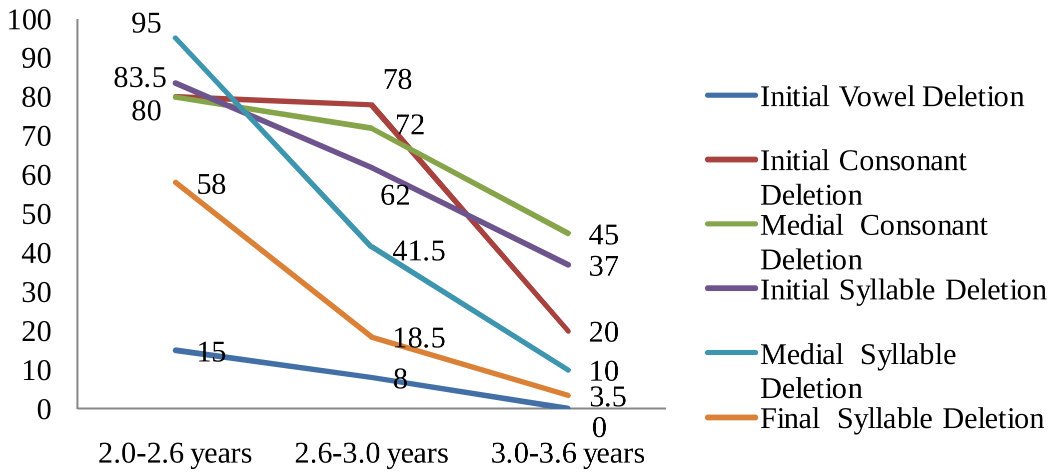


Fig 4.1. Percentage of children using the processes IVD, ICD, MCD, ISD, MSD and FSD

2. Initial consonant deletion (ICD)

*Example of **ICD**:* /u:gu/ for / mu:gu/

The trend in Fig 4.1 indicates that the percentage of children using ***ICD*** were as high as 80% in 2.0-2.6 years and 78% and in 2.6-3.0 years. The percentage steeply reduced to 20% in 3.0-3.6 years. The findings revealed that children below 3.0 years of age deleted initial consonants more frequently compared to older age groups. The study is in consonance with Rahul (2006) that ***ICD*** was a frequently occurring process in 2.0-2.6 years Hindi speaking children. However Ranjan (2009) reported on English speaking Indian children that ***ICD*** was least frequently occurring process in 3.0 -5.0 years of age. Thus the present result indicates that children beyond 3 years of age mastered different consonants compared to 2.0-3.0 years old children, hence the use of ***ICD*** drastically reduced. According to Deepa and Savithri (2010), most of the consonants except /r/, /h/, /ɭ/, /ʃ/ and /s/ were mastered by 90% of children during 3.0-3.6 years, which supports the present finding.

3. Medial consonant deletion(MCD)

*Example of **MCD**:* /kuuræ/ for /kuduræ/

Fig 4.1 depicts that the percentage of children using ***MCD*** was used by 80% of the 2.0-2.6 years and 72% of 2.6-3.0 years, but markedly reduced to 45% in 3.0-3.6 years. Thus the present study indicated that ***MCD*** was a frequently occurring process in 2.0 to 3.0 years, while had reduced usage in 3.0-3.6 years. The study parallels findings of Sunil (1998) and Sameer (1998) suggesting ***MCD*** as a less occurring process in 3 to 4 years old Kannada and Malayalam speaking children respectively.

Both ***ICD*** and ***MCD*** were found to be operational processes in children below 3 years of age which implies that they did not master consonants in initial and medial position in a word until 3 years of age. According to Deepa and Savithri (2010), most of the consonants except /r/, /h/, /Ǹ, /Ǘ and /s/ were mastered by 90% of children in 3.0-3.6 years, which supports the finding that 3.0-3.6 years of children rarely used *ICD* and ***MCD***.

4. Initial syllable deletion (ISD)

*Example of **ISD**:* /næ/ for /manæ/

Fig 4.1 indicates that ***ISD*** is highly prevalent in 2.0-2.6 years with 84% of the children using the process, and 62% at 2.6-3.0 years, while a marked reduction to 37% was noted at 3.0-3.6 years. Thus the findings revealed that ***ISD*** was highly prevalent in 2.0-2.6 years and continued to reduce as age increased but was not suppressed by 3.0-3.6 years.

5. Medial syllable deletion (MSD)

*Example of **MSD**:* /kiki / for /kitaki/

Fig 4.1 shows that the percentage of children using the process was 95% in 2.0-2.6 years which reduced to 42% in 2.6-3.0 years and to 10% in 3.0-3.6 years. The findings revealed that ***MSD*** was a most frequently occurring process in 2.0-2.6 years which markedly reduced during the later years.

6. Final syllable deletion (FSD)

Example of ***FSD****:* /ka:/ for /ka:ru/

Fig 4.1 shows that the percentage of children using the process was 58% in 2.0-2.6 years, which steeply reduced to 19% in 2.6-3.0 years and further dropped to a mere 4% in 3.0-3.6 years.

Of all the syllable deletions, medial syllable deletion was markedly present in 2.0-2.6 years. Initial and final syllable deletions had probability of occurrence mostly in disyllabic words (for e.g., ***ISD-*** /dɨ/ for /go: dɨ/., ***FSD-*** /mu:/ for /mu:gu/), while medial syllable deletion could occur only in more than 3 syllabic words (for e.g., ***MSD-*** /kiki / for /kitaki/). Thus complexity of syllable length could be a factor for predominant presence of ***MSD***.

7. Epenthesis (Epn)

Example of ***Epn****:* /a:sapate/ for / a:spatre/

Fig 4.2 shows that the percentage of occurrence of ***Epn*** was highest (34%) in 2.0-2.6 years, decreased to 7% in 2.6-3.0 years and 9% in 3.0-3.6 years. Thus the findings suggest that ***Epn*** is relatively active in 2.0-2.6 year old children, after which it declines but not suppressed even by 3.0-3.6 years. The finding is in agreement with Smit (1993) and Lowe (1996) suggesting that epenthesis continued to prevail at older age ranges, even in 7 years. ***Epn*** continued to operate in 3.0-3.6 years because it was a strategy for simplified cluster production. Children thus used ***Epn*** till clusters are acquired. Kannada speaking children acquired clusters from 4 years of age (Deepa & Savithri, 2010), hence ***Epn*** in this study operated in 3.0-3.6 years also.

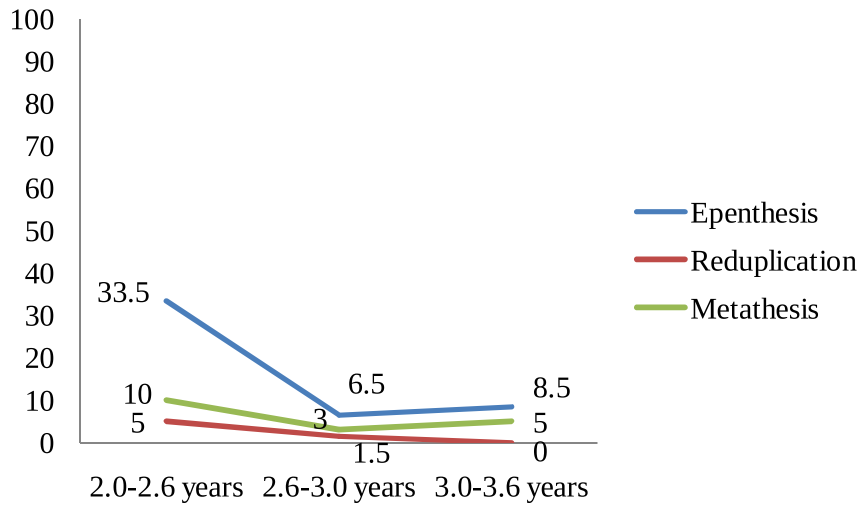


Fig 4.2. Percentage of children using the processes Epn, Red and Met

8. Reduplication (Red)

Example of ***Red****:* /dada/ for /dara/

Fig 4.2 depicts that the percentage of children using ***Red*** revealed the process was used only by 5% of the children in 2.0-2.6 years old, 1.5% in 2.6-3.0 years and none of the children in 3.0-3.6 years. Thus the findings implied that ***Red*** was rarely used process after 2 years in Kannada speaking children. According to Ingram (1989), this process persisted in presystematic or the first fifty word stage in child and disappears after this stage. The present study is in agreement with Ingramôs finding that ***Red*** was rarely seen after 2 years. According to Klein (1981), ***Red*** was an early strategy for syllable maintenance in multisyllablic words. Stoel- Gammon and Dunn (1985) in English and Sameer (1998) in Malayalam also suggested ***Red*** disappeared before 3 years of age. The finding is not in consonance with Santhosh (2001) suggesting the presence of this process in 3.0-4.0 year old Hindi speaking children.

Grunwell (1981) also reported the process existing in the childôs repertoire till 2.6 years. However Vasantaôs (1990) study suggests the process to be present in 4^{th} and 5^{th} graders contradicting the other reports.

9. Metathesis (Met)

*Example of **Met**:* /vinama / for / vimana /

Fig 4.2 depicts that the percentage of students using ***Met*** is 10% in 2.0-2.6 years which reduced to 3% in 2.6-3.0 years and 5% in 3.0-3.6 years. The finding indicates that ***Met*** was a rarely occurring process in children from 2.0 to 3.6 years. In English, James (2001) and Steol-Gammon and Dunn (1985) suggested the occurrence of this process as rare in childǒs phonology and was termed as idiosyncratic process. Hodson and Paden (1983) suggested the process to be occurring in 4 to 5 year old children and Jayashree (1999) suggested it is least occurring in this age group in Kannada. Thus the above studies support the present findings that 2.0-3.6 years old Kannada speaking children rarely altered/jumbled the syllables within a word.

10. Cluster simplification (CSim)

*Example of **Csim**:* / jaȘaga:na / for / jakǗága:na /

Fig 4.3 shows a trend in percentage of children using the process ***CSim*** where in children substituted completely another speech sound (e.g. /t⌂for /kǗin the example). Cluster was more simplified in younger age group of 2.0-2.6 years (42%), after which it reduced to 17% in 2.6-3.0 years and to 8% in 3.0-3.6 years. This indicates that children simplified clusters with other sounds in 2.0-2.6 years and however, these simplifications reduced drastically in 2.6-3.0 years indicating that children started acquiring clusters. Vani and Manjula (2006) reported that medial clusters appeared by 2 years but was predominant by 2.6-3.0 years. Watson and Scukanec (1997) indicating that cluster simplification was present in 2.9 years, that later reduced to 20% in 3 years of age.

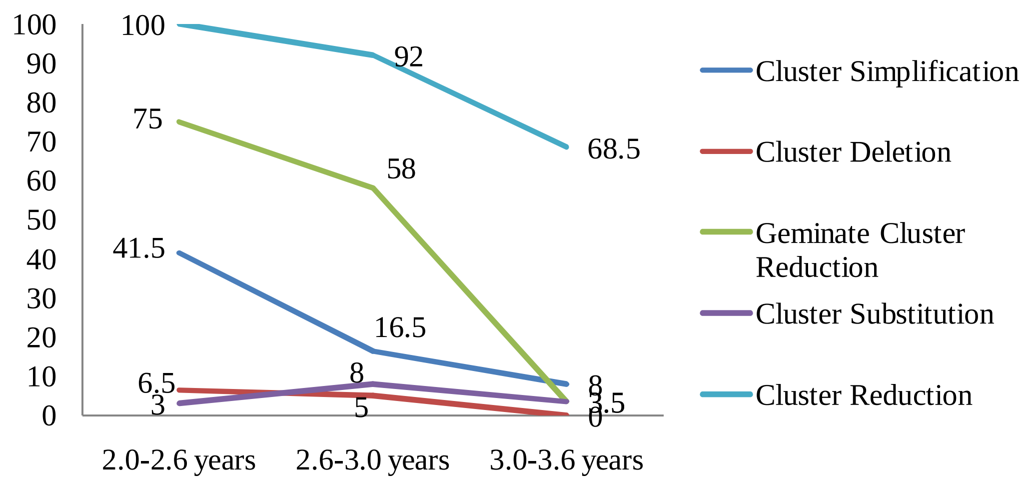


Fig 4.3: Percentage of children using the processes CSim, CD, GCR, CSub and CR

11. Cluster deletion (CD)

*Example of **CD**:* /janna/ for /jantɾa/

Fig 4.3 shows that ***CD*** was present infrequently in typically developing children. The process occurred in only 6.5% of the children in 2.0-2.6 years, 5% of 2.6-3.0 years and absent in 3.0-3.6 years children. Thus the finding indicated that children rarely used cluster deletion as a simplification strategy for cluster production, rather they used cluster simplification or cluster reductions.

12. Geminate cluster reduction (GCR)

*Example of **GCR**:* /uja:le/ for /ujja:le/

Fig 4.3 shows that the percentage of occurrence was 75% in 2.0-2.6 years, 58% in 2.6-3.0 years and dropped drastically to 3.5% in 3.0-3.6 years. Thus the findings indicate that ***GCR*** is highly persistent during 2.0 to 3.0 years of age and set off to suppress after that or rarely occurred in 3.0-3.6 years. Though various studies have shown that geminates are acquired as early as 1.0-1.6 years (Vani & Manjula, 2006) in child's repertoire, the present finding revealed its active operation till 3 years of age. This could be attributed to test words tested for geminates in the study. The geminate sounds in 2 syallabic words like /kappe/, /nalli/, /kabbu/, /kannu/, /katte/, /tǘtte/ etc are produced accurately compared to geminates in

3 or more syllabic words like /ujja:le/, /aivattu/, /irulli/ etc. Thus the finding showed reduction of geminates till 2.6-3.0 years and they were mastered in trisyllabic syllabic words by 2.6-3.0 years.

13. Cluster substitution (CSub)

*Example of **CSub**:* /jantla / for / jantra/

Fig 4.3 indicates that the percentage of children substituting a different cluster for target cluster (e.g. /tla/ for /tra/ in the example) was <10% in all the age groups. Cluster substitution was found in limited percentage implying that few children simplified clusters by substituting one of the consonants of the cluster with a glide.

14. Cluster reduction (CR)

*Example of **CR**:* /devasa:na/ for /devasta:na /

Fig 4.3 indicates that 100% children of 2.0-2.6 years used the process, which slightly reduced to 92% in 2.6-3.0 years and further to 68% in 3.0-3.6 years indicating that cluster reduction was highly frequent in 2 to 3.6 years. The study is supported by findings of Bharathy (2001) that suggested ***CR*** is widely prevalent in 3 to 4 years Tamil speaking children. Thus the results put forth that after 3 years children gradually advanced in the speech development in production of cluster. Deepa and Savithri (2010) found that cluster acquisition began afer 3.6 years in Kannada speaking children. Haelsing and Madison (1986), Smit et al (1990), Smit (1993), Lowe (1996) and Toblin (2009) suggested that cluster reductions persisited till older childhood.

The present study provides an insight into the development of clusters in native Kannada speaking children. Clusters are thus speculated to be acquired in the following steps

a) 2.0-2.6 years: Cluster simplification and cluster reduction

   Children of this age group were found to use clustersimplification ie; simplify clusters by substituting the clusters by a simple sound, for example they commonly substituted /t/

(/jataga:na/) for /kʃ/ in the target word /jakʃagana/ and they also commonly reduced a cluster to one of its cluster elements, for example, children produced one element /s/ for the cluster /st/ (/devasa:na/ for /devast a:na/).

b) 2.6-3.6 years: Cluster substitution, cluster simplification and cluster reduction.

Along with cluster simplifications and cluster reduction in the younger age group, children also substituted a different cluster for target cluster, for example., /jandra/ for /jantra/.

c) 3.0-3.6 years: Children of older age group was found to no longer use cluster substitutions and cluster simplification, but continued to reduce cluster by reducing the cluster element (cluster reduction). Various supporting studies (Haelsing & Madison, 1986; Smit et al, 1990; Smit, 1993; Lowe, 1996; Toblin, 2009, and Deepa & Savithri, 2010) have supported the fact of persistence of cluster reduction into later childhood.

Greenlee's (1974) stages differed from the present findings in that, each step followed in a successive manner i.e., in a target cluster CIC2V, stage 1: V followed by stage 2: C1V, followed by stage 3: C1C3V; and finally production of target CIC2V. However, in Kannada, present study indicates that 2-3 processes were present as a strategy to simplify a cluster at a stage i.e., C3V or C1V (2.0-2.6 years), followed by C3V or C1C4V or C2V (2.6-3.0 years), and followed by C2V. Cluster deletion was present in negligligable proportion in Kannada.

15. Stopping (Stp)

*Example of **Stp**:* /do:ʈe / for /do:se/

Fig 4.4 depicts that ***Stp*** was highly prevalent in 2.0-2.6 year age group with 72% of the children using the process. The process substantially reduced to an average of 35% in 2.6-3.0 years and finally to 13% in 3.0-3.6 years. The findings indicated that the process dropped markedly in 3.0-3.6 years of age. This indicates that children after 3 years started acquiring fricatives and affricates and no longer substituted them with stops. Studies have indicated that fricative /s/ (Usha, 1986 in Tamil & Padmaja, 1988 in Telugu) and affricate /tʃ/ (Maya, 1990 in Malayalam, Tasneem Banu, 1977, Prathima, 2009 & Deepa & Savithi, 2010 in Kannada) are acquired by 3.0-3.6 years, hence stopping is reduced in 3.0-3.6 years in the present study. The study is supported by findings of Martinez (1986) in Spanish, Sreedevi et al (2005) in Kannada, Merin and Sreedevi (2010) in Malayalam, suggesting that the process was commonly occurring in 2.0-3.0 year old children.

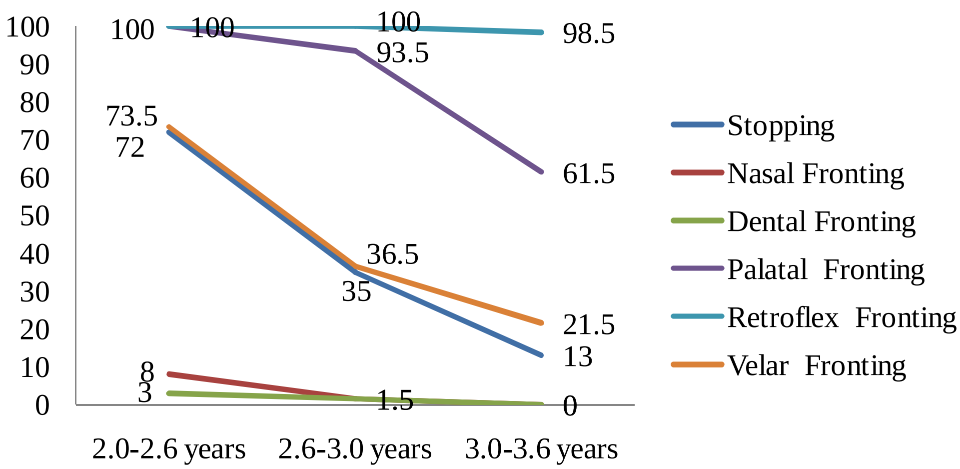


Fig 4.4. Percentage of children using the processes Stp, NF, DF, PF, RF and VF

16. Nasal fronting (NF)

*Example of **NF**:* /daji/ for / naji/

It was seen in Fig 4.4 that ***NF*** was used by 8% of 2.0-2.6 years, and 1.5% of 2.6-3.0 years. And the process was not present in 3.0-3.6 years.

17. Dental fronting (DF)

*Example of **DF**:* /aivappu/ for / aivaȘȘu/

Fig 4.4 shows that ***DF*** was rarely used by all the children. The process was suppressed by 3.0-3.6 years.

Both NF and DF occurred minimally before 3 years and were not present after 3 years. This finding is attributed to the reason that nasal (m, n, except Ẽ) and dental (t̪, d̪) speech sounds are acquired early as early as 2.0 years (Stoel-Gammon, 1985 in English;

Fudula & Reynolds, 2000) and 2.6 years (Padmaja, 1988 in Telugu, Sreedevi, 1976 in Kannada). Since all nasals except /Ẽ/ and dentals are mastered early, fronting of nasals and dentals are not operational after 2.6 year old Kannada speaking children

18. Palatal fronting (PF)

*Example of **PF**:* /lo:Şa/ for / lo:ta/, /audada/ for /auḍada/

It can be seen in Fig 4.4 that 100% of children in 2.0-2.6 years used ***PF***, used by 93.5% of the children in 2.6-3.0 years and reduced slightly to 61.5% in 3.0-3.6 years. The findings suggest that the process markedly occurred below 3 years and slightly reduced after that. This is because palatals /t/ and /d/ are mastered later in the developmental years, for e.g., only by 3.6-4.0 years (Deepa & Savithri, 2010). Hence until children acquired palatals, they used simpler and early acquired front sounds like labials, dentals or labiodentals for palatals. The study is in consonance with the findings of Grunwell (1987) indicating the presence of process from 2.6 to 3.6 years in English.

19. Retroflex fronting (RF)and /r/ fronting

*Example of **RF**:* /e:du/ for / e:lu/

Fig 4.4 evidently shows that 100% of children in 2.0-3.0 years used ***RF*** i.e substituted a dental or alveolar or labiodentals or labials for difficult to produce retroflexes /Ẽ/, /l/ and /r/ and continued to be used by 98.5% of the children in 3.0-3.6 years. The findings suggested that RF was highly operational in 2.0 to 3.6 years Kannada speaking children implying that retroflexes were not acquired below 3.6 years of age. This finding is supported from the study by Deepa and Sreedevi (2010) that indicated that retroflexes /n/ and /l/ are achieved only by 4.6 years and 4.5-5.0 years respectively.

It was interesting to note that /r/ is a frequently occurring phoneme in Kannada after /n/ with 5.43% of occurrence (Sreedevi & Vikas, 2013). This curiosity gave rise to study of patterns involved in /r/ acquisition form 2.0-3.6 years. The data revealed that /r/ sound was fronted as dentals most of the time for easy production.

The current finding indicated that /r/ was correctly produced by 6% of the time in 2.0-2.6 years, 23% in 2.6-3.0 years and 55% in 3.0-3.6 years. /r/ sound was either deleted or substituted for dental /d/ or alveolar /l/ or glide /j/ or retroflex /l/ or palatal /d/. /r/ simplifications in 2.0-2.6 years consisted of 54% deletions followed by 15% as dental /d/, 14% as alveolar /l/ and 6% as glide /j/, all fronting errors. In 2.6-30 years, 30% deletion occurred followed by 22% as dental /d/, 12% as alveolar /l/, 5% as glide /j/ and 4% as retroflex /l/, all fronting errors. The older group consisted of only 14% deletions followed by 11% as dental /d/ and as alveolar /l/, 4% as palatal /d/, 2% as glide /j/ and retroflex /l/ fronting. Thus mastery of /r/ involved higher deletion, fronting of /r/ as dental /d/, as alveolar /l/ and as glide /j/ in 2.0-2.6 years followed by fronting as palatal /d/ in 2.6-3.0 years and fronting as palatal /d/ and as retroflex /l/ in 3.0-3.6 years.

In Kannada, /r/ was reported to be acquired in later childhood by 4.6 years (Tasneem Banu, 1977) and 5 years of age (Deepa & Savithri, 2010) in Kannada, hence /r/ fronting was present in higher percentage in 2.0-3.6 years old children in the present study.

20. Velar fronting (VF)

Example of ***VF****:* /landa/ for / langa/

Fig 4.4 shows a trend in process as age increased. ***VF*** was present in 73.5% of children in 2.0-2.6 years, which steeply declined to 36.5% in 2.6-3.0 years and to 21.5% in 3.0-3.6 years. The findings reveal that velar fronting was operational in 2.0-2.6 years, and reduced in frequency of use after 2.6 years but not suppressed. ***VF*** was higher only in the younger age group due to two reasons. Firstly, the childôs tongue is larger in proportion to vocal tract than the adultôs (Fletcher 1973; Kent 1981; Crelin 1987), and it occupies a more anterior portion in the oral cavity (Kent 1992). Crelin (1987) suggested that until around two years of age, the tongue fills the oral cavity almost completely. Hence younger children used front sounds to substitute for velars compared to older children in the present study. The second reason could be because velars are early mastered sounds by 2 years of age (Deepa & Savithri, 2010) in Kannada. Hence children below 3 years are in the course of acquiring velars and hence they use front sounds to substitute for /k/ and /g/ for simpler production as found in the present study.

Various studies so far have majorly focused on fronting rather than studying the type of fronting in specific like nasal, dental, palatal, retroflex or velar fronting. Fronting process is persistent in 2 years English speaking (Dyson & Paden, 1983 and 3 years Spanish speaking children (Martinez, 1986). In Indian languages this process is present in 3 to 4 year old Kannada, Malayalam and Tamil speaking children (Sunil, 1998; Merin & Sreedevi, 2010, Sameer, 1998; and Bharathy, 2001). These studies support the present findings. Findings indicate that nasal and dental fronting were suppressed by 3.0 to 3.6 years that parallel with the findings of Haelsig and Madisonǿs (1986) and Bankson and Bernthalǿs (1990). The present study also reports that palatal, retroflex and velar fronting continued to persist at 3.6 years supported by Robert et al (1990), Dodd (2003) and James (2001).

21. Backing (Bak)

*Example of **Bak**:* /kaggu/ for / kabbu/

It can be seen in Fig 4.5 that the percentage of children using ***Bak*** is 15% in 2.0-2.6 years, after which the use of process was negligible in 2.6-3.0 years and disappeared at 3.0-3.6 years. This can be attributed to Deepa and Savithriǿs (2010) finding that /k/ and /g/ are mastered early by 2 years of age by 90% of the children. By 3 years of age all the sounds are achieved except some of the fricatives, affricates and retroflexes. Thus before the acquisition of other speech sounds, children were using /k/ and /g/. By and large, ***Bak*** was a rarely occurring process (<20%) in Kannada speaking children. The results find support from

Sameer (1998) and Ranjan (2009) stating that Bak was the least occurring process in 3-4 year old Malayalam and English speaking Indian children respectively. Dodd (1994) reported that Bak was an unusual phonological process in English.

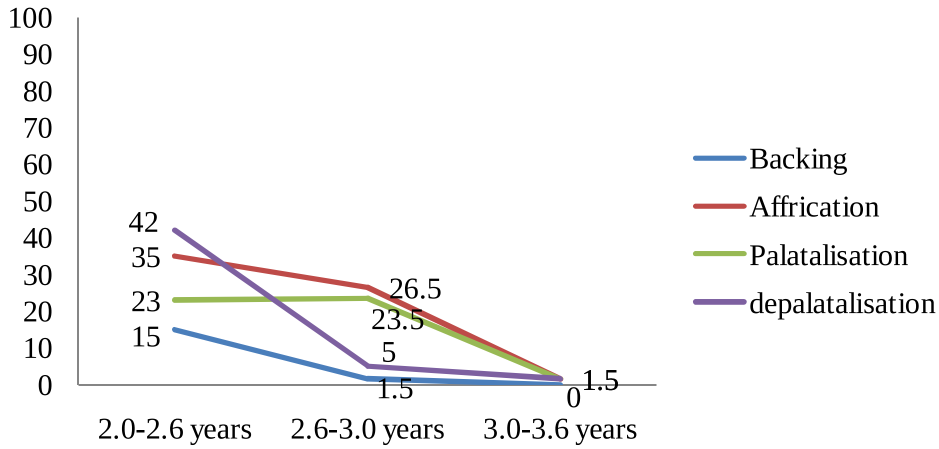


Fig 4.5. Percentage of children using the processes Bak, Aff, Pal and Dpal

22. Affrication (Aff)

Example of ***Aff****:* /mi:tǗe/ for / mi:se/

Fig 4.5 depicts that ***Aff*** was operational in <25% of children in 2 to 3 years children after which it reduced to 1.5% in 3.0-3.6 years. Aff was significantly present in 2 to 3 years Kannada speaking children indicating that children acquired affricates /tǗ and /ǳ̣/ later in 3.0-3.6 years. This is supported by Usha (1986) in Tamil, Arun Banik (1988) in Bengali, Maya (1990) in Malayalam, Prathima (1990) in Kannada and Deepa and Savithri (2010) in Kannada. This is in consonance with Rahulǿs (2006) finding that affrication frequently occurred in 2.6 to 3.0 years in Hindi speaking children.

23. Palatalisation (Pal)

Example of ***Pal****:* /do:tǗe/ for /do:se/

Fig 4.5 depicts that only 23% of 2.0 to 3.0 year old children used palatal sounds for alveolars and this occurrence was least in older group. The finding indicated that few typically developing Kannada speaking children less than 3.0 years did not gain mastery over palatals. They substituted easier alveolar front sounds till the mastery of palatals occurring after 3.0 years. Most of the studies report that alveolars are mastered earlier compared to palatals (Tasneem, 1977, Prathima, 2009, Deepa & Savithri, 2010) in Kannada. Hence ***Pal*** is a minimally occurring process in children.

24. Depalatalisation (Dpal)

*Example of **Dpal**:* /sanka/ for / Ǘnka/

Fig 4.5 depicts that ***Dpal*** was used over 40% of children in 2.0 to 2.6 years and reduced with age. The younger children below 2.6 years substitute alveolars for palatals as alveolar sounds are acquired early (Tasneem, 1977, Prathima, 2009, Deepa & Savithri, 2010). Alveolars are achieved by 3 years (Padmaja, 1988) compared to later mastered palatals by 3.6 years. The study is in agreement with Sreedevi et al (2005) which suggested that depalatalisation was commonly occurring process in 2 to 3 year old Kannada speaking children and Bankson and Bernthal (1990) suggested that the process was present in <3 years old children. ***Dpal*** was higher in 2.0-2.6 years could imply that children of this age group could not use palatal affricate (tǗ dz) or fricative (Ǘ and substitute it with an alveolar counterpart /s/.

25. Gliding (Gld)

*Example of **Gld**:* /o:je/ for / o:le/

Fig 4.6 obviously depicts a trend in the usage of the process. The percentage of children using ***Gld*** was 85% in 2.0-2.6 years, which reduced to 53.5% in 2.6-3.0 years and further to 18% in the older age group. This indicates that 2.0-2.6 year old children used glides to substitute complex palatals and retroflexes because glides are simpler and earlier acquired speech sounds. Deepa and Savithri, (2010) found that glides /j/ and /v/ were mastered by 90% of the children as early as 2.0 and 2.6 years respectively. Gliding was markedly negligible in older children since they had mastered all vowels and consonants (except /r/, /h/, /Ŀ, /ώ and

/s/) (Deepa & Savithri, 2010) by 3.0-3.6 years. The results are in agreement with Dyson and Paden (1983) and Roberts et al (1990) in English.

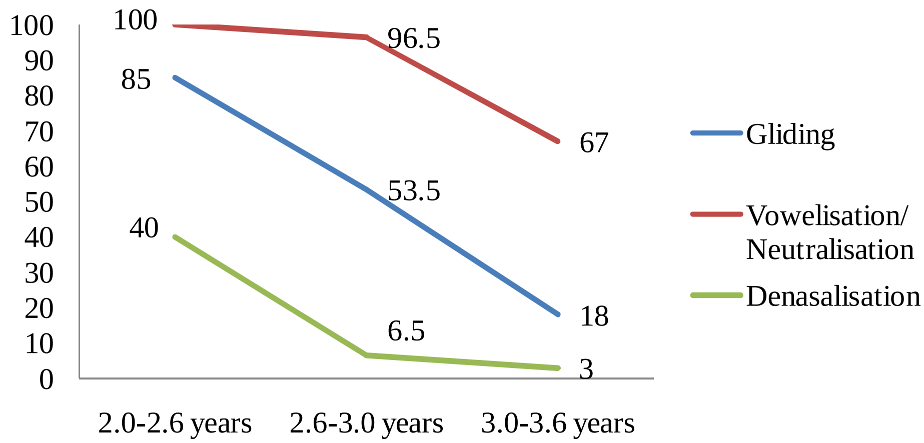


Fig 4.6: Percentage of children using the processes Gld, Vlz, and Dnas

26. Vowelisation/ Neutralisation (Vlz):

*Example of **Vlz**:* /gajiaa/ for /gadija:ra/

Fig 4.6 clearly depicts that process occurred in 100% and 96.5% of the children in 2.0 to 2.6 years and 2.6-3.0 years of age after which the occurrence of the process dropped to 67% in 3.0-3.6 years. The findings indicated that younger children (2 to 3 years) predominantly neutralised consonants for effortless production. The study is in harmony with Watson and Scukanec (1997) in English and Ranjan (2009) in 3 to 5 years old English speaking Indian children. According to Deepa and Savithri (2010), all the vowels were mastered by 2 years in Kannada speaking children, while all consonants except /ɭ/, /h/, /r/, /s/ and /ʃ/ were mastered by 3.0-3.6 years. Thus the present finding indicated predominant vowelization in younger group which reduced as they mastered consonants in older age group.

27. Denasalisation (Dnas)

*Example of **Dnas**:* /dibu/ for / dimbu/

The Fig 4.6 depicts presence of ***Dnas*** in 2.0-2.6 years was 40%, which declined to 6.5% in in 2.6-3.0 years and to 3% in 3.0-3.6 years. Thus the present study indicated that 2.0-2.6 year old children deleted nasals in a word, but Deepa and Savithri (2010) reported the mastery of nasals /m/ and /n/ as early as 2 years. However Rahul (2006) in Hindi and Sameer (1998) in Malayalam suggested that ***Dnas*** is common in 2.0-2.6 years.

28. Lateralization (Lat)

*Example of **Lat**:* /male/ for / mane/

Fig 4.7 depicts that ***Lat*** was present only < 30% in Kannada speaking children and further reduced with age. Only limited percentage of typically developing children substituted /l/ for other phonemes in the word. The findings indicated that the process was rare after 2.6-3.0 years. The study is supported by Deepa and Savithri (2010) suggesting that lateral /l/ was mastered by 3 years of age in Kannada.

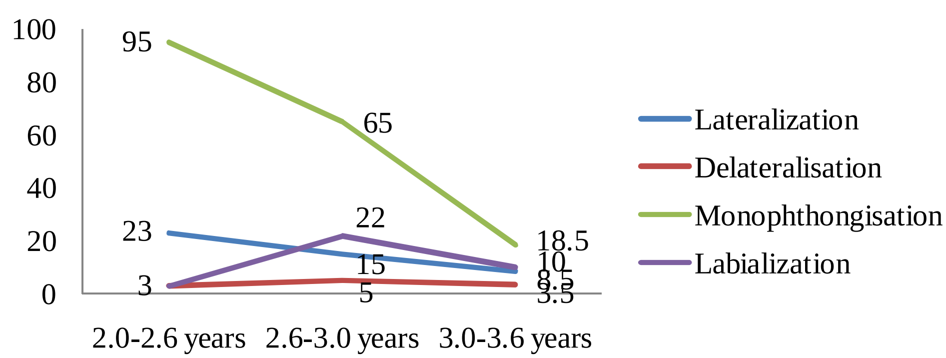


Fig 4.7: Percentage of children using the processes Lat, Dlat, Mon and Lab

29. Delateralization (Dlat)

Example of Dlat: /haŞŞu/ for / hallu/

Fig 4.7 shows that ***Dlat*** was very rarely used in Kannada speaking children. The finding indicates that seldom children substituted non lateral sounds for lateral sounds. Children were found to use stops for lateral sounds in younger age group and it was identified as stopping.

30. Monophthongization (Mon)

*Example of **Mon**:* /ad□u/ for / aid□u/

Fig 4.7 evidently depicts a trend in the percentage of children using the process. The percentage of children using Mon in 2.0-2.6 years were markedly high (95%) which reduced to 65% in 2.6-3.0 years and further sharply declined to 18.5% in 3.0-3.6 years. The findings showed high persistence of ***Mon*** in 2.0 to 3.0 years and reduced after 3 years. This implies that children after 3 years of age mastered diphthongs which is in agreement with Deepa and Savithri (2010). This finding is in consonance with Rahul (2006) in Hindi speaking children and Ranjan (2009) in English speaking Indian children.

31. Labialisation(Lab)

*Example of **Lab**:* /beppu/ for / bekku/

Fig 4.7 depicts the occurrence of ***Lab*** in 22% of 2.6-3.0 years of children and minimal occurrence in younger and older groups. Higher use of the process in 2.6-3.0 years indicates that labials were acquired at this age (Tasneem, 1977; Deepa & Savithri, 2010). Children in the older age no longer substituted labial sounds for other sounds since mastery of other sounds like dental stops, affricates and fricatives took over.

32. Progressive assimilation (PAss)

*Example of **Pass**:* / mu:mu/ for / mu:gu /

Fig 4.8 suggested a marked occurrence of the process in 2.0 to 3.0 years of age. The finding thus indicated that below 3 years, childrenǿs utterances can be influenced by previous segments.

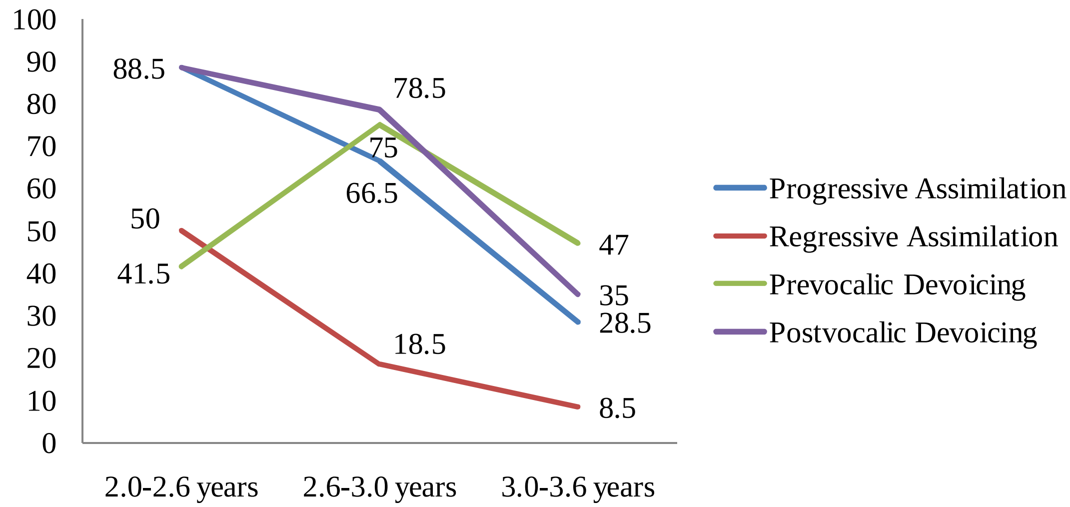


Fig 4.8. Percentage of children using the processes Pass, Rass, PreVD and PostVD

33. Regressive assimilation (RAss)

Example of ***RAss****:* /bimbu / for /d□imbu /

Fig 4.8 depicts that the percentage of children using the process was 50% in 2.0-2.6 years, which dropped drastically to after 3 years. The findings indicate that following segment affects the previous segment in 50% of the younger age group.

The present finding noted that progressive assimilation occurred higher compared to regressive assimilation. This finding is in agreement with Martinez (1986) in Spanish, Bharathy (2001) in Tamil and Ranjan (2009) in English speaking Indian children. Grunwell (1987), Lowe (1995) and Smit (1993, 2004) put forth that assimilations disappeared by 3 years of age, which did not parallel with the findings of the present study, though both assimilations showed reduced percentage in 3.6 years, they were not completely suppressed.

34. Prevocalic Devoicing (PreVD)

Example of ***PreVD***: / beppu / for / bekku/

Fig 4.8 depicts the percentage of children using process was 41.5% in 2.0-2.6 years which peaked to 75% in 2.6-3.0 years and further decreased to 47% in 3.0-3.6 years.

35. Postvocalic Devoicing (PostVD)

Example of ***PostVD****:* /go:ti/ for / go:di/

Fig 4.8 depicts that the percentage of children using the process was 88.5% in 2.0-2.6 years which reduced to 78.5% in 2.6-3.0 years and decreased to 35% in 3.0-3.6 years. PostVD was found to b active in 2 to 3 years of age. Toblin (2009) suggested the presence of the postvocalic devoicing in 2.0-3.1 years similar to findings in this study.

The finding is in consonance with Rahul (2006). Haelsig and Madison (1986) and James (2001) also stated the presence of devoicing in 3 years of age. The present study also revealed that the process was not suppressed by 3.6 years, this view is supported by Grunwell (1987), Lowe (1995) and Smit (1993, 2004) that the process disappear by 5 years of age.

After the number and percentage of children exhibiting each phonological processes were calculated, they were grouped into 3 major categories as classified by Ramadevi (2006). First category included the phonological processes occurring in 20% or less than **20%** of the children. These are considered as **occasionally occurring processes.** Second category, included the processes occurring in **more than 20% and less than 60%** of the children. These are considered as **frequently occurring** phonological processes. Third category included the processes occurring in **more than 60%** of the children. These are considered as processes occurring **most of the time** in children's speech. The phonological processes were thus identified and tabulated in Table 4.7 in the 3 age groups.

Table 4.7:

Categorization of phonological process based on the percentage of children exhibiting the processes in the 3 age groups (processes in bold occurred in 0% of children)

2.0-2.6 years			2.6-3.0 years			3.0-3.6 years		
Less than 20%	20-60%	More than 60%	Less than 20%	20-60%	More than 60%	Less than 20%	20-60%	More than 60%
IVD	FSD	ICD	IVD	MSD	ICD	**IVD**	ICD	CR
Red	Epn	MCD	FSD	GCR	MCD	MSD	MCD	RF
Met	CSim	ISD	Epn	Stp	ISD	FSD	ISD	Vlz
CD	Aff	MSD	Red	VF	CR	Epn	PF	
CSub	Pal	GCR	Met	Aff	PF	**Red**	VF	
NF	Depal	CR	CSim	Pal	RF	Met	PAss	
DF	Denas	Stp	CD	Gld	Vlz	CSim	PreVD	
Bak	Lat	PF	CSub	Lab	Mon	**CD**	PostVD	
Dlat	RAss	RF	NF		PAss	GCR		
Lab	PreVD	VF	DF		PreVD	CSub		
	Aff	Gld	Bak		PostVD	Stp		
		Vlz	Depal			**NF**		
		Mon	Dnas			**DF**		
		PAss	CD			**Bak**		
		PostVD	Lat			Aff		
			Dlat			Pal		
			RAss			Dpal		
						Gld		
						Dnas		
						Lat		
						Dlat		
						Mon		
						Lab		
						RAss		

It is well evident from Table 4.7 that the number of processes occurring less than 20% of the children in younger age group was less (10 processes) and increased towards 3.0-3.6 years (24 processes). However, processes in more than 60% category in 2.0-2.6 years were high (15 processes) and reduced in 3.0-3.6 years (7 processes). This is suggestive of the fact that speech-language skills developed, they used lesser simplification rules/ strategies to produce adult target production. Thus 15 processes were operational in 2.0-2.6 years old children, 11 processes in 2.6-3.0 year old children, and only 3 processes in 3.0-3.6 years. The 3 processes that were found to persisting in the older children were cluster reduction, retroflex fronting and vowelisation. This indicated that majority of children of 3-3.6 years had mastered most phonemes in the language and hence their usage of the processes had significantly reduced. It is also suggestive of the fact that clusters are still being acquired as cluster reduction was operational substantially.

Thus Table 4.7 shows the norm of phonological processes functioning in 2.0-2.6 years, 2.6-3.0 years and 3.0-3.6 years. The findings suggested that 16 processes frequently occurred in 2.0-2.6 years which reduced from to 11 in 2.6-3.0 years and to 3 processes in 3.0-3.6 years. Hence during the course of speech language development, the occurrence of processes reduced drastically till 3.6 years. While, vowelization, retroflex fronting and cluster reduction continued to operate even after 3.6 years in native Kannada speaking children. This can be evidently seen in Table 4.8. Table 4.8 shows the chronology of all the 35 processes in typically developing children from 2.0-2.6 years to 3.0-3.6 years. This norm data help clinician to identify if the process in typically occurring in child or deviant and also helps in targeting processes during speech- language therapy.

Table 4.8:

Chronology of Phonological processes from 2.0-2.6 years to 3.0-3.6 years

Sl. no	Phonological processes	2.0-2.6 years	2.6-3.0 years	3.0-3.6 years
1	Initial Vowel Deletion	Red	Red	Red
2	Initial Consonant Deletion	Green	Green	Blue
3	Medial Consonant Deletion	Green	Green	Blue
4	Initial Syllable Deletion	Green	Green	Blue
5	Medial Syllable Deletion	Green	Blue	Red
6	Final Syllable Deletion	Blue	Red	Red
7	Epenthesis	Blue	Red	Red
8	Reduplication	Red	Red	Red
9	Metathesis	Red	Red	Red
10	Cluster Simplification	Blue	Red	Red
11	Cluster Deletion	Red	Red	Red
12	Geminate Cluster Reduction	Green	Blue	Red
13	Cluster Substitution	Red	Red	Red
14	Cluster Reduction	Green	Green	Green
15	Stopping	Green	Blue	Red
16	Nasal Fronting	Red	Red	Red
17	Dental Fronting	Red	Red	Red
18	Palatal Fronting	Green	Green	Blue
19	Retroflex Fronting	Green	Green	Green
20	Velar Fronting	Green	Blue	Blue
21	Backing	Red	Red	Red
22	Affrication	Blue	Blue	Red
23	Palatalisation	Blue	Blue	Red
24	Depalatalisation	Blue	Red	Red
25	Gliding	Green	Blue	Red
26	Vowelisation/ Neutralisation	Green	Green	Green
27	Denasalisation	Blue	Red	Red
28	Lateralization	Blue	Red	Red
29	Delateralisation	Red	Red	Red
30	Monophthongisation	Green	Green	Red
31	Labialization	Red	Red	Red
32	Progressive Assimilation	Green	Blue	Blue
33	Regressive Assimilation	Blue	Red	Red
34	Prevocalic Devoicing	Blue	Green	Blue
35	Postvocalic Devoicing	Green	Green	Blue

Less than 20% or occassionally occurring processes	Red
20-60% or frequently occurring processes	Blue
More than 60% or most frequently occurring processes	Green

Along with categorizing of phonological processes according to Ramadevi (2006) classification, several researchers along with Grunwell (1985) classified the phonological processes as (a) Syllable structure, (b) substitution or feature contrast and (c) assimilation or harmony. The following figures (Fig 4.9, 4.10, 4.11, 4.12 & 4.13) show the percentages of children exhibiting phonological processes under each type of processes in the present study.

1. Syllable structure processes

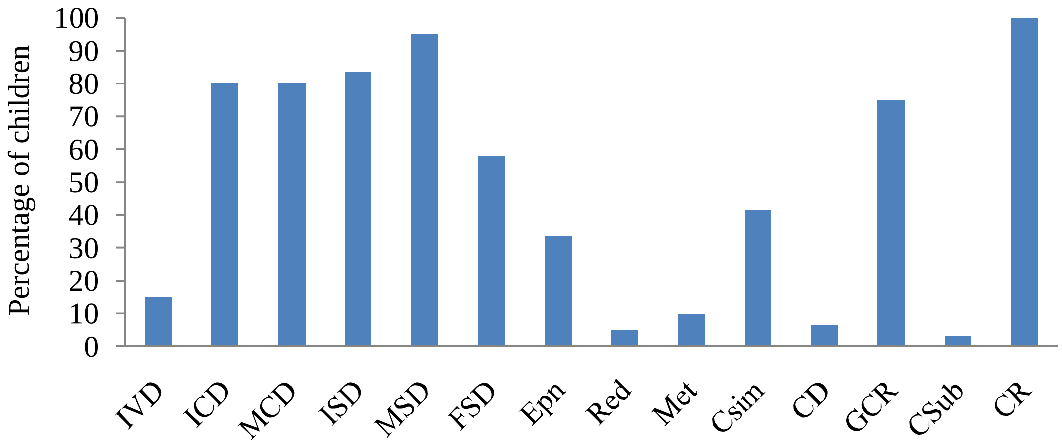


Fig 4.9. The percentage of children exhibiting the syllable structure processes in 2.0 ï 2.6 years

The syllable structure processes that showed marked presence in 2.0-2.6 years were cluster reduction, followed by medial syllable deletion, initial syllable deletion, medial consonant deletion, initial consonant deletion, and geminate cluster reduction. Reduplication, cluster deletion and cluster substitution occurred rarely.

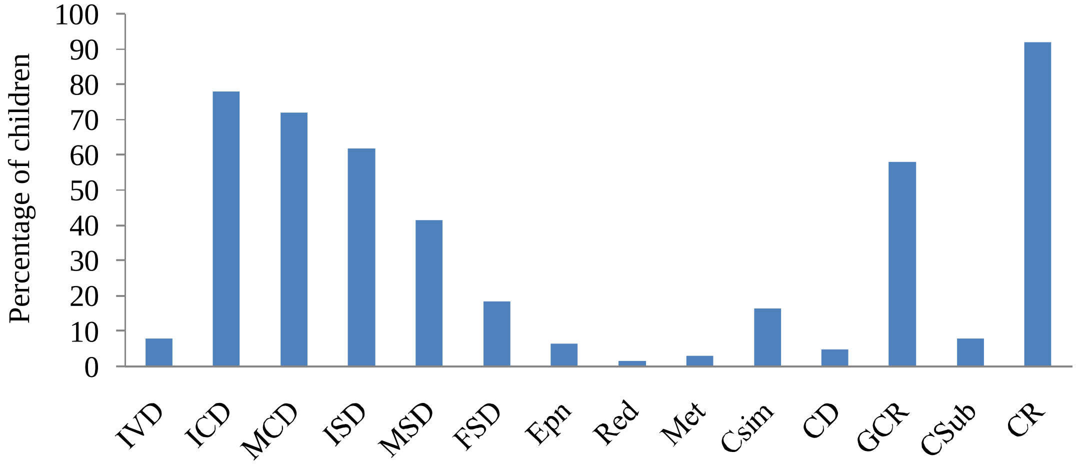


*Fig 4.10.*The percentage of children exhibiting the syllable structure processes in 2.6-3.0 years

It can be seen in Fig 4.10 that in 2.6-3.0 years, cluster reduction, followed by initial consonant deletion, medial consonant deletion, geminate cluster reduction, initial syllable deletion, and medial syllable deletion continued to occur in this age group. But final syllable deletion, epenthesis and cluster simplification reduced compared to the younger age group. Along with reduplication, cluster deletion and cluster substitution, initial vowel deletion, epenthesis, metathesis occurred rarely in this age group.

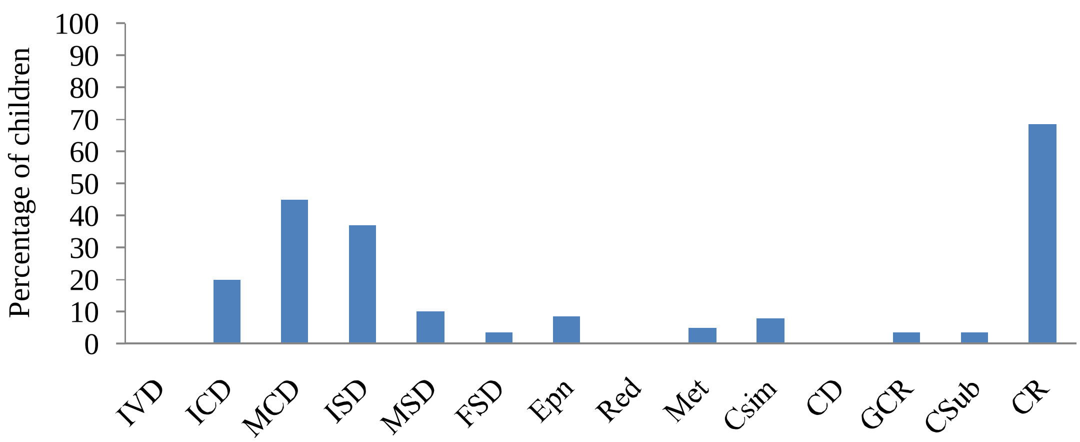


*Fig 4.11.*The percentage of children exhibiting the syllable structure processes in 3.0 ï 3.6 years

Fig 4.11 shows that there was a drastic reduction in all syllable structure processes, except cluster reduction. Cluster reduction was the process that affected the structure of syllables in this group. All the other processes occurred in <50% of the children. Certain processes like initial vowel deletion, reduplication, and cluster deletion did not occur in this group of children.

2. Substitution processes

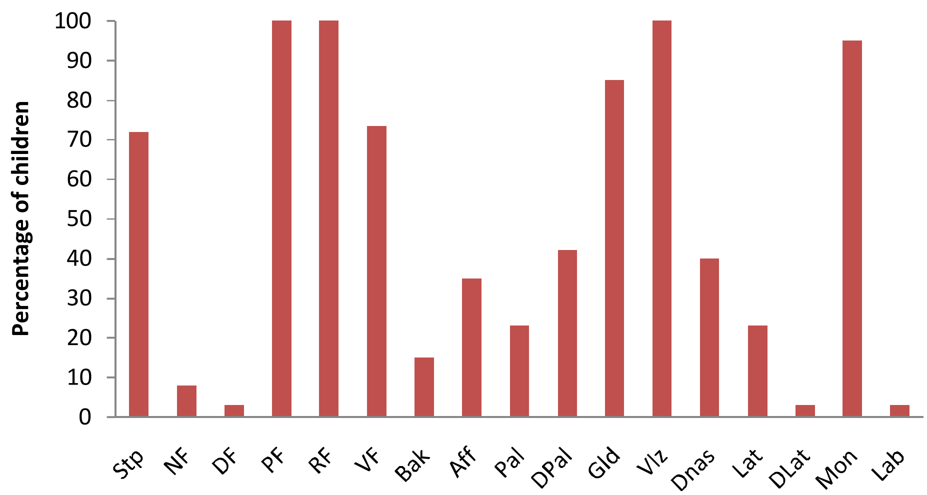


*Fig 4.12.*The percentage of children exhibiting the substitution processes in 2.0 ï 2.6 years

The substitution processes that occurred most of the time in 2.0-2.6 years were palatal fronting, retroflex fronting, vowelisation followed by monophthongisation, stopping, gliding, and velar fronting. Nasal fronting, dental fronting, backing, delateralisation and labialization occurred rarely.

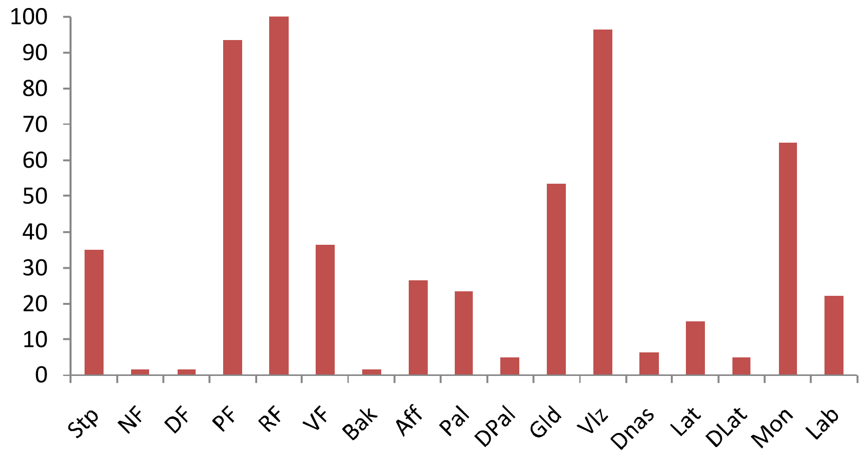


Fig 4.13: The percentage of children exhibiting the substitution processes in 2.6-3.0 years

Retroflex fronting, vowelisation, palatal fronting and monophthongisation continued to be highly operational substitution processes in 2.6-3.0 years. However, stopping, gliding, and velar fronting markedly reduced in their occurrence compared to the younger group.

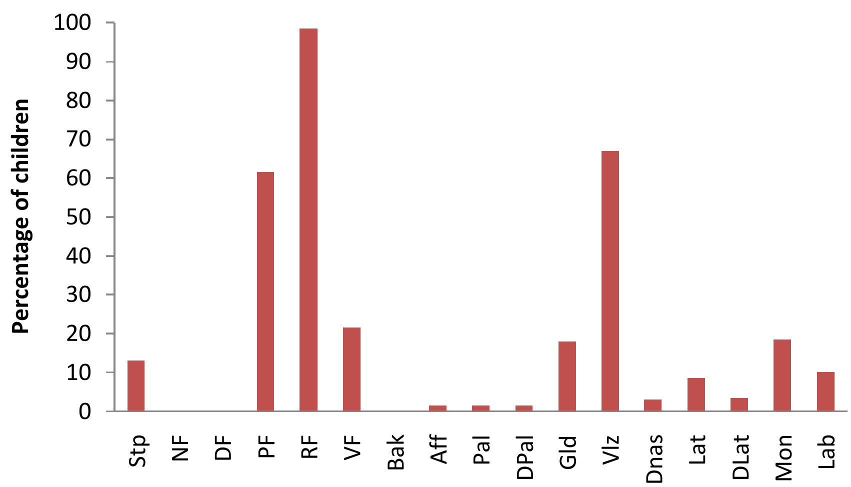
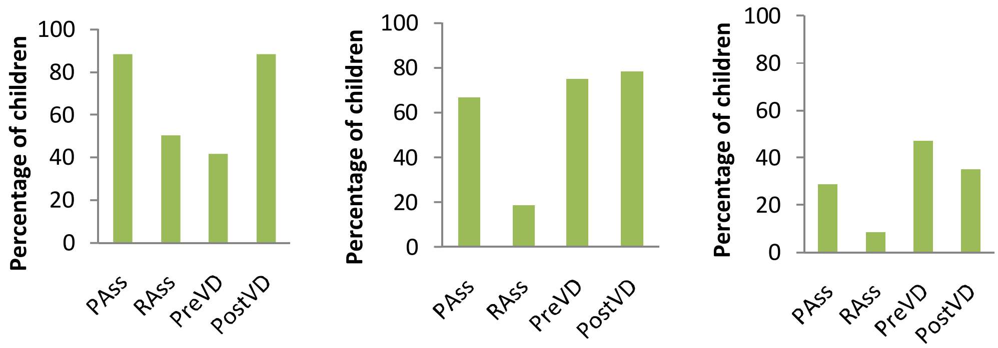


Fig 4.14. The percentage of children exhibiting the substitution processes in 3.0 ï 3.6 years

Fig 4.14 shows obvious reduction in occurrence of most of the processes except for marked presence of retroflex fronting, vowelisation and palatal fronting in 3.0-3.6 years. Nasal fronting, dental fronting, and backing that occurred rarely in 2.6-3.0 years were not present in this age group. Most of the processes including stopping, gliding, denasalisation, lateralization, delateralisation, labialization and monophthongisation occurred rarely in this age group.

3. *Assimilation processes*



a) b) c)

Fig 4.15: The percentage of children exhibiting the assimilation processes in a) 2.0 ï 2.6 years, b) 2.6-3.0 years and c) 3.0-3.6 years

Fig 4.15 (a) shows that all assimilation processes were operational in >40% of the children in the younger age group. Progressive assimilation and postvocalic devoicing occurred predominantly in this age group. In 2.6-3.0 years, along with these processes, prevocalic devoicing was also markedly operational. In the older age group, all assimilation processes occurred in <50% of the children.

The overall finding imply that assimilation processes reduced with age, except for prevocalic devoicing which was markedly present in 2.6-3.0 years. Assimilation processes continued to be persisting in 3.0-3.6 years. According to Bernsteinôs (1945) development of articulatory skills model, level E was responsible for disappearance of assimilations and maturation of which ranged from five years to 12 years. Thus findings suggested occurrence of assimilation processes even at 3.6 years.

After obtaining the percentage of children exhibiting the various processes, the statistical technique ñEquality of Proportionò in Smithôs Statistical Package (SSP); Version 2.80 was used to test the following hypothesis

1. ñThe percentage of children exhibiting phonological processes in males is greater than females at 0.05 level of significance in 2.0 - 2.6 years, 2.6 - 3.0 years and 3.0 - 3.6 yearsò.
2. ñThe 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 significanceò
3. ñThe percentage of children exhibiting phonological processes in males of 3.0 - 3.6 years is greater than males of 2.6 -3.0 years at 0.05 level of significanceò
4. ñThe percentage of children exhibiting phonological processes in males of 3.0 - 3.6 years is greater than males of 2.0 -2.6 years at 0.05 level of significanceò
5. ñThe 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 significanceò
6. ñThe percentage of children exhibiting phonological processes in females of 3.0 - 3.6 years is greater than females of 2.6 -3.0 years at 0.05 level of significanceò
7. ñThe percentage of children exhibiting phonological processes in females of 3.0 - 3.6 years is greater than females of 2.0 -2.6 years at 0.05 level of significanceò

The results of the statistical test ñEquality of Proportionò is shown in Tables 4.9 (a), (b) and (c), 4.9 (a), (b) and (c) and 4.10 (a), (b) and (c).

Table 4.9 (a):

Percentage of children exhibiting different phonological processes and significant difference ($p \le 0.05$) in the age range of 2.0-2.6 years in both males and females*

Sl.no	Phonological processes	Percentage of children exhibiting the process		value
		Boys	Girls	
1	Initial Vowel Deletion	20	10	1.08
2	Initial Consonant Deletion	80	80	0.00
3	Medial Consonant Deletion	83	77	0.65
4	Initial Syllable Deletion	90	77	1.39
5	Medial Syllable Deletion	93	97	0.32
6	Final Syllable Deletion	63	53	0.79
7	Epenthesis	47	20	2.19
8	Reduplication	7	3	0.59
9	Metathesis	13	7	0.86
10	Cluster Simplification	43	40	0.26
11	Cluster Deletion	10	3	1.04
12	Geminate Cluster Reduction	80	70	0.89
13	Cluster Substitution	3	3	0.00
14	Cluster Reduction	100	100	0.00
15	Stopping	87	57	2.59*
16	Nasal Fronting	3	13	1.40
17	Dental Fronting	3	3	0.00
18	Palatal Fronting	100	100	0.00
19	Retroflex Fronting	100	100	0.00
20	Velar Fronting	70	77	0.58
21	Backing	13	17	0.36
22	Affrication	43	27	1.35
23	Palatalisation	23	23	0.00
24	depalatalisation	47	37	0.79
25	Gliding	87	83	0.36
26	Vowelisation/ Neutralisation	100	100	0.00
27	Denasalisation	37	43	0.53
28	Lateralization	23	23	0.00
29	Delateralisation	3	3	0.00
30	Monophthongisation	93	97	0.59
31	Labialization	3	3	0.00
32	Progressive Assimilation	90	87	0.40
33	Regressive Assimilation	50	50	0.00
34	Prevocalic Devoicing	40	43	0.26
35	Postvocalic Devoicing	90	87	0.40

In 2.0-2.6 years as seen in Table 4.9 (a), occurrences of all the processes were higher in males compared to females, but significant higher occurrence was seen in males for

stopping at pÒ0.05. >80% of boys used stopping compared to <60% of girls in this age group. This indicated that stops were predominantly substituted for affricates, fricatives and other difficult sounds in male children of this age group.

Table 4.9 (b):

Percentage of children exhibiting different phonological processes and significant difference ($p \leq 0.05$) in the age range of 2.6-3.0 years in both males and females.*

Sl.no	Phonological processes	Percentage of children exhibiting the process		Z value
		Boys	Girls	
1	Initial Vowel Deletion	13	3	1.40
2	Initial Consonant Deletion	83	73	0.94
3	Medial Consonant Deletion	77	67	0.86
4	Initial Syllable Deletion	67	57	0.80
5	Medial Syllable Deletion	50	33	1.31
6	Final Syllable Deletion	17	20	0.33
7	Epenthesis	10	3	1.04
8	Reduplication	3	0	1.01
9	Metathesis	3	3	0.00
10	Cluster Simplification	20	13	0.70
11	Cluster Deletion	10	0	1.78
12	Geminate Cluster Reduction	73	43	2.36*
13	Cluster Substitution	13	3	1.40
14	Cluster Reduction	97	87	1.40
15	Stopping	30	40	0.81
16	Nasal Fronting	0	3	0.31
17	Dental Fronting	0	3	0.31
18	Palatal Fronting	90	97	1.04
19	Retroflex Fronting	100	100	0.00
20	Velar Fronting	40	33	0.54
21	Backing	3	0	1.01
22	Affrication	23	30	0.58
23	Palatalisation	27	20	0.61
24	Depalatalisation	7	3	0.59
25	Gliding	50	57	0.52
26	Vowelisation/ Neutralisation	100	93	1.44
27	Denasalisation	10	3	1.04
28	Lateralization	27	3	2.53*
29	Delateralisation	7	3	0.59
30	Monophthongisation	77	53	1.89*
31	Labialization	27	17	0.94
32	Progressive Assimilation	60	73	1.10
33	Regressive Assimilation	17	20	0.33
34	Prevocalic Devoicing	73	77	0.30
35	Postvocalic Devoicing	87	70	1.57

In 2.6-3.0 year age group as seen in Table 4.9 (b), males markedly used geminate cluster reduction, lateralization and monophthongisation higher than females at pÒ0.05. The

finding implies that male children of this age group reduced geminates more compared to females as in /uja:le/ for /ujja:le/, used lateral sound /l/ for palatals and retroflexes as in /u:lu/ for /u:ru/ and reduced diphthongs as in /avattu/ for /aivattu/. Girl children were found to use these processes lesser, indicating an advantage for girls. However gender effect was not found in laterals and diphthong acquisition in Deepa and Savithriôs (2010) study.

Table 4.9 (c):

Percentage of children exhibiting different phonological processes and significant difference (p≤0.05) in the age range of 3.0-3.6 years in both males and females*

Sl.no	Phonological processes	Percentage of children exhibiting the process		Z value
		Boys	Girls	
1	Initial Consonant Deletion	17	23	0.65
2	Medial Consonant Deletion	43	47	0.26
3	Initial Syllable Deletion	37	37	0.00
4	Medial Syllable Deletion	10	10	0.00
5	Final Syllable Deletion	7	0	1.44
6	Epenthesis	7	10	0.47
7	Metathesis	7	3	0.59
8	Cluster Simplification	13	3	1.40
9	Geminate Cluster Reduction	7	0	1.44
10	Cluster Substitution	7	0	1.44
11	Cluster Reduction	67	70	0.28
12	Stopping	13	13	0.00
13	Palatal Fronting	60	63	0.27
14	Retroflex Fronting	100	97	1.01
15	Velar Fronting	20	23	0.31
16	Affrication	3	0	1.01
17	Palatalisation	3	0	1.01
18	Depalatalisation	3	0	1.01
19	Gliding	23	13	1.00
20	Vowelisation/ Neutralisation	67	67	0.00
21	Denasalisation	3	3	0.00
22	Lateralization	10	7	0.47
23	Delateralisation	7	0	1.44
24	Monophthongisation	20	17	0.33
25	Labialization	3	17	1.72
26	Progressive Assimilation	30	27	0.29
27	Regressive Assimilation	7	10	0.47
28	Prevocalic Devoicing	47	47	0.00
29	Postvocalic Devoicing	43	27	1.35

As seen in Table 4.9 (c), no significant gender differences were noticed. Study revealed equal use of process in both genders in 3.0-3.6 years as also reported by Poole (1934). The finding indicates that boys and girls used the processes equally at higher ages. Statistical analysis was carried out to demarcate whether there is any significant difference across age in males and results are seen in Table 4.10 (a), (b) and (c).

Table 4.10 (a):

Shows the presence or absence of significant difference (p≤0.05 and p≤0.001**) across males in the age ranges 2.0-2.6 years and 2.6-3.0 years*

Sl.no	Phonological processes	No. of children exhibiting the process		Z value
		Boys (2.0-2.6 years)	Boys (2.6-3.0 years)	
1	Initial Vowel Deletion	6	4	0.69
2	Initial Consonant Deletion	24	25	0.33
3	Medial Consonant Deletion	25	23	0.65
4	Initial Syllable Deletion	27	20	2.19*
5	Medial Syllable Deletion	28	15	3.72*
6	Final Syllable Deletion	19	5	3.69*
7	Epenthesis	14	3	3.15*
8	Reduplication	2	1	0.59
9	Metathesis	4	1	1.40
10	Cluster Simplification	13	6	1.94*
11	Cluster Deletion	3	3	0.00
12	Geminate Cluster Reduction	24	22	0.61
13	Cluster Substitution	1	4	1.40
14	Cluster Reduction	30	29	1.01
15	Stopping	26	9	4.45**
16	Nasal Fronting	1	0	1.01
17	Dental Fronting	1	0	1.01
18	Palatal Fronting	30	27	1.78
19	Retroflex Fronting	30	30	0.00
20	Velar Fronting	21	12	2.34*
21	Backing	4	1	1.40
22	Affrication	13	7	1.64
23	Palatalisation	7	8	0.30
24	Depalatalisation	14	2	3.50*
25	Gliding	26	15	3.05*
26	Vowelisation/ Neutralisation	30	30	0.00
27	Denasalisation	11	3	2.44*
28	Lateralization	7	8	0.30
29	Delateralisation	1	2	0.59
30	Monophthongisation	28	23	1.81
31	Labialization	1	8	2.53*
32	Progressive Assimilation	27	18	2.68*
33	Regressive Assimilation	15	5	2.74*
34	Prevocalic Devoicing	12	22	2.61*
35	Postvocalic Devoicing	27	26	0.40

Statistical analysis across boys of 2.0-2.6 and 2.6-3.0 years in Table 4.9 (a) revealed that stopping, initial syllable deletion, medial syllable deletion, final syllable deletion, epenthesis, cluster simplification, velar fronting, depalatalisation, gliding, denasalisation, progressive assimilation and regressive assimilation were significantly higher in boys of younger age group at pÒ0.05. However, prevocalic devoicing and labialization occurred higher in 2.6-3.0 years males at pÒ0.001 implying that older group devoiced consonant preceding a vowel and replaced consonants with labial sounds more than younger males.

Table 4.10 (b):

Shows the presence or absence of significant difference ($p \leq 0.05$ and $p \leq 0.001$**) across males in the age ranges 2.6-3.0 years and 3.0-3.6 years*

Sl.no	Phonological processes	No. of children exhibiting the process		Z value
		Boys (2.6-3.0 years)	Boys (3.0-3.6 years)	
1	Initial Vowel Deletion	4	0	2.07*
2	Initial Consonant Deletion	25	5	5.16**
3	Medial Consonant Deletion	23	13	2.64*
4	Initial Syllable Deletion	20	11	2.33*
5	Medial Syllable Deletion	15	3	3.38**
6	Final Syllable Deletion	5	2	1.21
7	Epenthesis	3	2	0.47
8	Reduplication	1	0	1.01
9	Metathesis	1	2	0.56
10	Cluster Simplification	6	4	0.69
11	Cluster Deletion	3	0	1.78
12	Geminate Cluster Reduction	22	2	5.27**
13	Cluster Substitution	4	2	0.86
14	Cluster Reduction	29	20	3.00*
15	Stopping	9	4	1.57
18	Palatal Fronting	27	18	2.68*
19	Retroflex Fronting	30	30	0.00
20	Velar Fronting	12	6	1.69
21	Backing	1	0	1.01
22	Affrication	7	1	2.28*
23	Palatalisation	8	1	2.53*
24	depalatalisation	2	1	0.59
25	Gliding	15	7	2.14*
26	Vowelisation/ Neutralisation	30	20	3.46**
27	Denasalisation	3	1	1.04
28	Lateralization	8	3	1.67
29	Delateralisation	2	2	0.00
30	Monophthongisation	23	6	4.39**
31	Labialization	8	1	2.53*
32	Progressive Assimilation	18	9	2.34*
33	Regressive Assimilation	5	2	1.21
34	Prevocalic Devoicing	22	14	2.11*
35	Postvocalic Devoicing	26	13	3.52**

Table 4.10 (b) revealed that 11 processes: initial vowel deletion, medial consonant deletion, initial syllable deletion, cluster reduction, palatal fronting, affrication, palatalisation, gliding, labialization, progressive assimilation and prevocalic devoicing occurred significantly higher in males of 2.6-3.0 year old children compared to 3.0-3.6 year old children at pÒ0.05. 6 processes initial consonant deletion, medial syllable deletion, geminate cluster deletion, vowelisation, monophthongisation and postvocalic devoicing occurred in higher significance in males of 2.6-3.0 year old children compared to older males at pÒ0.001.

Table 4.10 (c):

Shows the presence or absence of significant difference (p≤0.05 and p≤0.001**) across males in the age ranges 2.0-2.6 years and 3.0-3.6 years*

Sl.no	Phonological processes	No. of children exhibiting the process		Z value
		Boys (2.0-2.6 years)	Boys (3.0-3.6 years)	
1	Initial Vowel Deletion	6	0	2.58*
2	Initial Consonant Deletion	24	5	4.91**
3	Medial Consonant Deletion	25	13	3.21*
4	Initial Syllable Deletion	27	11	4.29**
5	Medial Syllable Deletion	28	3	6.46**
6	Final Syllable Deletion	19	2	4.60**
7	Epenthesis	14	2	3.50**
8	Reduplication	2	0	1.44
9	Metathesis	4	2	0.86
10	Cluster Simplification	13	4	2.58*
11	Cluster Deletion	3	0	1.78
12	Geminate Cluster Reduction	24	2	5.73**
13	Cluster Substitution	1	2	0.59
14	Cluster Reduction	30	20	3.46**
15	Stopping	26	4	5.68**
16	Nasal Fronting	1	0	1.01
17	Dental Fronting	1	0	1.01
18	Palatal Fronting	30	18	3.87**
19	Retroflex Fronting	30	30	0.00
20	Velar Fronting	21	6	3.89**
21	Backing	4	0	2.07*
22	Affrication	13	1	3.66**
23	Palatalisation	7	1	2.28*
24	depalatalisation	14	1	3.88**
25	Gliding	26	7	4.93**
26	Vowelisation/ Neutralisation	30	20	3.46**
27	Denasalisation	11	1	3.23*
28	Lateralization	7	3	1.39
29	Delateralisation	1	2	0.59
30	Monophthongisation	28	6	5.73**
31	Labialization	1	1	0.00
32	Progressive Assimilation	27	9	4.74**
33	Regressive Assimilation	15	2	3.72**
34	Prevocalic Devoicing	12	14	0.52
35	Postvocalic Devoicing	27	13	3.83**

Statistical analysis in Table 4.10 (c) revealed that 24 processes were found to occur markedly higher in males of 3.0-3.6 years compared to males of 2.0-2.6 years. Initial vowel deletion, medial consonant deletion, cluster simplification, backing, affrication, palatalisation and denasalisation occurred significantly higher at pÒ0.05 and initial consonant deletion, initial syllable deletion medial syllable deletion, final syllable deletion, epenthesis, geminate cluster deletion, cluster reduction, stopping, palatal fronting, velar fronting, depalatalisation, gliding, vowelisation, monophthongisation, progressive assimilation, regressive assimilation and postvocalic devoicing occurred in higher significance at pÒ0.001. Statistical analysis was carried out to demarcate whether there is any significant difference across age in females and results are seen in Table 4.11 (a), (b) and (c).

Table 4.11 (a):

Shows the presence or absence of significant difference (p≤0.05 and p≤0.001**) across females in the age ranges 2.0-2.6 years and 2.6-3.0 years*

Sl.no	Phonological processes	No. of children exhibiting the process		Z value
		Girls (2.0-2.6 years)	Girls (2.6-3.0 years)	
1	Initial Vowel Deletion	3	1	1.04
2	Initial Consonant Deletion	24	22	0.61
3	Medial Consonant Deletion	23	20	0.86
4	Initial Syllable Deletion	23	17	1.64
5	Medial Syllable Deletion	29	10	5.14**
6	Final Syllable Deletion	16	6	2.68*
7	Epenthesis	6	1	2.01*
8	Reduplication	1	0	1.01
9	Metathesis	2	1	0.59
10	Cluster Simplification	12	4	2.34*
11	Cluster Deletion	1	0	1.01
12	Geminate Cluster Reduction	21	13	2.08*
13	Cluster Substitution	1	1	0.00
14	Cluster Reduction	30	26	2.07*
15	Stopping	17	12	1.29
16	Nasal Fronting	4	1	1.40
17	Dental Fronting	1	1	0.00
18	Palatal Fronting	30	29	1.01
19	Retroflex Fronting	30	30	0.00
20	Velar Fronting	23	10	3.37**
21	Backing	5	0	2.34*
22	Affrication	8	9	0.29
23	Palatalisation	7	6	0.31
24	depalatalisation	11	1	3.23*
25	Gliding	25	17	2.25*
26	Vowelisation/ Neutralisation	30	28	1.44
27	Denasalisation	13	1	3.66**
28	Lateralization	7	1	2.28*
29	Delateralisation	1	1	0.00
30	Monophthongisation	29	16	3.88**
31	Labialization	1	5	1.72
32	Progressive Assimilation	26	22	1.29
33	Regressive Assimilation	15	6	2.44*
34	Prevocalic Devoicing	13	23	2.64*
35	Postvocalic Devoicing	26	21	1.57

Table 4.11 (a) clearly depicts that 15 processes were markedly used by 2.0-2.6 year old females compared to 2.6-3.0 year old females. Medial syllable deletion, velar fronting, denasalization and monophthongisation were significantly higher at pÒ0.001 and final syllable deletion, epenthesis, cluster substitution, geminate cluster reduction, cluster reduction, lateralization, backing, depalatalisation, gliding and regressive assimilation were significantly high at pÒ0.05. Only prevocalic devoicing was higher in 2.0-2.6 year old males.

Table 4.11 (b):

Shows the presence or absence of significant difference ($p \leq 0.05$ and $p \leq 0.001$**) across females in the age ranges 2.6-3.0 years and 3.0-3.6 years*

Sl.no	Phonological processes	No. of children exhibiting the process		Z value
		Girls (2.6-3.0 years)	Girls (3.0-3.6 years)	
1	Initial Vowel Deletion	1	0	1.01
2	Initial Consonant Deletion	22	7	3.88**
3	Medial Consonant Deletion	20	14	1.56
4	Initial Syllable Deletion	17	11	1.55
5	Medial Syllable Deletion	10	3	2.19*
6	Final Syllable Deletion	6	0	2.58*
7	Epenthesis	1	3	1.04
9	Metathesis	1	1	0.00
10	Cluster Simplification	4	1	1.40
12	Geminate Cluster Reduction	13	0	4.07**
13	Cluster Substitution	1	0	1.01
14	Cluster Reduction	26	21	1.57
15	Stopping	12	4	2.34*
16	Nasal Fronting	1	0	1.01
17	Dental Fronting	1	0	1.01
18	Palatal Fronting	29	19	3.23*
19	Retroflex Fronting	30	29	1.01
20	Velar Fronting	10	7	0.86
22	Affrication	9	0	3.25*
23	Palatalisation	6	0	2.58*
24	depalatalisation	1	0	1.01
25	Gliding	17	4	3.52**
26	Vowelisation/ Neutralisation	28	20	2.58*
27	Denasalisation	1	1	0.00
28	Lateralization	1	2	0.59
29	Delateralisation	1	0	1.01
30	Monophthongisation	16	5	2.98*
31	Labialization	5	5	0.00
32	Progressive Assimilation	22	8	3.61**
33	Regressive Assimilation	6	3	1.08
34	Prevocalic Devoicing	23	14	2.39*
35	Postvocalic Devoicing	21	8	3.36**

14 processes were markedly used by 2.6-3.0 year old females compared to 3.0-3.6 year old females as seen in Table 4.11 (b). Initial consonant deletion, geminate cluster reduction, gliding, progressive assimilation and postvocalic devoicing showed significantly higher occurrence in 3.0-3.6 years at pÒ0.001 and in medial syllable deletion, final syllable deletion, stopping, palatal fronting, affrication, palatalisation, vowelisation, monophthongisation, and prevocalic devoicing at pÒ0.05.

Table 4.11 (c):

Shows the presence or absence of significant difference (p≤0.05 and p≤0.001**) across females in the age ranges 2.0-2.6 years and 3.0-3.6 years*

Sl.no	Phonological processes	No. of children exhibiting the process		Z value
		Girls (2.0-2.6 years)	Girls (3.0-3.6 years)	
1	Initial Vowel Deletion	3	0	1.78
2	Initial Consonant Deletion	24	7	4.39**
3	Medial Consonant Deletion	23	14	2.39*
4	Initial Syllable Deletion	23	11	3.13**
5	Medial Syllable Deletion	29	3	6.73**
6	Final Syllable Deletion	16	0	4.67**
7	Epenthesis	6	3	1.08
8	Reduplication	1	0	1.01
9	Metathesis	2	1	0.59
10	Cluster Simplification	12	1	3.45**
11	Cluster Deletion	1	0	1.01
12	Geminate Cluster Reduction	21	0	5.37**
13	Cluster Substitution	1	0	1.01
14	Cluster Reduction	30	21	3.25*
15	Stopping	17	4	3.52*
16	Nasal Fronting	4	0	2.07*
17	Dental Fronting	1	0	1.01
18	Palatal Fronting	30	19	3.67**
19	Retroflex Fronting	30	29	1.01
20	Velar Fronting	23	7	4.13**
21	Backing	5	0	2.34*
22	Affrication	8	0	3.04**
23	Palatalisation	7	0	2.82*
24	depalatalisation	11	0	3.67*
25	Gliding	25	4	5.43**
26	Vowelisation/ Neutralisation	30	20	3.46**
27	Denasalisation	13	1	3.66**
28	Lateralization	7	2	1.81
29	Delateralisation	1	0	1.01
30	Monophthongisation	29	5	6.25**
31	Labialization	1	5	1.72
32	Progressive Assimilation	26	8	4.69**
33	Regressive Assimilation	15	3	3.38**
34	Prevocalic Devoicing	13	14	0.26
35	Postvocalic Devoicing	26	8	4.69**

Table 4.11 (c) shows that 23 processes were markedly used by 2.0-2.6 year old females compared to 3.0-3.6 year old females. Initial consonant deletion, initial syllable deletion, medial syllable deletion, final syllable deletion, cluster simplification, geminate cluster reduction, palatal fronting, velar fronting, affrication, gliding, vowelisation, denasalization, monophthongisation, progressive assimilation, regressive assimilation and postvocalic devoicing were significantly higher at pÒ0.001 and medial consonant deletion, cluster reduction, stopping, velar fronting, backing, palatalisation and depalatalisation were significantly higher at pÒ0.05 in females of 3.0-3.6 compared to that of 2.0 - 2.6 years.

Thus to sum up the findings obtained on gender difference

a) Significant gender differences were seen in younger age groups of 2.0 - 2.6 years and 2.6 - 3.0 years. In both the age groups, significantly higher use was seen in males compared to females. Males in 2.0 - 2.6 years used stopping and 2.6-3.0 year old used geminate cluster reduction, lateralization and monophthongisation than females. Study revealed equal use of process in both genders in 3.0-3.6 years also reported by Poole (1934). No significant gender issues in 3.0-3.6 years indicated that males and females using the processes equally at higher ages. Thus gender differences were found in younger groups, after which they performed equally in speech-language skills. This suggested that younger females simplified adult target words lesser compared to younger males indicating an advantage for females over males below 3 years of age. This advantage is supported by various studies (Winitz, 1969; Maccoby and Jacklin, 1974; McCormack and Knighton, 1996). This lead for girls could be attributed to biological differences in structure of brain organisation (Kail, 1993). Fenson, Dale, Reznick, Bates, Thal and Pethick (1994) also reported a variation of 1-2% between gender in language development in 06-30 month old children.

b) In boys, 14 processes occurred significantly higher in 2.0-2.6 years compared to 2.6-3.0 years old boys, 17 processes occurred significantly higher in 2.6-3.0 years compared to 3.0-3.6 years and 24 processes were highly occurring in 3.0-3.6 years compared to 2.0-2.6 years.

c) In girls, 14 processes occurred higher in 2.6-3.0 years compared to 2.0-2.6 years, 14 processes occurred significantly higher in 2.6-3.0 years compared to 3.0-3.6 years and 23 processes were highly occurring in 3.0-3.6 years compared to 2.0-2.6 years.

Results of Phase II

Phase II of the present study aimed to develop a software to assist the clinician in assessing the phonological processes automatically with a minimum effort. Based on the administration of the Kannada Diagnostic photo Articulation Test (Deepa & Savithri, 2010) on 60 children each in the age range of 2.0 - 2.6 years, 2.6- 3.0 years and 3.0 - 3.6 years, a word list was developed for inclusion in the software. All 59 words were erroneously by 2.0-2.6 year old children, 63 words out of 67 words were errored by 2.6-3.0 year old children and 56 words out of 67 target words were produced erroneously by 3.0-3.6 year old children. Tables 4.12 (a), (b) and (c) shows number of children producing the incorrect responses for KDPAT test words out of the 60 children tested in each of the 3 age groups.

Table 4.12 (a):

The number of children producing incorrect responses in 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		
		Males	Females	Total			Males	Females	Total
1.	/aώ ώ I/	14	20	34	31	/aᆨligemane/	28	26	54
2.	/a:ne/	8	2	10	32	/a:spaẗre/	30	29	59
3.	/ili/	12	8	20	33	/Iruve/	29	27	56
4.	/i:rUᆨI/	30	30	60	34	/i:ᆨgemaÆe/	28	27	55
5.	/uÆgura/	28	28	56	35	/ujja:le/	22	20	42
6.	/u:ẗa/	26	29	55	36	/u:ru/	29	27	56
7.	/ele/	14	9	23	37	/eraᆨu/	29	29	58
8.	/e:ᆨu/	26	24	50	38	/e:ÆI/	23	19	42
9.	/aidu/	20	18	38	39	/aivaẗẗu/	27	24	51
10.	/onẗe/	26	23	49	40	/onᆨu/	8	6	14
11.	/o:le/	17	12	29	41	/o:ᆨu/	17	20	37
12.	/auώd a/	27	30	57	42	/ka:ru/	28	27	55
13.	/kaẗẗari/	30	29	59	43	/saIkallu/	29	29	58
14.	/bekku/	11	6	17	44	/ga:ᆨpaẗa/	28	26	54
15.	/gaᆨIja:ra/	30	30	60	45	/ka:ge/	15	25	40
16.	/mu:gu/	17	16	33	46	/ẗabala/	13	12	25
17	/ẗaẗẗe/	28	28	56	47	/kaẗẗe/	18	10	28
18.	/ko:ẗi/	7	4	11	48	/ᆨo:se/	12	11	23
19.	/ᆨa:ra/	29	26	55	49	/go:ᆨI/	18	16	34
20.	/kuᆨure/	29	26	55	50	/na:ji/	1	2	3
21	/nalli/	14	9	23	51	/mi:nu/	2	8	10
22	/devasẗa:na/	29	23	52	52	/pennu/	2	4	6
23	/pu:ri/	28	24	52	53	/ώủppůli/	29	21	50
24	/kappe/	7	10	17	54	/bůssu/	18	15	33
25	/ba:gilu/	23	21	44	55	/dImbu/	16	15	31
26	/kabbu/	12	18	30	56	/mu:ru/	28	25	53
27	/mane/	3	4	7	57	/a:me/	1	0	1
28	/jamme/	10	10	20	58	/jantra/	29	28	57
29	/jakώga:na/	30	29	59	59	/kůᆨůlekůI/	29	28	57
30	/tủnginak i/	26	26	52					

Table 4.12 (b):

The number of children producing incorrect responses in 2.6-3.0 years age group

SL.No.	Words	No of children with incorrect production			SL.No	Words	No of children with incorrect production		
		Males	Females	Total			Males	Females	Total
1.	/aϕ̹ ϕ̹ I/	14	8	22	35	/a˧ligemane/	19	17	36
2.	/a:ne/	0	0	0	36	/a:spaȉre/	27	24	51
3.	/ili/	4	2	6	37	/Iruve/	23	20	43
4.	/i:rU˩˩I/	26	23	49	38	/i:˧lgemaǼe/	29	26	55
5.	/uǼgura/	23	22	45	39	/ujja:le/	13	13	26
6.	/u:ȉa/	19	21	40	40	/u:ru/	26	21	47
7.	/ele/	6	1	7	41	/era˧lu/	25	27	52
8.	/e:˧u/	9	11	20	42	/e:ǼL/	20	21	41
9.	/aid u/	7	5	12	43	/aivaȉȉu/	15	9	24
10.	/onȉe/	16	19	35	44	/on˧lu/	3	1	4
11.	/o:le/	6	3	9	45	/o:˧lu/	12	13	25
12.	/auόad a/	19	15	34	46	/ka:ru/	22	21	43
13.	/kaȉȉari/	26	25	51	47	/saIkallu/	12	12	24
14.	/bekku/	3	1	4	48	/ga:˧paȉa/	18	21	39
15.	/ga˧Ija:ra/	27	24	51	49	/ka:ge/	10	11	21
16.	/mu:gu/	10	4	14	50	/ȉabala/	6	8	14
17	/ȉaȉȉe/	25	24	49	51	/kaȉȉe/	7	1	8
18.	/ko:ȉi/	1	0	1	52	/˧o:se/	11	8	19
19.	/˧a:ra/	27	24	51	53	/go:˧I/	16	11	27
20.	/ku˧ure/	26	21	47	54	/na:ji/	0	0	0
21	/nalli/	4	2	6	55	/mi:nu/	0	0	0
22	/devasȉa:na/	20	17	37	56	/pennu/	0	0	0
23	/pu:ri/	24	22	46	57	/ϕ̹ủppủli/	14	12	26
24	/kappe/	4	0	4	58	/bủssu/	11	10	21
25	/ba:gilu/	14	7	21	59	/dImbu/	10	7	17
26	/kabbu/	13	15	28	60	/mu:ru/	22	19	41
27	/mane/	1	0	1	61	/a:me/	0	1	1
28	/jamme/	4	0	4	62	/jantra/	22	22	44
29	/jakόaga:na/	30	27	57	63	/kủ˧ủlekủI/	25	21	46
30	/tủnginak i/	14	19	33	64	/vi:Ǽe/	24	23	47
31	/vǿna:na/	16	10	26	65	/hu:vu/	1	0	1
32	/kivi/	3	0	3	66	/langa/	7	2	9
33	/lo:ȉa/	11	15	26	67	/go:lI/	21	16	37
34	/hallu/	7	6	13					

Table 4.12 (c):

The number of children producing incorrect responses in 3.0 - 3.6 years age group

SL.No.	Words	No of children with incorrect production			SL.No	Words	No of children with incorrect production		
		Males	Females	Total			Males	Females	Total
1.	/aώ ώ I/	2	3	5	35	/a˧ligemane/	6	8	14
2.	/a:ne/	0	0	0	36	/a:spaȉre/	15	20	35
3.	/ili/	0	1	1	37	/Iruve/	13	5	18
4.	/i:rU˩ɫ/	16	13	29	38	/i:˧lgemaǼe/	14	7	21
5.	/uǼgura/	11	13	24	39	/ujja:le/	4	5	9
6.	/u:ȉa/	8	5	13	40	/u:ru/	19	9	28
7.	/ele/	0	0	0	41	/era˧lu/	12	21	33
8.	/e:˩u/	2	2	4	42	/e:ǼL/	21	10	31
9.	/aid u/	1	0	1	43	/aivaȉȉu/	3	3	6
10.	/onȉe/	2	4	6	44	/on˧lu/	0	1	1
11.	/o:le/	1	0	1	45	/o:˧lu/	2	2	4
12.	/auώad a/	5	4	9	46	/ka:ru/	8	12	20
13.	/kaȉȉari/	14	19	33	47	/saIkallu/	1	0	1
14.	/bekku/	0	1	1	48	/ga:˧paȉa/	10	7	17
15.	/ga˧lIja:ra/	21	16	37	49	/ka:ge/	5	1	6
16.	/mu:gu/	3	2	5	50	/ȉabala/	3	1	4
17	/ȉaȉȉe/	6	7	13	51	/kaȉȉe/	0	0	0
18.	/ko:ȉi/	0	0	0	52	/˧lo:se/	2	2	4
19.	/˧la:ra/	16	10	26	53	/go:˧lI/	11	9	20
20.	/ku˧lure/	12	17	29	54	/na:ji/	0	0	0
21	/nalli/	0	0	0	55	/mi:nu/	0	0	0
22	/devasȉa:na/	7	6	13	56	/pennu/	0	0	0
23	/pu:ri/	12	11	23	57	/ώủppủli/	5	2	7
24	/kappe/	1	0	1	58	/bủssu/	3	2	5
25	/ba:gilu/	4	1	5	59	/dImbu/	3	2	5
26	/kabbu/	4	1	5	60	/mu:ru/	15	12	27
27	/mane/	0	0	0	61	/a:me/	0	0	0
28	/jamme/	0	0	0	62	/jantra/	15	20	35
29	/jakώaga:na/	16	14	30	63	/kủ˧lủlekủI/	12	12	24
30	/tủnginak i/	2	1	3	64	/vi:Ǽe/	15	7	22
31	/vӧna:na/	3	2	5	65	/hu:vu/	1	0	1
32	/kivi/	1	0	1	66	/langa/	2	2	4
33	/lo:ȉa/	2	8	10	67	/go:lI/	9	7	16
34	/hallu/	1	0	1					

The percentage of children using the process was calculated for each of the 3 age groups as shown in Tables 4.13 (a), (b) and (c).

Table 4.13 (a):

The percentage of children producing incorrect responses in 2.0 - 2.6 years age group

SL.No.	Words	Percentage of children with incorrect production	SL.No	Words	Percentage of children with incorrect production
1.	/aǿ ǿ I/	57	31	/a˧ligemane/	90
2.	/a:ne/	17	32	/a:spaῖre/	98
3.	/ili/	33	33	/Iruve/	93
4.	/i:rU˧˩/	100	34	/i:˧lgemaǼe/	92
5.	/uǼgura/	93	35	/ujja:le/	70
6.	/u:ῖa/	92	36	/u:ru/	93
7.	/ele/	38	37	/era˧lu/	97
8.	/e:˧u/	83	38	/e:ǼL/	70
9.	/aidu/	63	39	/aivaῗῗu/	85
10.	/onῖe/	82	40	/on˧lu/	23
11.	/o:le/	48	41	/o:˧lu/	62
12.	/auǿad a/	95	42	/ka:ru/	92
13.	/kaῗῗari/	98	43	/saIkallu/	97
14.	/bekku/	28	44	/ga:˧paῖa/	90
15.	/ga˧Ija:ra/	100	45	/ka:ge/	67
16.	/mu:gu/	55	46	/ῖabala/	42
17	/ῖaῗῗe/	93	47	/kaῗῗe/	47
18.	/ko:ῗi/	18	48	/˧lo:se/	38
19.	/˧la:ra/	92	49	/go:˧lI/	57
20.	/ku˧lure/	92	50	/na:ji/	5
21	/nalli/	38	51	/mi:nu/	17
22	/devasῖa:na/	87	52	/pennu/	10
23	/pu:ri/	87	53	/ǿủppủli/	83
24	/kappe/	28	54	/bủssu/	55
25	/ba:gilu/	73	55	/dImbu/	52
26	/kabbu/	50	56	/mu:ru/	88
27	/mane/	12	57	/a:me/	2
28	/jamme/	33	58	/jantra/	95
29	/jakǿaga:na/	98	59	/kủ˧lủlekủI/	95
30	/tủnginak i/	87			

Table 4.13 (b):

The percentage of children producing incorrect responses in 2.6-3.0 years age group

SL.No.	Words	Percentage of children with incorrect production	SL.No	Words	Percentage of children with incorrect production
1.	/aῳ ῳ I/	37	35	/a˥igemane/	60
2.	/a:ne/	0	36	/a:spaȉre/	85
3.	/ili/	10	37	/Iruve/	72
4.	/i:rU˩˩/	82	38	/i:˧gemaǼe/	92
5.	/uǼgura/	75	39	/ujja:le/	43
6.	/u:ȉa/	67	40	/u:ru/	78
7.	/ele/	12	41	/era˥u/	87
8.	/e:˧u/	33	42	/e:ǼL/	68
9.	/aid u/	20	43	/aivaȉȉu/	40
10.	/onȉe/	58	44	/on˦u/	7
11.	/o:le/	15	45	/o:˥u/	42
12.	/auώd a/	57	46	/ka:ru/	72
13.	/kaȉȉari/	85	47	/saIkallu/	40
14.	/bekku/	67	48	/ga:˧baȉa/	65
15.	/ga˥Ija:ra/	85	49	/ka:ge/	35
16.	/mu:gu/	23	50	/ȉabala/	23
17	/ȉaȉȉe/	82	51	/kaȉȉe/	13
18.	/ko:ȉi/	2	52	/˦o:se/	32
19.	/˦a:ra/	85	53	/go:˦I/	45
20.	/ku˦ure/	78	54	/na:ji/	0
21	/nalli/	10	55	/mi:nu/	0
22	/devasȉa:na/	62	56	/pennu/	0
23	/pu:ri/	77	57	/ῷůppůli/	43
24	/kappe/	7	58	/bůssu/	35
25	/ba:gilu/	35	59	/dImbu/	28
26	/kabbu/	47	60	/mu:ru/	68
27	/mane/	2	61	/a:me/	2
28	/jamme/	7	62	/jantra/	73
29	/jakώga:na/	95	63	/ků˥ůlekůI/	77
30	/tůnginak i/	55	64	/vi:Ǽe/	78
31	/vǒna:na/	43	65	/hu:vu/	2
32	/kivi/	5	66	/langa/	15
33	/lo:ȉa/	43	67	/go:lI/	62
34	/hallu/	22			

Table 4.13 (c):

The percentage of children producing incorrect responses in 3.0 - 3.6 years age group

SL.No.	Words	Percentage of children with incorrect production	SL.No	Words	Percentage of children with incorrect production
1.	/aῳ ῳ I/	8	35	/aᆟigemane/	23
2.	/a:ne/	0	36	/a:spaẗre/	58
3.	/ili/	2	37	/Iruve/	30
4.	/i:rUꜜꜜl/	48	38	/i:ꜜlgemaǼe/	35
5.	/uǼgura/	40	39	/ujja:le/	15
6.	/u:ẗa/	22	40	/u:ru/	47
7.	/ele/	0	41	/eraᆟu/	55
8.	/e:ꜜu/	7	42	/e:ǼL/	52
9.	/aid u/	2	43	/aivaẗẗu/	10
10.	/onẗe/	10	44	/onᆟu/	2
11.	/o:le/	2	45	/o:ᆟu/	7
12.	/auǿad a/	15	46	/ka:ru/	33
13.	/kaẗẗari/	55	47	/saIkallu/	2
14.	/bekku/	2	48	/ga:ꜜpaẗa/	28
15.	/gaᆟIja:ra/	62	49	/ka:ge/	10
16.	/mu:gu/	8	50	/ẗabala/	7
17	/ẗaẗẗe/	22	51	/kaẗẗe/	0
18.	/ko:ẗi/	0	52	/ᆟo:se/	7
19.	/ᆟa:ra/	43	53	/go:ᆟI/	33
20.	/kuᆟure/	48	54	/na:ji/	0
21	/nalli/	0	55	/mi:nu/	0
22	/devasẗa:na/	22	56	/pennu/	0
23	/pu:ri/	38	57	/ῳủppủli/	12
24	/kappe/	2	58	/bủssu/	8
25	/ba:gilu/	8	59	/dImbu/	8
26	/kabbu/	8	60	/mu:ru/	45
27	/mane/	0	61	/a:me/	0
28	/jamme/	0	62	/jantra/	58
29	/jakǿaga:na/	50	63	/kủᆟủlekủI/	40
30	/tủnginak i/	5	64	/vi:Ǽe/	37
31	/vǿma:na/	8	65	/hu:vu/	2
32	/kivi/	2	66	/langa/	7
33	/lo:ẗa/	17	67	/go:lI/	27
34	/hallu/	2			

The percentage of children using the processes were arranged in descending order i.e., from the most erroneously produced word to the least erroneously produced test word starting from 100% to 0% for each of the 3 age groups as shown in Tables 4.14 (a), (b) and (c).

Table 4.14 (a):

The percentage of children producing incorrect responses in 2.0 - 2.6 years age group in descending order

Sl. no.	Words	Percentage of children with incorrect production	Sl. no	Words	Percentage of children with incorrect production
1.	/i:rU˧ɭl/	100	31	/ujja:le/	70
2.	/ga˥Ija:ra/	100	32	/e:ǼL/	70
3.	/kaᴵᴵ̋ari/	98	33	/ka:ge/	67
4.	/jakώga:na/	98	34	/aidu/	63
5.	/a:spaᴵ̋re/	98	35	/o:˥u/	62
6.	/era˥u/	97	36	/aῴ ῴ I/	57
7.	/saIkallu/	97	37	/go:˧I/	57
8.	/auώd a/	95	38	/mu:gu/	55
9.	/jantra/	95	39	/bủssu/	55
10.	/kủ˥ủlekủI/	95	40	/dImbu/	52
11.	/uǼgura/	93	41	/kabbu/	50
12.	/ᴵ̋aᴵᴵ̋e/	93	42	/o:le/	48
13.	/Iruve/	93	43	/kaᴵᴵ̋e/	47
14.	/u:ru/	93	44	/ᴵ̋abala/	42
15.	/u:ᴵ̋a/	92	45	/ele/	38
16.	/˧a:ra/	92	46	/nalli/	38
17	/ku˧ure/	92	47	/˧o:se/	38
18.	/i:˧gemaǼe/	92	48	/ili/	33
19.	/ka:ru/	92	49	/jamme/	33
20.	/a˥igemane/	90	50	/bekku/	28
21	/ga:˧þaᴵ̋a/	90	51	/kappe/	28
22	/mu:ru/	88	52	/on˧u/	23
23	/devasᴵ̋a:na/	87	53	/ko:ᴵ̋i/	18
24	/pu:ri/	87	54	/a:ne/	17
25	/tủnginak i/	87	55	/mi:nu/	17
26	/aivaᴵᴵ̋u/	85	56	/mane/	12
27	/e:˧u/	83	57	/pennu/	10
28	/ῴủppủli/	83	58	/na:ji/	5
29	/onᴵ̋e/	82	59	/a:me/	2
30	/ba:gilu/	73			

Table 4.14 (b):

The percentage of children producing incorrect responses in 2.6-3.0 years age group in descending order

SL.No.	Words	Percentage of children with incorrect production	SL.No	Words	Percentage of children with incorrect production
1.	/jakớaga:na/	95	35	/ộủppủli/	43
2.	/i:ɻlgemaǼe/	92	36	/o:˥lu/	42
3.	/era˥lu/	87	37	/aivaǖǖu/	40
4.	/kaǖǖari/	85	38	/saIkallu/	40
5.	/ga˥lIja:ra/	85	39	/aộ ộ I/	37
6.	/˦la:ra/	85	40	/ba:gilu/	35
7.	/a:spaǖre/	85	41	/ka:ge/	35
8.	/i:rUɻǐl/	82	42	/bủssu/	35
9.	/ǖaǖǖe/	82	43	/e:ɻu/	33
10.	/ku˦lure/	78	44	/˦lo:se/	32
11.	/u:ru/	78	45	/dImbu/	28
12.	/vi:Ǽe/	78	46	/mu:gu/	23
13.	/pu:ri/	77	47	/ǖabala/	23
14.	/kủ˥lủlekủI/	77	48	/hallu/	22
15.	/uǼgura/	75	49	/aid u/	20
16.	/jantra/	73	50	/o:le/	15
17	/Iruve/	72	51	/langa/	15
18.	/ka:ru/	72	52	/kaǖǖe/	13
19.	/e:ǼL/	68	53	/ele/	12
20.	/mu:ru/	68	54	/ili/	10
21	/u:ǖa/	67	55	/nalli/	10
22	/bekku/	67	56	/kappe/	7
23	/ga:ɻpaǖa/	65	57	/jamme/	7
24	/devasǖa:na/	62	58	/on˦lu/	7
25	/go:lI/	62	59	/kivi/	5
26	/a˥ligemane/	60	60	/ko:ǖi/	2
27	/onǖe/	58	61	/mane/	2
28	/auớad a/	57	62	/a:me/	2
29	/tủnginak i/	55	63	/hu:vu/	2
30	/kabbu/	47	64	/a:ne/	0
31	/go:˦lI/	45	65	/na:ji/	0
32	/vớna:na/	43	66	/mi:nu/	0
33	/lo:ǖa/	43	67	/pennu/	0
34	/ujja:le/	43			

Table 4.14 (c):

The percentage of children producing incorrect responses in 3.0-3.6 years age group in descending order

SL.No.	Words	Percentage of children with incorrect production	SL.No	Words	Percentage of children with incorrect production
1.	/ga˥lIja:ra/	62	35	/mu:gu/	8
2.	/a:spaẗre/	58	36	/ba:gilu/	8
3.	/jantra/	58	37	/kabbu/	8
4.	/kaẗẗari/	55	38	/vǒma:na/	8
5.	/era˥u/	55	39	/bủssu/	8
6.	/e:ÁL/	52	40	/dImbu/	8
7.	/jakớaga:na/	50	41	/e:˧u/	7
8.	/i:rU˧i/	48	42	/o:˥u/	7
9.	/ku˧ure/	48	43	/ẗabala/	7
10.	/u:ru/	47	44	/˧o:se/	7
11.	/mu:ru/	45	45	/langa/	7
12.	/˧a:ra/	43	46	/tủnginak i/	5
13.	/uÁgura/	40	47	/ili/	2
14.	/kủ˥ủlekủI/	40	48	/aid u/	2
15.	/pu:ri/	38	49	/o:le/	2
16.	/vi:Áe/	37	50	/bekku/	2
17	/i:˧gemaÁe/	35	51	/kappe/	2
18.	/ka:ru/	33	52	/kivi/	2
19.	/go:˧I/	33	53	/hallu/	2
20.	/Iruve/	30	54	/on˧u/	2
21	/ga:˧paẗa/	28	55	/saIkallu/	2
22	/go:lI/	27	56	/hu:vu/	2
23	/a˥igemane/	23	57	/a:ne/	0
24	/u:ẗa/	22	58	/ele/	0
25	/ẗaẗẗe/	22	59	/ko:ẗi/	0
26	/devasẗa:na/	22	60	/nalli/	0
27	/lo:ẗa/	17	61	/mane/	0
28	/auớad a/	15	62	/jamme/	0
29	/ujja:le/	15	63	/kaẗẗe/	0
30	/ῴủppủli/	12	64	/na:ji/	0
31	/onẗe/	10	65	/mi:nu/	0
32	/aivaẗẗu/	10	66	/pennu/	0
33	/ka:ge/	10	67	/a:me/	0
34	/aῴ ῴ I/	8			

After the target words were arranged in descending order, it was found that all 59 words were incorrectly produced in younger age group of 2.0-2.6 years and the percentage of children with incorrect productions ranged from 100% to 2%. In 2.6-3.0 years, 4 out of 67 test words were correctly produced and the percentage of children incorrectly producing the target words ranged from 95% to 0%. In the older age group, 11 words out of 67 test words were correctly produced and the error percentage reduced to 62%. This implies that as age increased, phonological organization and articulatory skills developed, hence children errored on fewer words.

From descending order list, all the words which were produced incorrectly by less than 20% of the children (criteria given by Haelsig & Madison, 1986 and Roberts et al, 1990) were selected for the software tool preparation with the idea that errors in >20% of children represented typical developmental errors in that age group. Thus the test words selected for developing software that have high probability to be accurate in typical population and if errored by any child is considered unusal or non developmental error for that language age. Thus based on less than 20% criterion, 7, 15, and 30 words were selected for 2.0-2.6 years, 2.6-3.0, and 3.0-3.6 years respectively. It is noted that test words in younger age group was lower because high proportion of test words were errorred by >20% of 2.0-2.6 year old children. Thus less words were errorred in <20% of the children in this age group. With increase in age, majority of children errored on less test words, hence more words were included under the criterion of <20% of children producing incorrectly.

Hence, 7, 15, and 30 words were selected for including in the software in 2.0-2.6 years, 2.6-3.0, and 3.0-3.6 years respectively. The words along with frequent and common variations of the target words were also selected. Tables 4.14 (a), (b) and (c) shows all the words selected based on less than 20% criteria with the various patterns in the children in the age range of 2.0 - 2.6 years, 2.6 - 3.0 years and 3.0-3.6 years. The number within the brackets indicates the number of children producing such patterns.

Table 4.15 (a):

Various patterns of productions observed for the selected target words in the 2.0 - 2.6 years age range with frequency of production in bracket

Sl.No	Target word	1	2	3	4	5
1	/ko:ʈ̈i/	/ʈ̈o:ʈ̈i/ (4)	/o:ʈ̈i/ (3)	/ʈ̈i/ (2)	/ ʈ̈i:ʈ̈i/ (1)	
2	/a:ne/	/a:e/ (5)	/a:ɳe/ (1)			
3	/mi:nu/	/i:nu/ (7)	/mi:u/ (2)	/mi:du/ (1)		
4	/mane/	/ane/ (5)	/mae/ (1)	/ale/ (1)	/male/ (1)	/maɳe/ (1)
5	/pennu/	/ennu/ (3)	/penu/ (1)	/bennu/ (1)	/enu/ (1)	
6	/na:ji/	/a:ji/ (1)	/ɖa:ji/ (1)	/ʈ̈a:ji/ (1)		
7	/a:me/	/a:e/ (1)				

Table 4.15 (b):

Various patterns of productions observed for the selected target words in the 2.6-3.0 years age range with frequency of production in bracket

Sl.No	Target word	1	2	3	4	5
1	/aiɭu/	/a:ɭu/ (7)	/e:ɭu/ (2)	/a:ʈ̈u/ (2)	/aiʈ̈u/ (1)	/aʈ̈u/ (1)
2	/o:le/	/o:e/ (7)	/o:je/ (2)	/o:ke/ (1)	/o: ɭe/ (1)	/o: ʈ̈e/ (1)
3	/langa/	/anga/ (6)	/lanka/ (2)	/laka/(2)	/nanga/(1)	
4	/kaʈ̈ʈ̈e/	/kaʈ̈e/(4)	/ʈ̈aʈ̈ʈ̈e/(2)	/aʈ̈ʈ̈e/(2)		
5	/ele/	/ee/(6)	/eje/(1)			
6	/ili/	/iɖi/(2)	/ii/(2)	/li/(1)	/ini/(1)	
7	/nalli/	/nali/(3)	/alli/(3)	/nanni/(1)		
8	/kappe/	/appe/(2)	/kaʈ̈ʈ̈e/(1)	/ʈ̈appe/(1)		
9	/jamme/	/jame/(2)	/amme/(2)			
10	/onɭu/	/onu/(3)	/oɭu/(1)			
11	/kivi/	/ivi/(2)	/kibi/(1)	/ʈ̈ivi/(1)		
12	/ko:ʈ̈i/	/o:ʈ̈i/(1)	/ʈ̈o:ʈ̈i/(1)			
13	/mane/	/mae/(1)	/maÆe/(1)			
14	/a:me/	/a:ne/(1)				
15	/hu:vu/	/u/(1)				

Table 4.15 (c):

Various patterns of productions observed for the selected target words in the 3.0 - 3.6 years age range with frequency of production in bracket

Sl.No	Target word	1	2	3	4	5
1	/lo:ʈ̋a/	/lo: ʈ̋a/(9+2)	/o:ʈ̋a/(1)	/o:ta/		
2	/auɖa˦la/	/ʹƟɖa˦la/(6)	/auɖ̤a˦la/(2)	/aɖa˦la/(1)	/asa˦la/(1)	
3	/uja:le/	/uva:le/(4)	/ula:le/(2)	/ula:je/(2)	/uja:je/(2)	
4	/ɖ̤ủppủli/	/ʈ̋ủppẠli/(6)	/ɖ̤ủppi/(1)	/ʈ̋ủppi/(1)		
5	/onʈ̋e/	/onʈ̋e/(6)	/onde/(1)	/ote/(1)	/ote/(1)	
6	/aivaʈ̋ʈ̋u/	/avaʈ̋ʈ̋u/(4)	/aijaʈ̋ʈ̋u/(1)	/aiʈ̋ʈ̋u/(1)		
7	/ka:ge/	/ka:ke/(6)	/ka:ʈ̋e/(1)	/ka:e/(1)		
8	/aɖ̤ ɖ̤ I/	/aɖ̤ɖ̤I/(5)	/addI/(1)			
9	/mu:gu/	/mu:ku/(4)	/mu:du/(1)			
10	/ba:gilu/	/ba:ku/(2)	/ba:gu/(2)	/ba:lu/(1)	/ba:giu/(1)	
11	/kabbu/	/kappu/(3)	/kabu/(1)	/kaʈ̋u/(1)		
12	/vɖ̋ma:na/	/vɖ̋va:na/(2)	/bɖ̋ma:na/(2)	/ɖ̋ma:na/(1)	/vɖ̋a:na/(1)	
13	/bủssu/	/bủʈ̋ʈ̋u/(4)	/bủɖu/(1)			
14	/dImbu/	/ʈ̋Imbu/(3)	/dImpu/(1)	/ʈ̋Imbu/(1)	/dipu/(1)	/dImu/(1)
15	/e:˧u/	/e:ju/(1)	/e:lu/(2)			
16	/o:˦lu/	/o:du/(4)	/o:u/(1)			
17	/ʈ̋abala/	/ʈ̋apala/(4)	/ʈ̋apla/(1)	/ʈ̋abaÑ/(1)		
18	/˦o:se/	/˦o:ʈ̋e/(4)	/˦o:ɖ̤e/(1)			
19	/langa/	/lanka/(2)	/landa/(1)	/nanga/(1)	/laʈ̋a/(1)	
20	/ʈ̋ủnginakai/	/ʈ̋ủnginaʈ̋ai/(2)	/ʈ̋ủn˦ikai/(1)	/ʈ̋ủn˦inaʈ̋ai/(1)	/ʈ̋ủn˦iakai/(1)	/ʈ̋ủnakai/(1)
21	/ili/	/idi/(1)	/ii/(1)			
22	/aidu/	/aiʈ̋u/(2)				
23	/o:le/	/o: de/(1)	/o: Ñe/(1)			
24	/bekku/	/beʈ̋ʈ̋u/(1)	/bakku/(1)			
25	/kappe/	/kape/(1)	/ʈ̋appe/(1)	/appe/(1)		
26	/kivi/	/ivi/(1)				
27	/hallu/	/allu/(2)				
28	/on˦u/	/onnu/(1)				
29	/saIkallu/	/ɖ̤aIkallu/(1)	/ʈ̋aIkallu/(2)	/ʈ̋eIkallu/(1)	/sekallu/ (1)	
30	/hu:vu/	/u/(1)	/u:u/(1)			

Thus most erroneous words along with its most commonly occurring patterns were prepared and the material was provided to a software professional at Thiruvananthapuram

(ENFIN Technologies India Pvt Ltd www.enfintechnologies.com), for the development of the assessment software CAPP-K.

Framework: The software application was developed using the Adobe Flash Builder 4.7 called an Adobe AIR application [SDK Version 2.6]. To run the software, CAPP-K, 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. The Adobe AIR framework (link for the download is http://get.adobe.com/air/) and winrar (http://www.rarlab.com/download.htm) was downloaded and installed. The application (CAPP-K) can be run in any computer provided the framework Adobe AIR is installed in the system intended for the assessment procedure. The application tool CAPP-K is available for testing in the form of a compact disk with the framework Adobe AIR.

Working: The steps for using CAPP-M are elaborated below.

Step1: Installation of framework: The framework is installed from the CAPP-K CD. After the installation, the software program (CAPP-K) is run by clicking the desktop icon ñCAPPKò.

Step 2: The opening page of the tool shows the name of the test along with the name, address and logo of the institute, authors and the funding agency (Fig. 4.16).

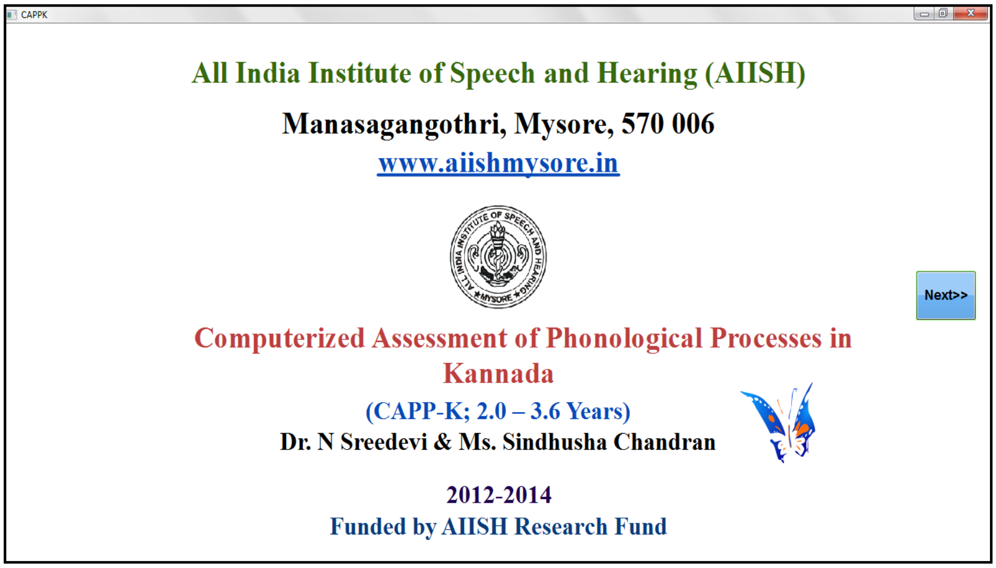


Fig 4.16. Shows the opening page of CAPP-K

Step 3: The option ónextô in the page provides access to move to the next page of the tool. Following the first page are brief introduction and instructions for the familiarization of the tool as seen in Fig 4.17 and 4.18. This provides the user a comprehensive and brief introduction regarding the use of CAPP-K.

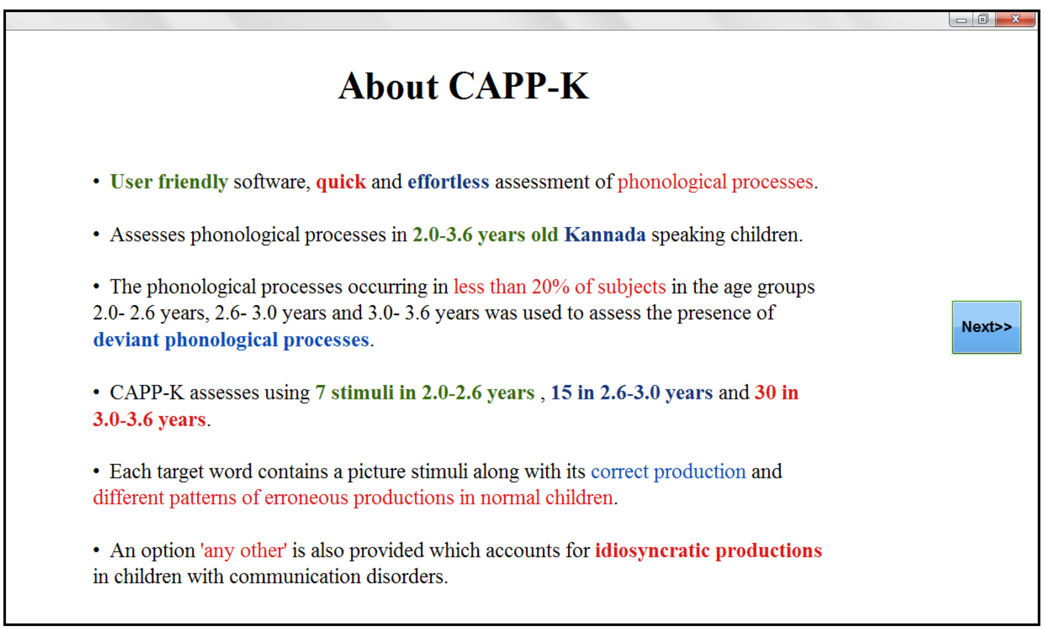


Fig 4.17. Shows the Introduction page of CAPP-K

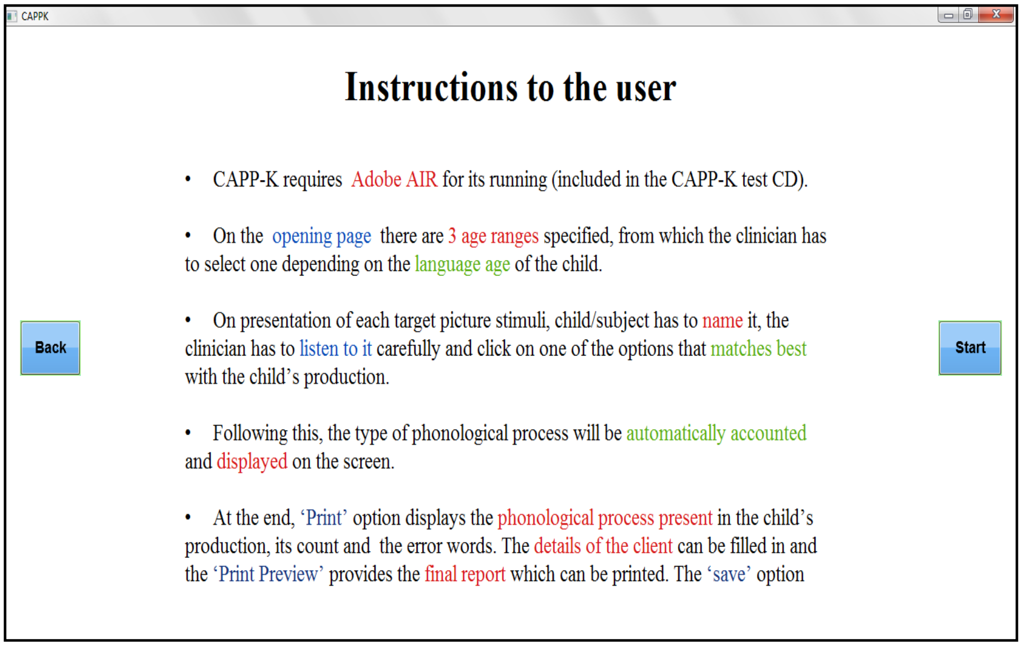


Fig 4.18: Shows the instruction page of CAPP-K

Step 4: The next page provides options to select the language age of the child to be tested to administer the tool. Language age of the child can be determined by administering the language assessment tools such as Receptive Expressive Emergent Language skills (REELS, Bzoch & League, 1991) or Three Dimensional Language Acquisition Test (3D LAT, Geetha Harlekar, 1986) or Scales for Early Communication Skills for Hearing Impaired children (SECS, Moog & Geers, 1975) or Computerized linguistic protocol for screening (CLiPS) (Anitha & Prema, 2004) or Three Dimensional Language Acquisition Test- Adapted (3D-LAT-ad) (Prema, Geetha & Mamatha, 2004). Based on language age of the child, clinician selects the appropriate language age range: 2.0 - 2.6 years or 2.6 - 3.0 years or 3.0 - 3.6 years as seen in Fig 4.19.

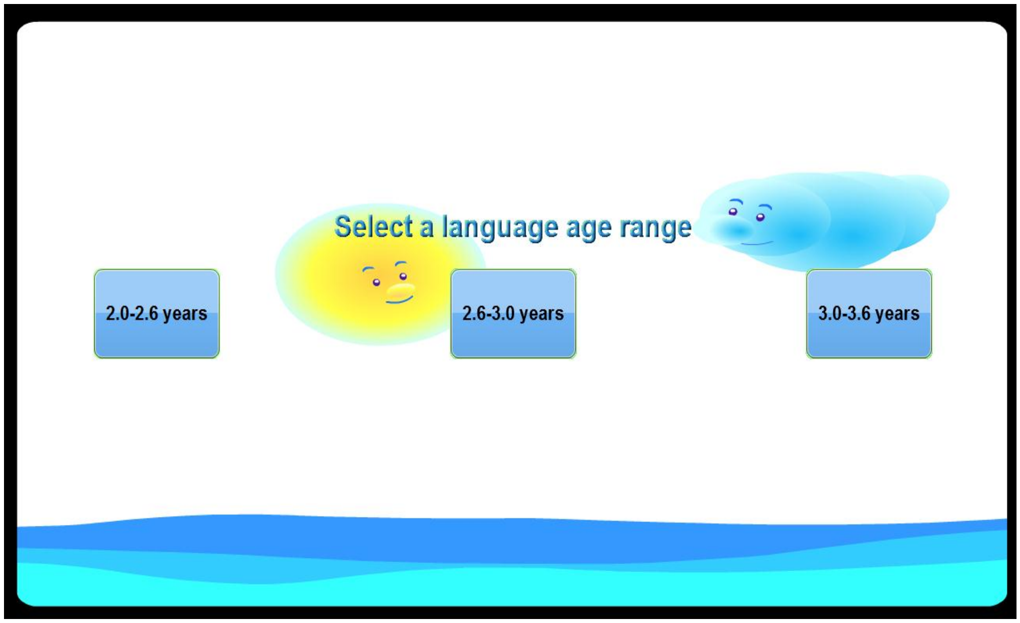


Fig 4.19: Shows the page of CAPP-K to select the language age of the child

Step 5: Once the language age range is selected, the test stimuli starts appearing on the screen automatically as seen in the Fig 4.20. A sample target word in the tool is displayed in picture form along with its various possible production patterns in typical children.

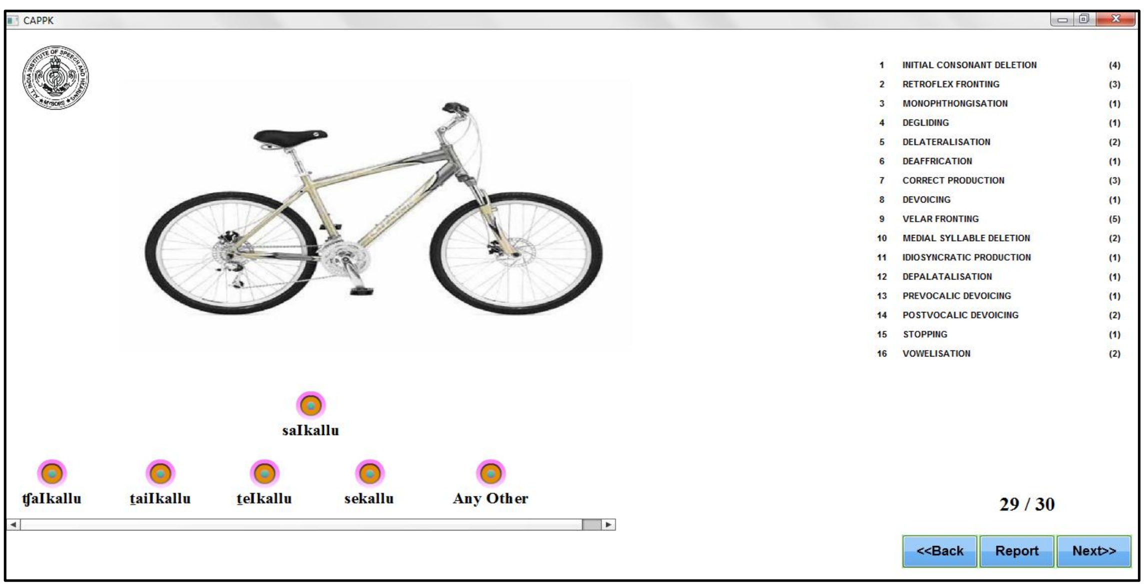


Fig 4.20: Shows a sample test page of CAPP-K

The screen contains the picture of the intended target word on the left. Below the picture are the correct production and other utterances shown in IPA symbols i.e. the four most possible patterns of the intended target word along with an option called ñAny otherò. The option ñAny otherò is for any other production by the subject which does not fall under the common patterns of production listed. The child to be tested is asked to name the picture stimulus. The clinician has to listen to the childôs 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; ñAny otherò. If ñAny otherò option is clicked, then the process is listed under the idiosyncratic process. The top right screen shows the phonological processes present in the child as and when the selection is made. Similarly the clinician tests all the test words present in CAPP-K of that particular language age.

Step 6: Towards the bottom right of the page, are two options: óBackô and óNextô. The option óNextô is to select the next stimulus in the tool. It has to be noted that only when at least one of the option for the target word is selected, the next test screen is displayed. The option óBackô aids in returning to the previous stimuli.

Step 7: Once the entire list of test words are administered, the page test completed will be displayed as seen in Fig 4.21.

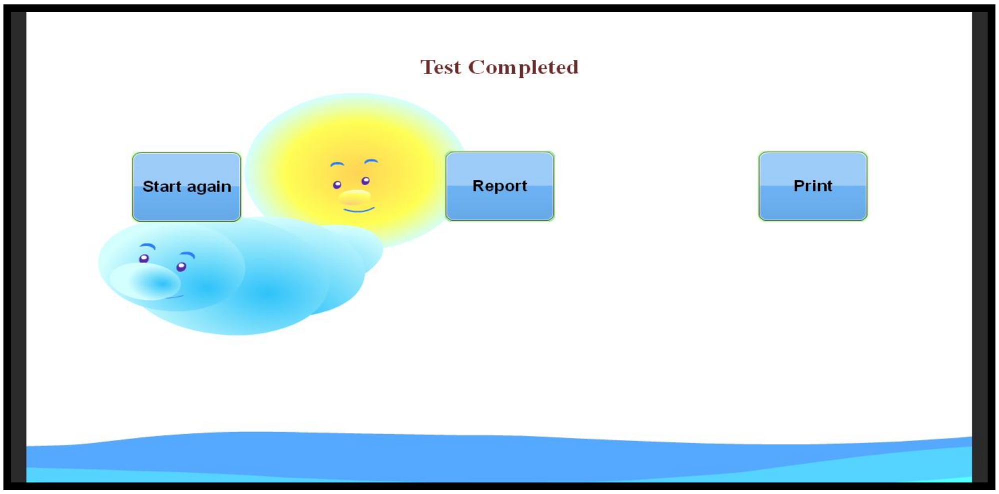


Fig 4.21: Shows a test completion page

This page has three options namely: óstart againô, óreportô and óprintô. The óStart againô option will help the clinician to go back to the page which displayed the age ranges for selection. The option óReportô displays the list of phonological processes identified in the child tested in the form of a graph as seen in the Fig 4.22.

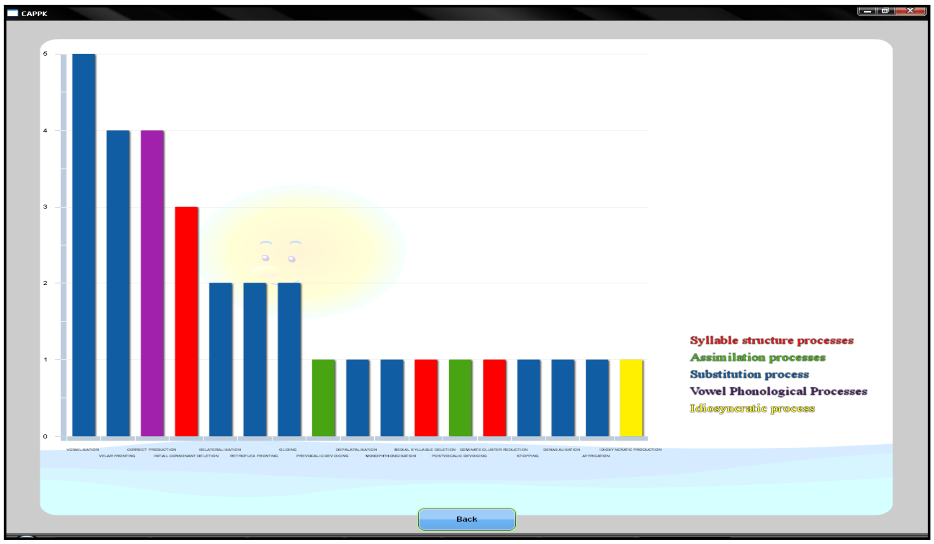


Fig 4.22: *Shows the report page of CAPP-K*

The graph generated by the tool is a representation of the count of deviant phonological processes operating in the child. The graph indicates what are the processes present, their frequency of occurrence and the category of the phonological process i.e; syllable structure/ assimilation / substitution / vowel processes / idiosyncratic processes. The next option is óPrintô which aids in taking a print or save the print sheet for documentation of the test results. When the óPrintô option is selected, a page is accessed in which the clinician needs to enter the demographic details of the child (Fig.4.23).

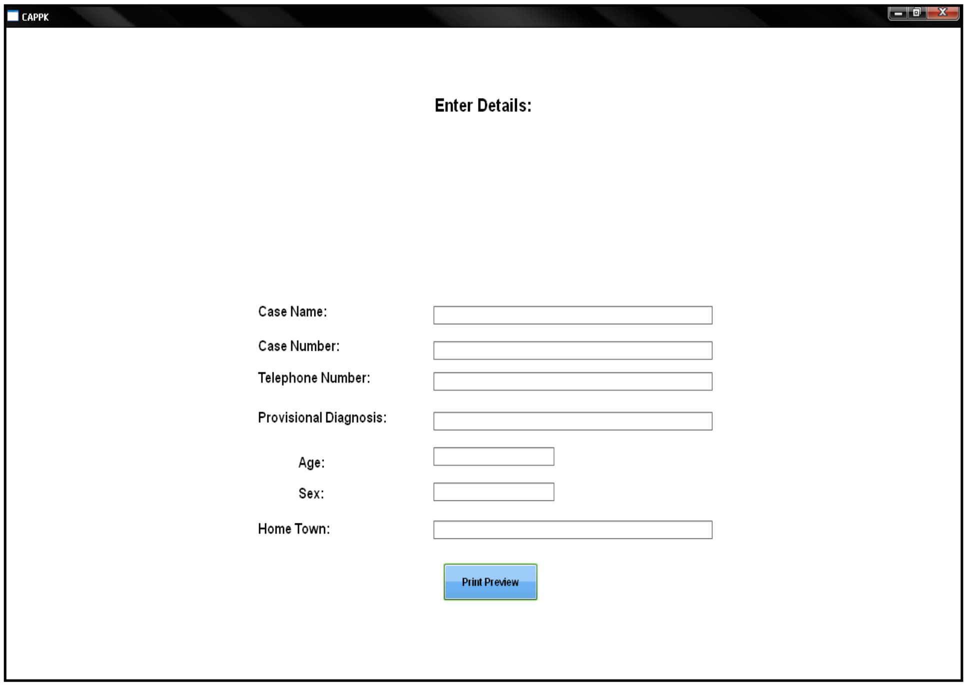


Fig 4.23: *Shows the page for the demographic details of the child tested*

The details include childǾs name, case number, telephone number, childǾs provisional diagnosis, age and gender along with name of the childǾs home town in Karnataka.

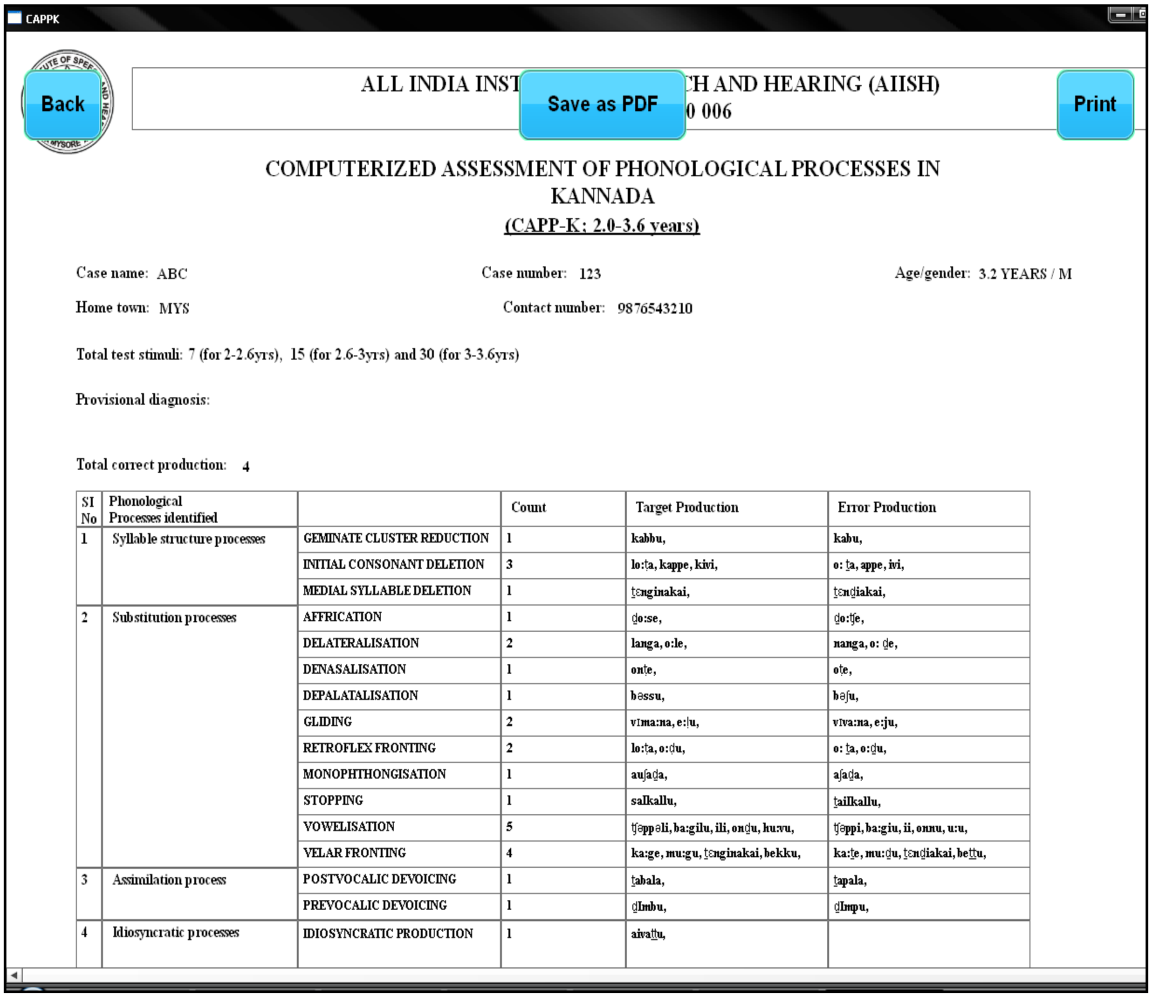
Step 8: After all the details are entered, the option ǿprint previewǿ needs to be clicked. The resulting page as shown in Fig 4.24 contains the following informations

a. All the demographic information entered in the previous step,

b. Tabulated list of phonological processes under the classification of categories: syllable structure, substitution, assimilation and idiosyncratic processes,

c. The number of times processes has occurred,

d. The target words errored and error production of the child.



CAPPK

Back

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Print

COMPUTERIZED ASSESSMENT OF PHONOLOGICAL PROCESSES IN KANNADA

(CAPP-K: 2.0-3.6 years)

Case name: ABC   Case number: 123   Age/gender: 3.2 YEARS / M

Home town: MYS   Contact number: 9876543210

Total test stimuli: 7 (for 2-2.6yrs), 15 (for 2.6-3yrs) and 30 (for 3-3.6yrs)

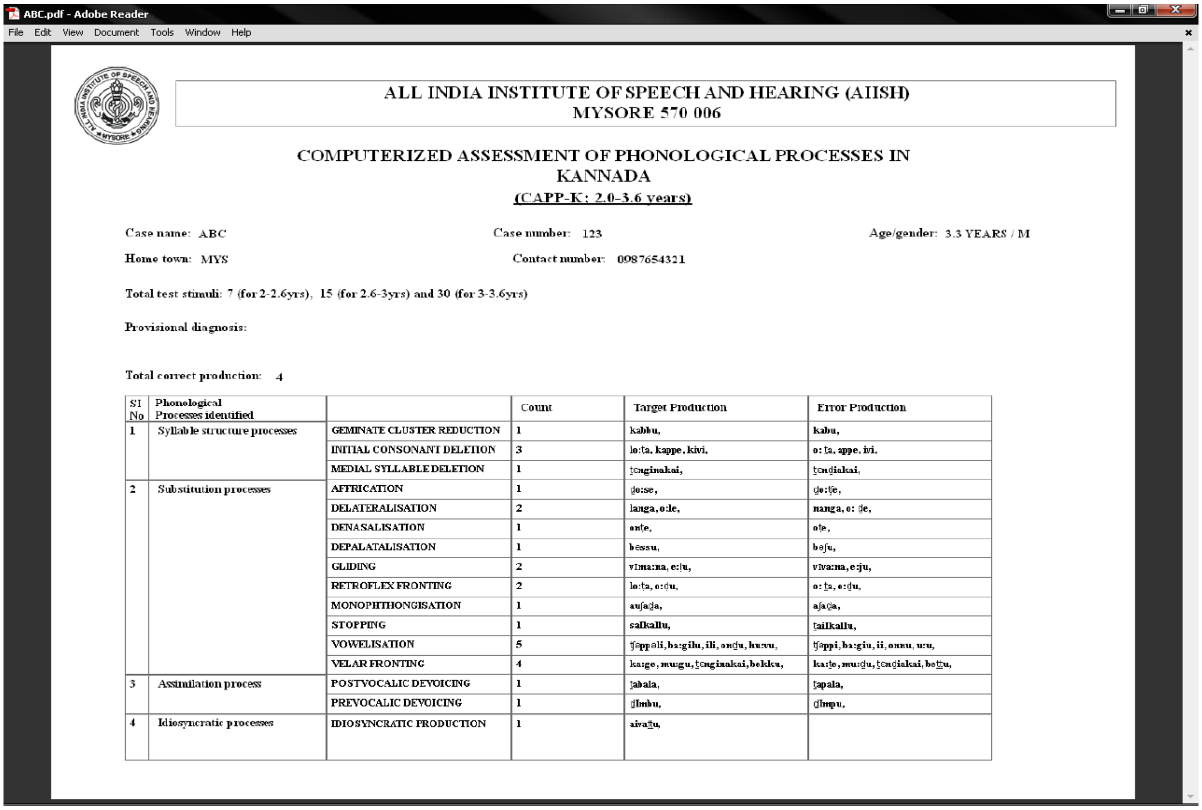
Provisional diagnosis:

Total correct production: 4

SI No	Phonological Processes identified		Count	Target Production	Error Production
1	Syllable structure processes	GEMINATE CLUSTER REDUCTION	1	kabbu,	kabu,
		INITIAL CONSONANT DELETION	3	lo:ṭa, kappe, kivi,	o: ṭa, appe, ivi,
		MEDIAL SYLLABLE DELETION	1	ṯɛnginakai,	ṯɛnḏiakai,
2	Substitution processes	AFFRICATION	1	ḏo:se,	ḏo:ʧe,
		DELATERALISATION	2	langa, o:le,	nanga, o: ḏe,
		DENASALISATION	1	onṭe,	oṭe,
		DEPALATALISATION	1	bəssu,	bəʃu,
		GLIDING	2	vɪma:na, e:ḷu,	vɪva:na, e:ju,
		RETROFLEX FRONTING	2	lo:ṭa, o:ḍu,	o: ṯa, o:ḏu,
		MONOPHTHONGISATION	1	auʃaḏa,	aʃaḏa,
		STOPPING	1	salkallu,	ṯailkallu,
		VOWELISATION	5	ʧəppəli, ba:gilu, ili, onḏu, hu:vu,	ʧəppi, ba:giu, ii, onnu, u:u,
		VELAR FRONTING	4	ka:ge, mu:gu, ṯɛnginakai, bekku,	ka:ṯe, mu:ḏu, ṯɛnḏiakai, beṯṯu,
3	Assimilation process	POSTVOCALIC DEVOICING	1	ṯabala,	ṯapala,
		PREVOCALIC DEVOICING	1	ḏɪmbu,	ḏɪmpu,
4	Idiosyncratic processes	IDIOSYNCRATIC PRODUCTION	1	aivaṯṯu,	

Fig 4.24: *Shows the print page of CAPP-K*

Clinician can obtain the print out by selecting the option ÷Printô on the top right corner of the page or selecting ÷save as PDFô to save the results to the computer as seen in Fig 4.25.


ABC.pdf - Adobe Reader

File Edit View Document Tools Window Help

ALL INDIA INSTITUTE OF SPEECH AND HEARING (AIISH)
MYSORE 570 006

COMPUTERIZED ASSESSMENT OF PHONOLOGICAL PROCESSES IN KANNADA
(CAPP-K: 2.0-3.6 years)

Case name: ABC   Case number: 123   Age/gender: 3.3 YEARS / M

Home town: MYS   Contact number: 0987654321

Total test stimuli: 7 (for 2-2.6yrs), 15 (for 2.6-3yrs) and 30 (for 3-3.6yrs)

Provisional diagnosis:

Total correct production: 4

SI No	Phonological Processes identified		Count	Target Production	Error Production
1	Syllable structure processes	GEMINATE CLUSTER REDUCTION	1	kabbu,	kabu,
		INITIAL CONSONANT DELETION	3	lo:ṭa, kappe, kivi,	o: ṭa, appe, ivi,
		MEDIAL SYLLABLE DELETION	1	ṭɛnginakai,	ṭɛnḏiakai,
2	Substitution processes	AFFRICATION	1	ḏo:se,	ḏo:ʧe,
		DELATERALISATION	2	langa, o:le,	nanga, o: ḏe,
		DENASALISATION	1	onṭe,	oṭe,
		DEPALATALISATION	1	bɛssu,	bɛʃu,
		GLIDING	2	vɪma:na, e:ḷu,	vɪva:na, e:ju,
		RETROFLEX FRONTING	2	lo:ṭa, o:ḍu,	o: ṯa, o:ḏu,
		MONOPHTHONGISATION	1	auʃaḏa,	aʃaḏa,
		STOPPING	1	salkallu,	ṯailkallu,
		VOWELISATION	5	ʧəppəli, ba:gilu, ili, onḏu, hu:vu,	ʧəppi, ba:giu, ii, onnu, u:u,
		VELAR FRONTING	4	ka:ge, mu:gu, ṭɛnginakai, bekku,	ka:ṭe, mu:ḏu, ṭɛnḏiakai, beṯṯu,
3	Assimilation process	POSTVOCALIC DEVOICING	1	ṯabala,	ṯapala,
		PREVOCALIC DEVOICING	1	ḏɪmbu,	ḏɪmpu,
4	Idiosyncratic processes	IDIOSYNCRATIC PRODUCTION	1	aivaṯṯu,	

Fig 4.25. Shows the page of saved PDF output of CAPP-K report

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. This will give access to the "Test completed" page and the clinician can easily select "Start again" option to restart the test.

Phase III: Sensitivity evaluation of CAPP-K

The tool developed named Computer based Assessment of Phonological Processes in Kannada (CAPP-K) was verified for its sensitivity. CAPP-K was administered on 60 children with communication disorders after assessing their language ages using the Computerized linguistic protocol for screening (CLiPS)" and the Three Dimensional Language Acquisition Test- Adapted (3D-LAT-ad). Children with mental retardation (MR) and hearing impairment (HI) were selected as the target groups with the aim to examine the productions of children with hearing impairment and mental retardation that matched with the various production patterns included in CAPP-K.

For each child tested, the number of productions that matched with the templates in the software was counted and the percentage score was calculated. This percentage score is the percentage of childô production matching with the various patterns in the tool developed. Again mean percentage score was calculated for each age range. Higher the percentage score, higher will be the correlation between the childô productions 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 Tables 4.16 (a), (b), and (c) for children with Hearing impairment and Tables 4.17 (a), (b) and (c) for children with Mental retardation in the three age groups.

Sensitivity of CAPP-K in children with Hearing impairment (HI)

Ten children with HI each in the age groups 2.0-2.6 years, 2.6-3.0 years and 3.0-3.6 years were selected. Thus a total of 30 children with HI were selected from the AIISH preschool section. All participants were diagnosed as bilateral mixed or sensory neural hearing loss ranging in severity from mild to profound degree. All participants were aided with binaural behind-the-ear digital hearing aid and attended a minimum of 6 months of speech, language and listening training at the institute. Other than hearing loss none of the participants had any associated problems. The result os sensitivity evaluation in children with HI is shown in Table 4.16 (a), (b) and (c) for the three language age groups.

Table 4.16 (a):

The number of productions in children with hearing impairment matching with the templates in CAPP-K in the language age of 2.0 - 2.6 years

Sub	Age (in years)/ Gender	Duration of Speech and Language therapy attended	Degree of Hearing loss	No of correct productions (Total stimuli=7)	Idiosyncratic errors	No of productions which matched with CAPP-K templates	Percentage of matching (%)
1	4/M	6 months	B/L Severe HL	5	0	7	100
2	4.4/M	1 year	R: Severe HL L: Moderately Severe HL	3	0	7	100
3	3. 6/M	2 years	B/L Moderately Severe HL	1	0	7	100
4	5/M	6 months	B/L Severe Hearing loss	3	1	6	85.71
5	3.4/M	2.5 years	R: Severe HL L: Moderately Severe HL	3	0	7	100
6	3.3/M	1.0 year	B/L: Severe HL	3	2	5	71.43
7	4.5/F	10 months	R: Moderately Severe HL L: Severe HL	0	2	5	71.43
8	5/M	5 months	B/L Moderately Severe HL	2	0	7	100
9	6/M	7 months	B/L Severe HL	0	2	5	71.43
10	5/M	10 months	B/L Severe HL	3	1	6	85.71

Table 4.16 (a) shows that productions of 5 subjects: 1, 2, 3, 5, and 8 matched 100% with the templates of the CAPP-K in 2.0-2.6 year group. The remaining 2 subjects (subjects 4 & 10) and 3 subjects (subjects 6, 7 & 9) obtained a correlation of 85.71% and 71.43% respectively. The reduced percentage in subjects 6, 7 and 9 could be possibly due to higher degree (severe) of hearing impairment, poor quality of auditory feedback through the hearing aid, inadequate home training, delayed identification of hearing impairment etc. Gordon-Brannan and Weiss (2007) stated that articulatory skills were highly associated to degree of hearing impairment in children with HI.

Table 4.16 (b):

The number of productions in children with hearing impairment matching with the templates in CAPP-K in the language age of 2.6-3.0 years

Sub	Age (in years)/ Gender	Duration of Speech and Language therapy attended	Degree of Hearing loss	No of correct productions (Total stimuli=15)	Idiosyncratic errors	No of productions which matched with CAPP-K templates	Percentage of matching (%)
1	4.3/F	1 year	B/L Severe HL	12	1	14	93.33
2	5.3/M	1.6 years	R: Severe HL L: Moderately Severe HL	3	3	12	80
3	3.8/M	1.4 years	B/L Moderately Severe HL	11	1	14	93.33
4	4.2/M	9 months	B/L Severe Hearing loss	11	1	12	93.33
5	4.2/F	1.6 years	R: Severe HL L: Moderately Severe HL	10	3	12	80
6	5.6/F	1.0 year	R: Moderately Severe HL L: Severe HL	10	3	12	80
7	4.3/M	1.0 year	R: Moderately Severe HL L: Severe HL	3	3	12	80
8	5/M	1.0 year	B/L Moderately Severe HL	3	3	12	80
9	3.3/M	7 months	B/L Severe HL	6	4	11	73.33
10	3.8/F	1.0 year	B/L Severe HL	13	0	15	100

It can be seen in Table 4.16 (b) that productions of only subject 10 matched 100% with the templates of the CAPP-K in 2.6-3.0 year group. Subject 9 obtained lower percentage matching compared to others, this is possibly because he had a bilateral severe degree of hearing impairment and attended only 7 months of speech, language and hearing training. Even though subject 10 had bilateral severe degree of hearing impairment, the correlation was 100% because the hearing loss was identified early and she attended one year of speech, language and hearing training regularly.

Table 4.16 (c):

The number of productions in children with hearing impairment matching with the templates in CAPP-K in the language age of 3.0 - 3.6 years

Sub	Age (in years)/ Gender	Duration of Speech and Language therapy attended	Degree of Hearing loss	No of correct productions (Total stimuli=30)	Idiosyncratic errors	No of productions which matched with CAPP-K templates	Percentage of matching (%)
1	4.3/F	8 months	B/L Severe HL	10	6	24	80
2	5/F	1.6 years	R: Severe HL L: Moderately Severe HL	10	1	29	96.67
3	5/F	1.4 years	B/L Moderately Severe HL	10	1	29	96.67
4	6/M	9 months	B/L Severe Hearing loss	14	3	27	90
5	7/M	9 months	R: Severe HL L: Moderately Severe HL	14	2	28	93.33
6	15/M	2.0 years	R: Moderately Severe HL L: Severe HL	10	7	23	76.67
7	5.5/F	10 months	R: Moderately Severe HL L: Severe HL	11	5	25	83.33
8	6/F	6 months	B/L Moderately Severe HL	11	5	25	83.33
9	5.8/M	7 months	B/L Severe HL	9	6	24	80
10	7/M	10 months	B/L Severe HL	9	5	25	83.33

None of the subjects in 3.0-3.6 year group had 100% matching with CAPP-K templates as seen in Table 4.16 (c). The percentage of template matching varied from 96.67% to 76.67%. The participants with higher percentage of matching were due to longer duration of speech, language and listening training. Subject 6 had lower percentage matching as he had delayed intervention.

Sensitivity of CAPP-K in children with Mental retardation (MR)

Ten children with MR, each in the age groups 2.0-2.6 years, 2.6-3.0 years and 3.0-3.6 years were selected. Thus a total of 30 children with MR were selected from the AIISH preschool section. All participants were diagnosed as mental retardation ranging from mild to moderate degree and attended minimum 6 months of speech language intervention at the institute. Other than mental retardation none of the participants had any associated problems. The result os sensitivity evaluation in children with MR is shown in Table 4.17 (a), (b) and (c) for the three language age groups.

Table 4.17 (a):

The number of productions in children with mental retardation matching with the templates in CAPP-K in the language age of 2.0 - 2.6 years

Children	Age (in years)/ Gender	Duration of Speech and Language therapy attended	Level of Mental Retardation	No of correct productions (Total stimuli=7)	Idiosyncratic errors	No of productions which matched with CAPP-K templates	Percentage of matching
1	5.5/M	1.2 years	Moderate	3	1	6	85.71
2	5.7/M	1.6 years	Moderate	3	1	6	85.71
3	6/M	3 years	Mild	6	0	1	100
4	6/M	2 years	Mild	6	0	1	100
5	7/F	6 months	Mild	4	1	6	85.71
6	7.5/M	1.0 year	Mild to moderate	4	1	6	85.71
7	7.5/M	10 months	Mild	0	1	6	85.71
8	8/F	4 months	Mild	0	2	5	71.43
9	5/M	2 years	Mild	2	0	7	100
10	6.2/M	2 years	Moderate	0	2	5	71.43

It can be noted from Table 4.17 (a) that productions 3 subjects (subjects 3, 4 & 9) in 2.0-2.6 year group had 100% matching with CAPP-K templates. This could be because degree of MR was mild, and hence their phonological and articulatory skills are less affected.

2 subjects obtained lesser correlation could be because subject 8 lacked early speech language intervention and subject 10 had a moderate degree of MR.

Table 4.17 (b):

The number of productions in children with mental retardation matching with the templates in CAPP-K in the language age of 2.6-3.0 years

Children	Age (in years)/ Gender	Duration of Speech and Language therapy attended	Level of Mental Retardation	No of correct productions (Total stimuli=15)	Idiosyncratic errors	No of productions which matched with CAPP-K templates	Percentage of matching
1	10.5/F	1 year	Moderate	11	1	14	93.33
2	11/F	1.6 years	Mild	11	1	14	93.33
3	7.10/M	3 years	Moderate	10	0	15	100
4	8/M	9 months	Moderate	10	0	15	100
5	7.2/M	9 months	Mild	7	0	15	100
6	8.5/M	1.0 year	Moderate	3	4	11	73.33
7	7.5/F	10 months	Mild	7	0	15	100
8	4/F	6 months	Moderate	13	0	15	100
9	5/M	7 months	Mild	3	3	12	80
10	9/F	10 months	Mild	4	3	12	80

It can be seen in Table 4.17 (b) that productions of 5 subjects (3, 4, 5, 7 & 8) matched 100% with the templates of the CAPP-K in 2.6-3.0 year group, though not necessarily correct production, is attributed to early identification and intervention and regular home training. Subject 6 with moderate degree of mental retardation obtained poor scores possibly because he underwent only a year of intervention at an older age.

Table 4.17 (c):

The number of productions in children with mental retardation matching with the templates in CAPP-K in the language age of 3.0 - 3.6 years

Children	Age (in years)/ Gender	Duration of Speech and Language therapy attended	Level of Mental Retardation	No of correct productions (Total stimuli=30)	Idiosyncratic errors	No of productions which matched with the templates in CAPP-K	Percentage of matching
1	6.2/F	1.9 years	Mild	10	0	30	100
2	9/M	2 years	Mild	11	0	30	100
3	9/F	1.7 years	Moderate	12	0	30	100
4	9/M	2.8 years	Moderate	11	0	30	100
5	4.2/F	9 months	Borderline to mild	18	1	29	96.67
6	6/F	1.0 year	Mild	19	2	28	93.33
7	4.9/F	3 years	Mild	12	3	27	90
8	5/F	6 months	Moderate	13	2	28	93.33
9	9.6/F	2.6 years	Moderate	17	3	27	90
10	7/M	3years	Mild	10	3	27	90

It can be noted in Table 4.17 (c) that productions of all the subjects in 3.0-3.6 year group had 90% and above matching with CAPP-K templates. 100% matching was seen in 4 subjects as they attended >1.5 years of speech language therapy with better home training.

The mean percentage of matching in children with HI and MR of language age 2.0-2.6 years, 2.6-3.0 years and 3.0-3.6 years are depicted in Fig 4.26. The percentage matching in children with HI were 88.57%, 85.33% and 86.55% in 2.0-2.6 years, 2.6-3.0 years and 3.0-3.6 years respectively. And in children with MR, the scores were 87.14%, 91.99% and 95.33% for 2.0-2.6 years, 2.6-3.0 years and 3.0-3.6 years respectively.

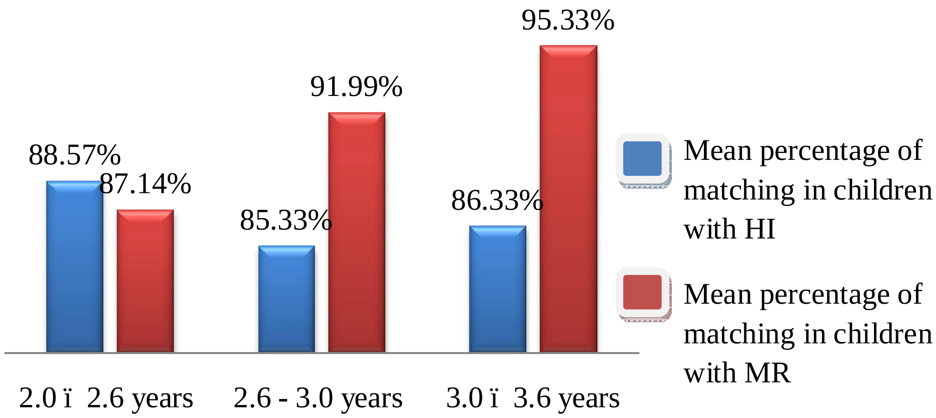


Fig 4.26: *Shows the sensitivity score in children with HI and MR*

In children with HI, younger age group (2.0-2.6 years) had higher correlation which could be because they were early identified and intervened. However, in children with MR, older age group (3.0-3.6 years) had highest correlation. This is possibly because 6 out of 10 participants of this age group had mild degree of mental retardation and gained better from speech-language therapy. It was also noted that children with MR had a higher mean correlation score compared to children with HI except in the younger age group 2.0-2.6 years. This can be attributed to reduced articulatory skills, voicing errors, timing control (Levitt & Stromberg, 1983) and reduced/distorted auditory feedback in children with hearing impairment compared to children with mental retardation of the same language age. Thus with increase in age, children with MR showed typical errors compared to children with HI.

The overall sensitivity score for both children with HI and MR were found to be greater than 85%. This implies that templates of CAPP-K were sensitive to the correct and erroneous productions of children with communication disorders and thus aid in identifying deviant phonological processes in these children effectively.

CHAPTER V

SUMMARY AND CONCLUSIONS

The principal aim of the study was to develop an indigenous computerized tool called ñComputer based Assessment of Phonological Processes in Kannada (CAPP-K)ò to identify unusual or deviant phonological processes in 2.0-3.6 year old native Kannada speaking children. This tool was devised by identifying normal phonological processes in typically developing children in Phase I; preparation of the software tool (CAPP-K) in Phase II; and evaluating the sensitivity of this tool in children with communication disorders in Phase III.

In Phase I, 30 boys and 30 girls each in the age group of 2.0-2.6 years, 2.6-3.0 years and 3.0-3.6 years were administered test words from the KDPAT articulation testl. 35 processes present in the sample were analyzed sound by sound and the percentage of children using them was determined. The processes seen in 100% of the children were cluster reduction, palatal fronting, retroflex fronting and vowelization in 2.0-2.6 years, retroflex fronting in 2.6-3.0 years and none of the processes were 100% in older age group. All the processes showed a trend in occurrence in each of the age groups. Most of the processes occurred in high percentage in younger group and reduced towards 3.0-3.6 years. Children at a younger age use higher simplification rules and used lesser processes towards the older age group as they mastered phonological skills. Certain processes like reduplication, metathesis, cluster substitution, cluster deletion, nasal fronting, dental fronting and delateralisation occurred in only <10% of children across the age groups. These processes were rarely occurring processes in Kannada. However, certain processes like labialization and prevocalic devoicing was present in 2.6-3.0 years, compared to younger and older age groups. The identified phonological processes were classified into the most frequently occurring (>60% of the children), frequently occurring (20-60% of the children) and occasionally occurring processes (<20% of the children). 15 processes were found to be most frequently occurring in

2.0-2.6 years, 11 in 2.6-3.0 years and 3 processes in 3.0-3.6 years. Findings in gender differences revealed significantly higher use of certain processes: stopping, geminate cluster reduction, lateralization and monophthongisation in younger boys in 2.0-3.0 years, after which both performed equally in phonological skills. This advantage for girls could be attributed to biological differences in the structure of brain organization (Kail, 1993) at younger age group.

In Phase II, to prepare material for the software, the test words were arranged in descending order from to most erroneous to the least. The words errored by <20% of the children were selected as the target words for the software preparation in each age group with the concept that words errorred by <20% of the children are unsual or rarely incorrectly produced words in that age group. Based on this criterion, 7, 15, and 30 stimulus words were selected for 2.0-2.6 years, 2.6-3.0years, and 3.0-3.6 years respectively. These words along with its frequent and common variations of the target words were selected and provided to software professional for the making of CAPP-K. CAPP-K was developed using the Adobe Flash Builder 4.7 called an Adobe AIR application [SDK Version 2.6]. First, the clinician is required to select the language age of the child (either 2.0-2.6 years or 2.6-3.0 years or 3.0-3.6 years). When test is initiated, child is instructed to name the target picture one by one. Clinician is required to keenly listen to childøs utterance and select one of the options that best matched with the childøs production. As test progresses, phonological processes operating in the child are automatically evaluated by CAPP-K. The approximate duration of testing is 10-15 minutes. At the test completion, output of the test is in graphical form and tabulated form (a table showing demographic details, list of phonological processes under syllable structure, substitution, assimilation and idiosyncratic processes, their frequencies, target words errorred and the childøs error production). The report page of individual child can be either printed or saved as PDF for future reference.

In Phase III, sensitivity of CAPP-K was tested on children with HI and MR. A total of 60 children with communication disorders (10 participants * 3 age groups * 2 communication disorder groups) participated in sensitivity evaluation. The correlation of childôs utterances was examined with the templates present in CAPP-K. The findings revealed that CAPP-K was >85% sensitive to productions of children with communication disorders. Thus CAPP-K was sensitive to the correct and erroneous productions of children with communication disorders.

CAPP-K is a very user friendly software. It analyses and profiles deviant phonological patterns in the child quickly and accurately in Kannada speaking children. This software is superior to CAPP-M in that the graph is color coded for easy depiction, identified processes could be classified, error words and their production can be viewed, and the report can be generated and saved in the computer system for future references. Thus CAPP-K can be used by speech language pathologists in the assessment and management of phonological process in 2.0-3.6 year old native Kannada speaking children. It can be effectively used for pre-post therapy evaluations also. The major highlight is that phonological processes can be quickly identified which avoids manual tedious traditional analysis.

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Appendix A

(Test stimuli for the age range of 2.0-2.6 years)

Sl.No	Target stimuli	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5
1	/ko:ĭ̋i/	/ĭ̋o:ĭ̋i/	/o:ĭ̋i/	/ĭ̋i/	/ ĭ̋i:ĭ̋i/	
2	/a:ne/	/a:e/	/a:n≽e/			
3	/mi:nu/	/i:nu/	/mi:u/	/mi:du/		
4	/mane/	/ane/	/mae/	/ale/	/male/	/man≽e/
5	/pennu/	/ennu/	/penu/	/bennu/	/enu/	
6	/na:ji/	/a:ji/	/d⌂a:ji/	/ĭ̋a:ji/		
7	/a:me/	/a:e/				

Appendix B

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

Sl.No	Target word	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5
1	/aiɭu/	/a:ɭu/	/e:ɭu/	/a:ʈu/	/aiʈu/	/aʈu/
2	/o:le/	/o:e/	/o:je/	/o:ke/	/o: ɭe/	/o: ʈe/
3	/langa/	/anga/	/lanka/	/laka/	/nanga/	
4	/kaʈʈe/	/kaʈe/	/ʈaʈʈe/	/aʈʈe/		
5	/ele/	/ee/	/eje/			
6	/ili/	/iɖi/	/ii/	/li/	/ini/	
7	/nalli/	/nali/	/alli/	/nanni/		
8	/kappe/	/appe/	/kaʈʈe/	/ʈappe/		
9	/jamme/	/jame/	/amme/			
10	/onɭu/	/onu/	/oɭu/			
11	/kivi/	/ivi/	/kibi/	/ʈivi/		
12	/ko:ʈi/	/o:ʈi/	/ʈo:ʈi/			
13	/mane/	/mae/	/maɳe/			
14	/a:me/	/a:ne/				
15	/hu:vu/	/u/				

Appendix C

(Test stimuli for the age range of 3.0-3.6 years)

Sl.No	Target word	1	2	3	4	5
1	/lo:ȉ̋a/	/lo: ȉ̋a/	/o:ȉ̋a/	/o:ta/		
2	/auɗa˧˥la/	/ʹƊa˧˥la/	/auɗ̤a˧˥la/	/aɗa˧˥la/	/asa˧˥la/	
3	/uja:le/	/uva:le/	/ula:le/	/ula:je/	/uja:je/	
4	/ɗ̤ủppủli/	/ȉ̋ủppȦ̤li/	/ɗ̤ủppi/	/ȉ̋ủppi/		
5	/onȉ̋e/	/onȉ̋e/	/ondɛe/	/otɛe/	/otɕe/	
6	/aivaȉ̋ȉ̋u/	/avaȉ̋ȉ̋u/	/aijaȉ̋ȉ̋u/	/aiȉ̋ȉ̋u/		
7	/ka:ge/	/ka:ke/	/ka:ȉ̋e/	/ka:e/		
8	/aɗ̤ ɗ̤ I/	/aɗ̤ɗ̤I/	/adɛɛI/			
9	/mu:gu/	/mu:ku/	/mu:dɔu/			
10	/ba:gilu/	/ba:ku/	/ba:gu/	/ba:lu/	/ba:giu/	
11	/kabbu/	/kappu/	/kabu/	/kaȉ̋u/		
12	/vɗ̉ma:na/	/vɗ̉va:na/	/bɗ̉ma:na/	/ɗ̉ma:na/	/vɗ̉a:na/	
13	/bủssu/	/bủȉ̋ȉ̋u/	/bủɗu/			
14	/dImbu/	/ȉ̋Imbu/	/dImpu/	/ȉ̋Imbu/	/dipu/	/dImu/
15	/e:ɫu/	/e:ju/	/e:ɫu/			
16	/o:˥lu/	/o:dɫu/	/o:u/			
17	/ȉ̋abala/	/ȉ̋apala/	/ȉ̋apla/	/ȉ̋abaǸ/		
18	/˧˥lo:se/	/˧˥lo:ȉ̋e/	/˧˥lo:ɗ̤e/			
19	/langa/	/lanka/	/landa/	/nanga/	/laȉ̋a/	
20	/ȉ̋ủnginakai/	/ȉ̋ủnginaȉ̋ai/	/ȉ̋ủn˧˥ikai/	/ȉ̋ủn˧˥inaȉ̋ai/	/ȉ̋ủn˧˥iakai/	/ȉ̋ủnakai/

Appendix C (Continued)

(Test stimuli for the age range of 3.0-3.6 years)

21	/ili/	/idɦi/	/ii/		
22	/aidɫu/	/aiʈ̋u/			
23	/o:le/	/o: dɫe/	/o: Ǹe/		
24	/bekku/	/beʈ̋ʈ̋u/	/bakku/		
25	/kappe/	/kape/	/ʈ̋appe/	/appe/	
26	/kivi/	/ivi/			
27	/hallu/	/allu/			
28	/on˧lu/	/onnu/			
29	/saIkallu/	/ώ̧aIkallu/	/ʈ̋aiIkallu/	/ʈ̋eIkallu/	/sekallu/
30	/hu:vu/	/u/	/u:u/		