ACQUISITION OF CLUSTERS IN TYPICALLY DEVELOPING KANNADA SPEAKING CHILDREN: 3-6 YEARS

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April, 2018

CERTIFICATE

This is to certify that this dissertation entitled **"Acquisition of clusters in typically developing Kannada speaking children: 3-6 years"** is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 16SLP009. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Acquisition of clusters in typically developing Kannada speaking children: 3-6 years"** is the result of my own study under the guidance of Dr. N.Sreedevi, Professor & Head, Department of Clinical Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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CHAPTER I

INTRODUCTION

Speech is a form of verbal behavior or verbal communication. Speech acquisition in child progresses through various stages like crying, cooing-going, babbling, word and sentence productions and finally to an adult like sophisticated intelligible speech. This series of developmental milestones in speech acquisition shows an increasingly complex pattern, beginning with involuntary reflexive vocalizations to the voluntary production of complex speech sounds in words and sentences. Speech production is controlled by various neuro-anatomical and physiological variables. Thus, along with continuous speech acquisition, other skills like cognitive, perceptual, social, linguistic, and physiologic skills also develop simultaneously.

Various researchers have developed norms across the languages for describing different stages of speech sound acquisition in typically developing children, learnt at a specific age. These norms can be used for diagnosing and treating children with speech sound disorder.

The typical speech sound learning during infancy can be broadly classified under two categories: (1) reflexive vocalizations- cry, cough, burp, and hiccups, which are automatic responses indicating the physical state of the child; and (2) non-reflexive stage- they are voluntary productions which includes cooing, babbling, and playful screaming (Oller, 2000; Stark 1980). Oller, 2000; Oller and Griebel, (2008), classified early vocalizations of the infant into four stages of infra-phonological skills. Theses stages are described in Table 1.1

Table 1.1

Infra-phonological Stage in infants (Oller, 2000; Oller & Griebel, 2008)

Infra-phonological Stage	Age	Productions
Phonation	Birth to 2 Months	Reflexive vocalization, quasi-vowels
Primitive articulation	1 to 4 Months	Goos
Expansion	3 to 8 Months	Period of vocal play, full vowels, raspberries (bilabial or lingual trills), marginal babbling
Canonical babbling	5 to 10 Months	Canonical babbling, reduplicated babbling, variegated babbling. The child's repertoire now consists of stops, nasals, glides and lax vowels.
Integrative stage	In infants till 18 months	Jargon which is meaningful words combined with non-meaningful babbled sounds.

The subsequent stages overlap on each other through the continuous development in speech acquisition. These stages are followed by production of real words, and simultaneous expansion of new vowel and consonant repertoire present in the child's native language.

Each language has an inventory of sounds that its speakers learn to produce and thus, forming a part of their language repertoire. Some phonemes are shared across languages; others are unique to a particular language. Shriberg and Kent (2013) reported that, there are about 100 phonemes in the repertoire of languages across the world. American English includes 24 consonants, 14 vowels and 6 diphthongs. Modern Kannada language includes 11 vowels and 34 consonants (Sridhar, 1990).

Consonants are produced either as a singleton (alone) or as a combination of singletons forming clusters. Consonant clusters occur "when two or more consonants

co-occur at the same position in syllable structure" (Grunwell, 1987). In a majority of the world's languages, consonant clusters form an indispensable entity. Each language has specific phonotactic rules, which allow producing speech sounds in specific combinations possible in the language. For instance, in French, Malecot (1974) reported 5,835 occurrences of clusters in the initial position, 6,591 occurrences in medial position, and 1,645 occurrences in final position. Some of the Polynesian languages such as Hawaiian, Maori, Samoan, and Tongan have very simple syllable structure and the consonant cluster productions are restricted (Stojanović, 2013). In English, clusters can occur in word-initial, word-medial and word-final positions, whereas in Kannada predominantly clusters occur in the word-medial position. Clusters in word-final positions are not possible in both colloquial and literary Kannada (Nayak, 1967).

In English, there are as many as two to four element syllable consonant clusters (e.g. *<u>cl</u>ass*, *<u>spr</u>ing*). Among them, many final consonant clusters are morphophonemic, which are created by the addition of grammatical morphemes (e.g. *plural markers, tense markers*). A large variety of clusters are permissible both at the beginning and at the end of the syllables, which makes monosyllables also extraordinarily complex (in words such as *Strength*).

Consonant clusters occurring in Kannada can be broadly classified into 2 types: non-identical or non-geminate clusters and identical or geminate clusters (Hiremath, 1980). Geminate clusters are more often described as doubled consonants. They differ from their singleton counterpart on the basis of length or duration (Ladefoged & Maddieson, 1996). In Kannada, geminate clusters occur primarily in the medial position such as /appa/- 'father'. Non-geminate clusters: they are the combination of two or more singleton consonants such as /patra/- 'letter'. The

geminate clusters are acquired earlier to non-geminate clusters (Sreedevi, 1976; Rupela & Manjula, 2006). Thus, cluster acquisition varies depending on the phonotactics of the specific language. Therefore, establishment of language-specific norms to assess phonological skills is mandatory.

Cluster acquisition in English can be seen as early as in two-year-old children (Stoel-Gammon, 1987); however, children require many years (till 9;0-12;0 years of age) for mastery of cluster production (McLeod & Arcuili, 2009). Ingram (1989) reported that, 'word spurt' is linked to a significant development in children's phonological analysis of the receptive vocabulary in terms of phonotactics. Consonant clusters represent an important departure in phonotactics from earlier word shapes of CV, VC or CVCV. The acquisition of consonant clusters is one of the longest lasting phases of speech acquisition observed in normally developing children (McLeod, Doorn, & Reed, 2001). Thus, it is a very complex development which is affected by some of the factors like position of the cluster, the phonetic composition of the cluster, language and others. Hence, there is a need to develop norms considering these factors.

In Indian languages, most of the research on cluster acquisition has been carried out as a part of the study related either to normal phonological development or standardization and development of test materials for singleton consonants. However, a limited number of consonant clusters are investigated by these studies. Very limited studies have been conducted in Indian languages, exclusively on the acquisition of non-geminate consonant clusters. Sneha and Sreedevi (2012) carried out a developmental study for obtaining normative data exclusively on the acquisition of non-geminate consonant clusters in native Telugu speaking children of age range 4;0to 6;0 years. They report a developmental trend in cluster acquisition. Hence, there

is a need to fill the gap in the literature regarding the same, in the Indian context for other languages.

Need for the study`

In recent years, the phonological acquisition in children is found to be more advanced when compared to the earlier norms established. Currently, parents of young children are well educated and are aware of the speech sound disorders, leading to a greater demand for the accuracy in children's speech. This creates a need for the Speech-Language Pathologists to have a complete and an updated knowledge about children's phonological aspects. Thus, the establishment of revised norms is required for complete profiling of phonological development. Appropriate diagnosis and intervention of speech sound disorder is essential as its prevalence is high among communication disorders.

According to AIISH Annual report (2016-17), 361 children have reported with speech sound disorders for clinical services. Cluster production is difficult for most of the children with speech impairments. This difficulty in very young children, could have potential predictive value for early identification of speech impairment (McLeod, et al., 2001a). The speech intelligibility is reported to be very poor particularly as a result of the difficulty in cluster production in children with speech sound disorder (Hodson & Paden, 1981).The currently used test material for evaluation of speech sound disorders in Kannada,(Kannada Diagnostic Photo Articulation Test by Deepa and Savitri, 2010) examines only 11 clusters. Thus, this study is warranted to provide input to facilitate diagnosis and intervention in children with speech sound disorders. This necessitates the development of norms in Kannada for facilitating better diagnosis and intervention of children with speech sound disorder.

Aim of the study

The aim of the study is to develop norms for the acquisition of non-geminate consonant clusters in native Kannada speaking children in the age range of 3;0 to 6;0 years.

The specific objectives of the study

1) To obtain norms for non-geminate cluster acquisition in 3;0- to 6;0- year old typically developing Kannada-speaking children.
2) To compare the non-geminate consonant cluster acquisition skills across age and gender.
3) To determine the positional variations in the acquisition of non-geminate consonant clusters.

CHAPTER II

REVIEW OF LITERATURE

Clusters can be defined as a combination of two or more consonants adjacent to each other produced simultaneously. Consonant clusters have been categorized in numerous ways in order to describe variations in acquisition of different consonant clusters. They have been categorized according to the word and syllable position of the cluster, the number of constituents, constituent phones, features of the elements within the cluster, etc. These categorizations facilitate to discuss how the different cluster categories develop differently during acquisition; to observe how cluster reduction happens in non-adult productions; to report about treatment generalization occurring within a category of the cluster targeted in treatment, etc. Thus, knowledge about the categorization of clusters is crucial.

Categorization of consonant clusters

Articulation Based analyses of speech focusing on constituent phones includes categories like,/s/ clusters, /1/ clusters, /r/ clusters, and /w/ cluster, etc. (Templin, 1957). This categorization was useful in case of describing the generalization of therapy gains within the respective category of a phone which was treated. However, according to the constituent phone categorization, few clusters can be placed in more than one category for instance,/sl/, /sw/, /spl/, /spr/, /str/, and /skw/.This type of categorization could not account the word-final consonant clusters (McLeod, Doorn, & Reed, 1997).

Categorisation based on features within the consonant cluster includes categories such as stop +liquid, fricative + liquid, nasal + stop, nasal + obstruent and obstruent + approximant (Chin & Dinnsen, 1992; Greenlee, 1974; Grunwell, 1987).

The marked member of the consonant cluster was most commonly omitted by typically developing children. This categorization is supportive in explaining why one element (feature) preserved over other based on markedness theory. However, there is no core categories of consonant clusters explained based on the features explained in the literature. Some of the researchers use both phone and feature based categorizations of consonant clusters.

Based on position, the consonant clusters can occur in word-initial, word-medial and word-final positions. Based on the number of constituents within the consonant clusters (Grunwell, 1985), the clusters could be categorized as two, three or four element clusters.

Based on the constituents, clusters can also be classified as Non-geminate and Geminate. Example: Consonant clusters occurring in Kannada can be broadly classified into 2 types: non-identical or non-geminate clusters and identical or geminate clusters (Hiremath, 1980).

Based on the articulators involved in cluster production, heterorganic and homorganic clusters have originally been discussed in Gestural Phonology Model of Browman and Goldstein (1990). When cluster constituents have a different place of articulation (i.e. belong to the different tier), they are called heterorganic consonant clusters (e.g., in Kannada- /ʃabda/- "noise"). In homorganic clusters, the cluster constituents usually share the same place of articulation (i.e. belong to the same tier) usually comprise of nasal+voiced stop such as /mp/, /mb/, etc. (e.g /ɖimbu/ - 'pillow')

Based on the placement of clusters with within a syllable or across the syllable, they can be categorized into tautosyllabic and heterosyllabic clusters. Tutosyllabic clusters are those in which elements of the cluster are part of the same syllable (e.g.,

/br-/ in ‘bring’). Heterosyllabic clusters are those in which elements of the cluster are split across two syllables (e.g., /nt-/ in ‘winter’, /dimbu/- ‘pillow’) (Chervela, 1981).

No single system of categorization gives complete information about the cluster. Thus, it would be better to use multiple ways of describing the categories of clusters to indicate development or production variations across them. Most of the studies related to consonant clusters use a combination of two or more categories to describe the acquisition.

Development of consonant clusters: the non-adult realization of clusters during the acquisition

Children do not acquire the target cluster production directly; during the process of development, the child's production passes through serious of non-adult productions. These non-adult productions have to be investigated to understand the typical and atypical pattern in production throughout the development and to gain knowledge about how the complex cluster acquisition is gradually developing. The non-adult productions during cluster acquisition have been described in a range of systems as listed below.

Analysis by early researchers focused more on determining whether, the production acquired by the children was normal or not, however, the non-adult realizations of consonant clusters were not evaluated in detail. (Templin, 1957).

During phonological development, children exhibit various phonological processes. Based on these processes, non-adult productions of clusters were defined by several researchers (Grunwell, 1985; Shriberg& Kwiatkowski, 1980). Hence, Cluster reductions were used most commonly for describing the errors in the production of consonant clusters in typically developing children.

The development of clusters is also described in terms of phonological processes such as cluster reduction, cluster simplification, epenthesis, coalescence, and metathesis.

- *Cluster reduction:* is the deletion of one or more consonants from a target cluster so that only single consonant occurs at syllable margins (Grunwell, 1987)
- *Cluster simplification:* occurs when two elements of the clusters are produced, but one or both the elements are produced in a non-adult manner. (Grunwell, 1987)
- *Epenthesis:* is the insertion of a vowel (frequently schwa vowel) between the consonants within the cluster resulting in a change in the syllable shape. (Shriberg & Kwiatkowski, 1980) (e.g. /pallet/ for plate)
- *Coalescence:* occurs when the reduced cluster contains a new consonant composed of features from original consonants (e.g. /fim/ for swim)
- *Metathesis:* is the reversal of adjacent segments or migration of an element within the word. (Shriberg & Kwiatkowski, 1980)(e.g. /aks/ for ask)

In case of cluster reduction, either first or second member of the cluster could be deleted based on the markedness of the phonemes within the clusters. However, the definition of cluster reduction is very general and it does not explain the detailed pattern of non-adult realizations of clusters in the children (McLeod et al., 1997).

Greenlee's stages of development of stop + liquid clusters, was another approach used for the two- consonant clusters, for analyzing the cluster production in children (Greenlee, 1974). Elbert and McReynolds (1979) described that, the sequence of

acquisition of two element consonant clusters (Table 2.1) extending on three stages given by Greenlee (1974) by the addition of the fourth stage. These do not explain Epenthesis, where the reduction and substitution happens together (McLeod et al., 1997). A similar study in Telugu by Chervela (1981) stated that, the following sequence of processes during cluster acquisition: Total deletion, reduction+ substitution, substitution+ assimilation, substitution of one or both consonants, and finally adult clusters.

Table 2.1

Four stages of cluster acquisition (Greenlee, 1974; Elbert & McReynolds, 1979)

First Stage	Omission of the entire cluster.
Second Stage	Reduction of the cluster to one member. Generally, the marked member of the cluster will be omitted and the unmarked will be produced.
Third Stage	Use of cluster with the substitution of a sound for the previously omitted marked member of the cluster.
Fourth Stage	Mastery of the cluster with the production of both the segments accurately.

Dyson and Paden (1983)reported each child may not go through all the stage of such developmental trend and described three different "ordered sets" which children may adapt for the acquisition of clusters:

i. Cluster reduction →Correct

ii. Cluster reduction → one segment distorted or substituted →correct

iii. Deletion of final cluster → cluster reduction → correct final cluster

Thus, there were some conflicting studies reporting of individual variability especially in very young children between 2;0 to 3;0 years.

Smit (1993) described the ‘Mismatches’, i.e. error forms of target productions and their frequency of occurrence in typically developing children for word-initial consonant cluster s across each age range. Typical errors noted by Smit (1993) were, (a) Reduction of obstruent+ approximant clusters to obstruent and (b) Reduction to the second element in /s/ clusters. When clusters were preserved with one element correct and the other substituted, the error in substitution was same as the typical error for the singleton consonants.

The process of cluster reduction has been explained based on the Optimality theory by various authors using some of the models described below.

a. Ingram (1989) model referring to deletion patterns as the result of the markedness values of the individual elements in the cluster. This model presumes that relative markedness plays a role in reduction strategies: The less marked consonant on the cluster is the one produced, for e.g. in /s/+ plosives, /s/+nasal, /s/+ glide; plosive, nasal and glide respectively is retained as they are less marked the /s/, in case of other combinations like obstruent+ glide, obstruent is preserved because it is marked than liquid. Markedness scale arranged from least to the most marked follows as plosive, nasal, glide >/s/, /l/.
b. Model on sonority- based onset selection assumes that least sonorous consonants survive in the cluster. (Fikkert 1994; Chin & Powell, 1996; Gierut 1999, Ohala 1999, Pater & Barlow, 2003; Gnanadesikan, 2004; Barlow 2005). Sonority refers to resonant characteristics that correspond with the degree of constriction. Sonority scale for hierarchy from most to the least sonorant segment is low vowel > high vowels > glides > liquids > nasals > voiced fricative > voiceless fricatives > voiced stops > voiceless stops. Thus, reduction in sonority pattern includes preserved obstruent (in obstruent+

liquid), plosive (/s/ + plosive), /s/ (in /s/ + glide) as they are lesser sonority over the other member of the cluster. However, asymmetries (Goad &Rose, 2004) are observed in such pattern, some of the studies report of another pattern, namely head pattern followed by few children. /S/-initial clusters: in the sonority pattern, the least sonorous consonant is retained in output forms (e.g. /Sl/ → /S/); in the head pattern, it is the sonorant that survives (e.g. /Sl/ → /l/).

c. A third potential explanation relies on contiguity principle. It states that segments adjacent in the input should be adjacent in the output (McCarthy & Prince, 1995). This principle is perceptually motivated since a consonant adjacent to a vowel is perceptually more salient than a consonant adjacent to another consonant due to the sharp transition (Steriade, 2001). The contiguity principle predicts that children will prefer producing the second consonant of the cluster, for example, /s/+ plosive → plosive, /s/+ nasal→ nasal, /s/+glide→ glide, obstruent+ liquid→ liquid.

However, these different accounts make contrast presumptions for some deletions, such as in /s/+nasal and /s/+glide clusters. The markedness and the contiguity accounts predict the realization of C2. However, the sonority based onset selection predicts C1 realization. On the other hand, in case of stop+ fricative clusters, the markedness and the sonority based onset selection accounts predicts realization of C1, while the contiguity predicts realization of C2. Thus, the data on the acquisition of cluster reduction provided in the literature is inconclusive.

Overall, the suitable analysis system is lacking for the description of non-adult realizations of consonant clusters The cluster reduction pattern is difficult to place

children into one of the described methods, since it does not allow an accurate description of the most commonly occurring non-adult realizations types.

Acquisition of consonant clusters

Phonological development occurs from simple to complex stage, thus the acquisition of speech segments gradually progresses with age. Dyson (1998) defined three types of the age of acquisition in phonological development. They are described in Table2.2

Table 2.2

Age of acquisition in phonological development (Dyson, 1998)

Age of customary production	At least 50% of children in an age group produce the sound correctly in at least two positions
Age of acquisition	At least 75% of children in an age group produce the sound correctly in all positions
Age of mastery	At least 90% of children in an age group produce the sound correctly in all positions

In literature, various percentage criteria (50, 75, 90 or 100%) for the acquisition of consonants and consonant clusters are defined. In most of the recent studies, the term 'mastery' was often assumed when at least 90% of the children in the sample produce the target consonant cluster correctly (Shriberg& Kwiatkowski, 1980; Dodd, Holm, Hua, & Crosbie, 2003; Mcleod & Arcili, 2009).

The cluster acquisition could emerge as early as two years old children however, the mastery could continue till 9;0 to 12;0 years. Stoel-Gammon (1987) studied phonological skills of two year old children, findings showed that 58% of children produced at least two different initial clusters, and while 48% produced final clusters only 30% produced two or more words with abutting consonants or clusters

medially. The results of the study conducted by Dyson (1998) indicated that (see Table 2.3), a wide variety of consonant clusters appearing in both word-initially and finally by the age range of 2;0-3;3 years.

Table 2.3

Acquisition of word-initial and word-final consonant clusters in English (Dyson, 1998)

Mean Age	**2;0 years**	**2;5 years**	**2;9 years**	**3;3 years**
Initial Clusters	/fw/	/fw/, /br/,	/fw/, /kw/	/fw/, /bw/, /kw/, /tr/, /sp/, /st/, /sn/, /sl/, /bw/
Final Clusters	/ts/, /ŋk/	/ps/, /ts/, /ntʃ/, /ŋk/	/ps/, /ts/. /nts/, /ŋk/	/ps/, /ts/, /ns/, /ntʃ/, /ŋk/

Supporting this, Wantson and Scukanec (1997) also noted that, by 2; 6 years word-initial and word-final consonant clusters were emerging; the clusters in the inventory of 2;0 to 3;0 year old are listed in Table 2.4.

Table 2.4

Inventory of word-initial and word-final consonant clusters in 2- to 3- old English speaking children (Watson & Scukanec, 1997)

Age (Years)	**Clusters**
2;6	[pw, bw, -nd, -ts]
2;9	[pw, bw, pl, -nd, -ts, nt, nz]
3;0	[st, sp, pl, -nd, -ts, -nt, -nz, -st, -ŋk]

Similar trends were reported by Macleod, Doorn, and Reed (2001b); two-year-old children began to produce few consonant clusters having /w/in word-initial clusters and nasals in word-final consonant clusters. Although, these clusters were present in their phonetic inventory, they did not produce exact adult like production.

The realization of consonant clusters approached towards adult target gradually with the developing phonological maturity.

Mastery of the consonant clusters was reported to begin by four years (Templin, 1957; Smit, Hand, Freilinger, Bernthal, & Bird, 1990; Shriberg& Kwiatkowski, 1980). Four-year-old children were found to produce 90% of consonant clusters correctly in spontaneous speech (Shriberg & Kwiatkowski, 1980).Templin (1957) investigated the development of word-initial and word-final clusters and Smit et al., (1990) investigated word-initial clusters; these authors considered 75% mastery criteria. Both the authors found similar pattern in mastery: earlier cluster to be mastered was stop + /w/ followed by stop + /l/ cluster, then stop+ /r/ and /s/ clusters, lastly the three element clusters were mastered. However, there was some difference, in Templin's data. 75% acquisition for clusters were reported earlier than the acquisition of the constituent singleton of the cluster; however, Smit et al. (1990), reported clusters reach 75% acquisition either at the same age as the singleton or later. Smit et al. (1990) described that, by 4;0 years very few clusters were mastered, however by 6;0-7;0 years of age most of the clusters were mastered, although Templin's (1957) study reports mastery at a relatively earlier age (e.g. by 4;0 years /s+ stop/, /s+ nasal/, /stop+ nasal/, /stop+ liquid/ and /stop+ w/were mastered in the initial position).One more difference is, Smit et al. reported of gender difference while Templin reports of no difference across gender for cluster acquisition.

Another more recent study by Mcleod and Arcili (2009), explored the acquisition of /s/ and /r/ clusters in word-initial position by 5;0-12;0 year age typically developing children using two elicitation modalities (Picture description and reading the material). 94.5% consonant clusters were produced correctly, as the children became older; more consonant clusters were produced correctly. Two element /s/

clusters, two element /r/ clusters and three element /s/ cluster were produced correctly by 96.8%, 94.0% and 92.05% respectively. Overall, all the participants exhibited the following fashion of correct production: Most often, /tr/ and /kr/ were correctly produced (by 98%), followed by /sp, /st/, /sm/, /sn/ (by 97.4%) and the least likely to be produced was /θr/ (by 82.2%). Few of the clusters were found to be difficult in 5- to 8 year-old children, and were produced correctly by less than 90% of the children aged 5;0 to 6;0 years old for /pr, fr, θr , spl/, and /spr/clusters and by 7;0 to 8;0 year old children for /pr/, /dr/, /gr/, /θr/ , /spr/, /skr/, and /str/ clusters. Although, a majority of clusters were mastered (90%) by 5;0 to 6;0 years, children aged 5;0 to 8;0 years continue to masters few two and three element clusters, and between the age of 9;0 and 12;0 years children completed mastery of consonant clusters. In younger group (5;0 to 8;0 years) pictorial elicitation was more efficient, since the use of written stimulus would require more imitative prompts. Written and pictorial mode of elicitation showed no difference to the accuracy of production by 9;0 to 12;0 years.

During the development, children exhibited non-adult realization of consonant clusters. Some of the non-adult productions noted by Mcleod and Arcili (2009) were, for two element /s/ consonant clusters, /s/ realized either as an inter-dental or lateral lisp whereas the second element preserved. In contrast, for two element /r/ clusters, the first element was correct and the /r/ realized as [w]. The three-element consonant clusters were reduced to two elements (/spl/ →/sp/, /skr/→/sk/, /spr/ →/sp/, and /str/→/st/) in children aged 5;0–8;0 years. A comparison of the mastery of the word-initial clusters in English by various authors is depicted in Table 2.5

Table 2.5

Age of acquisition of word-initial consonant clusters in 3 to 12 years old English speaking children (McLeod & Baker, 2016, pp-204)

Study	**McLeod &Arciuli (2009)**	**Smit et al. (1990)**		**Templin (1957)**
Age range	5;0-12;11	3;0-9;0		3;0-8;0
Criterion	90%	75%		75%
Sample size (N)	74	997		480
Gender	Females and Males	Females	Males	Females and Males
/w/ cluster				
tw	-	3;6	3;6	4;0
kw	-	3;6	3;6	4;0
/l/ cluster				
pl	-	4;0	5;6	4;0
bl	-	4;0	5;0	4;0
kl	-	4;0	5;6	4;0
gl	-	4;6	4;6	4;0
fl	-	4;6	5;6	5;0
/r/ cluster				
pr	9;0-10;0	6;0	5;6	4;0
br	5;0-6;0	6;0	6;0	4;0
tr	5;0-6;0	6;0	5;6	4;0
dr	5;0-6;0	6;0	5;0	4;0
kr	5;0-6;0	4;6	5;6	4;0
gr	5;0-6;0	6;0	5;6	4;6
fr	7;0-8;0	6;0	5;6	4;6
θr	9;0-10;0	7;0	7;0	6;0
2- element /s/ cluster				
sp	5;0-6;0	4;6	5;0	4;0
st	5;0-6;0	4;6	5;0	4;0
sk	5;0-6;0	4;6	6;0	4;0
sm	5;0-6;0	5;6	7;0	4;0
sn	5;0-6;0	6;0	5;0	4;0
sl	5;0-6;0	6;0	7;0	4;0
sw	5;0-6;0	4;6	6;0	6;0
3- element /s/ cluster				
spl	7;0-8;0	6;0	7;0	6;0
spr	9;0-10;0	8;0	8;0	5;0
str	5;0-6;0	8;0	8;0	5;0
skw	5;0-6;0	4;6	7;0	6;0
skr	5;0-6;0	8;0	8;0	6;0

Summarizing the study by Macleod et al., (2001a) the following general trends were observed in consonant cluster development.

1. Two-year-old children have few consonant clusters in their inventory; however, they may not be the same form as the target as in the ambient language.
2. Word-final consonant clusters generally appear in inventories earlier than word-initial clusters.
3. Two- element clusters are acquired and mastered earlier to three- element clusters.
4. Clusters containing stops (e.g. /pl/, /kw/) are acquired generally before consonant clusters fricatives (e.g. /st/, /sr/)
5. Young children typically delete one element of the consonant cluster (cluster reduction)
6. Homonymy occurs in young children's attempts to produce consonant clusters; it can as a result of cluster reduction or cluster creation.
7. The most common form of non-adult realizations of the consonant cluster is cluster simplification. Epenthesis and coalescence were also reported, and rarely metathesis.
8. The acquisition of consonant clusters is gradual and follows a typical developmental sequence. For word-initial clusters, children may initially delete a member of a consonant cluster (one element realization), then preserve the members but one may be produced in a non-adult manner (two element realization) and finally correct production (correct realization of two elements). Other development sequences are possible, particularly for word-final consonant clusters.

9. In terms of phonological processes, with development the cluster reduction diminishes, cluster simplification increases eventually mastery of correct production.
10. Despite a typical developmental sequence being found, the acquisition of clusters is marked by reversals and revisions with considerable individual variations.

Cluster acquisition in other languages

African American English

African American English is spoken all over the USA but it is the most likely observed wherever African Americans are densely populated. Stockman (2006) observed that word-initial clusters are used as early as 2;8 years of age and the earliest ones are likely to be the stop+ sonorant type (e.g. /pl-/ , /tw-/). Between 3;6 and 5;0 years, the broad range of initial consonant clusters are acquired; by this age clusters with two obstruent as in the case of /sk-/ and /st-/ are learned (Wilcox & Anderson, 1998). The children's ability to reproduce initial and medial /s/ clusters in bi-syllabic non sense words progressed with age, and by 8;0 years in both the positions no errors were observed (Stockman 1993).

Irish English

In Irish English, Grunwell (1987) noted, obstruent+ approximants cluster reduction cease between 2;6 to 3;0 years. Waring, Fisherand, and Aitken (2001) reported the percentage of consonant clusters correct in Table 2.6. Children aged 3;5-3;11 acquired a mean of 51/59 (86.4%) consonant clusters correctly later it advanced to 58/59 (98.3%) by age 7;0- 7;11 years.

Table 2.6

Age of acquisition for Irish English consonant clusters (Waring, Fisher, & Aitken, 2001)

Age (Years)	Consonant clusters (Waring, Fisher & Aitken, 2001)
3;0-3;11	86.4%
4;0-4;11	88.1%
5;0-5;11	94.9%
6;0-6;11	96.6%
7;0- 7;11	98.3%

New Zealand English

By 5;0 years /l/ clusters /bl/, /pl/, /kl/, /gl/, /sl/, /fl/were mastered (90%) in New Zealand English speaking children. 80 and 90 percent 5;0 years old girls produced all common consonant clusters in word- initial position and three element consonant clusters (i.e. /spr/, /str/ and /skr/) accurately. However, 80% or more boys were reported to produce three element consonant clusters by 6;0 and 7;0 years. Boys were reported to acquire consonant clusters later than girls (Moyel, 2005)

French

Rose (2000) stated, in French onset clusters appear to develop in a positional determined way. Children acquired clusters in (final) stressed syllables before being acquired in (non-final) unstressed syllables. However, Kehoe and Hilaire-Debove (2004), reported that in their study of the development of France French, did not find such an effect.

Dutch

In Dutch, Jongstra (2003) determined the percentages of correct production of 5,562 instances of word-initial consonant clusters (from a total of 23,167 instances) produced by 34 children between the ages of 1;11 and 3;4 years. Results in terms of percentage are given in Table 2.7.

Table 2.7

Percent correct for Dutch initial consonant clusters (Jongstra, 2003)

Consonant cluster	Percentcorrect	Consonant cluster	Percent correct
kn	17.51	br	46.99
sx	21.05	tɾ	47.08
sn	25.58	kʋ	49.90
dr	32.28	pr	54.77
sw	33.94	st	55.81
sk	36.07	kɾ	58.46
fr	38.67	fl	61.20
tw	38.82	sl	62.29
sp	42.15	bl	62.77
sm	43.10	pl	73.60
xl	45.39	kl	73.68
xr	45.44	total	45.86

German

Fox and Schäfer (2006) reported a range of clusters were present in the inventory of children as early as 2;0 to 2;5 years old German-speaking children, however, clusters started to be acquired by the age of 3;0 to 3;11 years (Fox & Dodd, 1999). Clusters containing /ʃ/ + other consonant were observed to be produced correctly between 3;6 and 4;6 years of age.

Hebrew

Studies on the acquisition of clusters in Hebrew have focused on three topics: age of acquisition, the order of acquisition and type of errors, all on initial clusters, as the common type in Hebrew. Rosenberg's (1983) cross-sectional study of 33 children aged 2;0 to 4;11 years showed that more than half of clusters (56%) were produced correctly by around age 2;6 years when the most common error was reduction of the cluster to a single member. Other types of errors were the deletion of the whole cluster and producing a cluster with one of its member replaced by another consonant. At age 3;6, the vast bulk (85%) of the clusters were produced correctly, with almost

no deletion of an entire cluster at the age 4;6 years, more than 90% of the clusters were produced correctly, leading Rosenberg to conclude that the age of acquisition of clusters by Hebrew- speaking children is around 4;0 years.

A cross-sectional study by Forkush (1997), included 36 children between ages 1;8 and 4;8 years showed findings similar to Rosenberg's (1983). The younger subjects (aged 1;8 to 2;11 years) produced only around one-third (33%) of the clusters correctly, increasing to well over half (58%) between ages 3;0 and 3;10 and reaching nearly ceiling (87.6%) after 4;0 years. The most frequent errors across the population were reduction of the cluster to one member. Further, across age groups, clusters in CCV syllables were produced more correctly than clusters in CCVC syllables. Ben- David (2001) found that before the age of 2;6 years, all 10 children in the study produced at least three or four word-initial consonant clusters. As in the other studies deletion of one consonant of the cluster was the most frequent error. Other errors were epenthesis of a vowel between the two components of the cluster and coalescence of features from the two consonants into one consonant.

Japanese

In Japanese, cross-sectional studies by Umebayashi and Takagi (1965), Yasda (1966) and Sakauchi (1967) show that [Cj] clusters with an initial labial consonant (/mj/, /pj/, /bj/) reach the criterion of 75% correct production by 3;0. Velar palatal clusters (/kj/, /gj/, /hj/) reach the criterion slightly later (around 3; 0 to 3;6 years). The /rj/ cluster is the last the be acquired (around 4;0 to 4;5 years)

Spanish

Preschool (i.e., three and four-year-olds) Spanish- speaking children are able to produce consonant clusters relatively (Goldstein and Iglesias, 1996) with near

accuracy of 1005 by five years of age (Bichotte, Dunn, Gonzalez, Orpi, and Nye, 1993). The percentage of clusters produced correctly for three years old was 85%. The percentage increased to over 90% for 4-year-olds. By the time Spanish- speaking children are five years of age; consonant cluster accuracy is near 100% (Bichotte et al., 1993).

Maltese

The study by Grech (1998) showed the percentage of consonant clusters produced correctly and reported respective data (Table 2.8) at age 2;0, 2;5, 3;0 and 3;6 years for syllable- initial and syllable-final position of clusters, respectively.

Table 2.8

Acquisition of consonant clusters at age 3.6 in Maltese (Grech, 1998)

Consonant cluster type	**Syllable position**	**Percent usage at age 3;6years**
Plosives+ approximants	Initial	100.00%
Fricative+ approximant	Initial	100.00%
Fricative+ nasal	Initial	94.74%
Plosive+ Plosive	Initial	80.00%
Affricate+ Approximant	Initial	66.67
Others	Initial	100.00%
Nasal+ Fricative	Final	94.12%
Nasal+ Affricate	Final	100.00%
Approximant+ Plosive	Final	88.89%
Approximant+ approximant	Final	75.00%
Plosive+ Fricative	Final	100.00%
Others	Final	90.00%

In the syllable-initial position the clusters attempts at 3;6 years of age-matched with the adult from between 46% and 83% depending on cluster type. In the final position, results were even more favourable; all attempt made matched with the adult ones in 75% or more of the cases.

Greek

In Greek, PAL (1995) and Papadopoulou (2000) investigated the acquisition of consonant clusters, both these studies used the criterion of 75% correct production regardless of the position in the word. Results of the study conducted by PAL (1995) and Papadopoulou (2000) are compared in Table 2.9.

Table 2.9

Age of acquisition for Greek consonant clusters (PAL, 1995; Papadopoulou, 2000)

Consonant cluster	PAL (2000)	Papadopoulou (2000)	Consonant cluster	PAL (2000)	Papadopoulou (2000)
sp	3;6- 4;0	-	fr	4;6- 5;0	4;1- 4;6
st	4;0- 4;6	-	vr	5;0- 5;6	4;1- 4;6
sk	4;0- 4;6	-	ɣr	5;0- 5;6	*(4;6)
sc	4;0- 4;6	3;7- 4;0	θr	5;0- 5;6	*(4;6)
sf	4;6- 5;0	4;1- 4;6	ðr	5;0- 5;6	*(4;6)
sx	*(6;0)	4;1- 4;6	pç	3;6- 4;0	-
pl	3;6- 4;0	3;7- 4;0	bʝ	*(6;0)	-
kl	3;6- 4;0	3;7- 4;0	tç	*(6;0)	-
fl	4;0- 4;6	3;7- 4;0	ðʝ	4;0- 4;6	-
vl	3;6- 4;0	3;7- 4;0	zm	4;0- 4;6	-
ɣl	5;0- 6;0	4;1- 4;6	zɣ	4;6- 5;0	-
ft	4;6- 5;0	3;7- 4;0	pn	3;6- 4;0	-
st	-	3;7- 4;0	kn	3;6- 4;0	-
xt	4;0- 4;6	3;7- 4;0	mn	4;0- 4;6	-
ps	4;0- 4;6	4;1- 4;6	xn	4;6- 5;0	4;1- 4;6
ks	4;0- 4;6	4;1- 4;6	vɣ	3;6- 4;0	3;7- 4;0
pr	-	4;1- 4;6	spr	-	*(4;6)
br	-	4;1- 4;6	str	5;0- 5;6	*(4;6)
tr	4;0- 4;6	*(4;6)	xtr	5;6- 6;0	-
dr	4;6- 5;	*(4;6)	ftç	*(6;0)	-
kr	4;0- 4;6	4;1- 4;6	sfr	-	*(4;6)

Note: *=sounds were not acquired at the given age in Parentheses; - = Sound was not tested.

The most active period of cluster acquisition was between 3;6 and 4;6 years, when most of the two-element clusters with /s/, the clusters consisting of plosive/fricative + /l/, most of the nasal clusters were acquired. Most of the three-element clusters and clusters with palatal fricatives were yet to be acquired by 6;0 years; thus, Cluster acquisition was not completed by the age of 6;0 years.

Clusters are common in world's most of the languages. The acquisition of consonant clusters varies across the languages due to various linguistic factors such as word frequency, vocabulary size, and phonotactics, the phonetic/articulatory complexity of segments, etc in a given language. However, very little work has been reported in the literature on systematically investigating acquisition in different the languages.

Consonant cluster acquisition in Indian languages

In Indian languages, most of the research on cluster acquisition has been carried out as a part of the study related either to normal phonological development or standardization and development of test materials, examining only a limited number of consonant clusters. Some of the studies have been summarized below.

Telugu

Chervela (1981) longitudinally studied the acquisition of medial clusters in 1;6-3;0 years old Telugu speaking children. Findings revealed cluster reduction, substitution and assimilation were predominant in this age group.

Padmaja (1988), as a part of development of Telugu Test of Articulation and Discrimination, studied the acquisition of clusters such as /bla/, /sla/, /ksha/, and /sra/ in 160 Telugu speaking children between the age range of 2.5 to 4.5 years and noted

that all the clusters were acquired within the age of 3.6 years itself by 85% of the sample.

Neethipriya and Manjula (2007) studied phonotactic development in typically developing Telugu speaking children of the age group 3;0 to 6;0 years. Results on cluster acquisition are as follows;

- Medial clusters occurred predominantly with 60-70% of frequency and within medial geminated clusters occurred with a frequency of 30-40%.
- Medial non-geminate clusters occurred with a higher frequency of 45-55%. Nasal+homorganic stops (/nt/, /nd/, /nk/, /mt/ etc.) were predominantly noticed in the samples followed by fricatives + plosive combination (-st-).
- Initial and final clusters occurred with a frequency of less than 3% and typically occurred in borrowed words in all age groups.
- Three consonant clusters occurred medially with the combination of nasal + stop + liquid combination (-ntl-). Three consonant clusters have a frequency of occurrence less than 3%.Two consonant clusters were frequently occurring than three-consonant clusters.

Usha and Sreedevi (2010) studied the articulatory acquisition in Telugu speaking 2;0 to 3;0 year old children. Out of four consonant clusters tested, some geminate clusters were achieved by 2.6 to 2.9 years of age. 60% of the children achieved some of the non-geminate clusters by the age of 3 years.

Sneha and Sreedevi (2012)carried out a developmental study for obtaining normative data exclusively on the acquisition of non-geminate consonant clusters in native Telugu speaking children of age range 4;0 to 6;0 years. Twelve word-initial clusters and 14 word-medial clusters were tested. Findings indicated that, medial

clusters were mastered earlier to initial clusters. The performance was easier in word imitation task than story narration and picture description. However, it showed lesser variability than the latter two tasks. Girls acquired the target productions in advance than boys; however, the difference is not significant. Cluster reduction process was commonly observed to decrease with increase in age. The initial cluster /sn/ was reported to be the most difficult non-geminate cluster to produce, followed by /pr/. In medial position, the non-geminate /ndl/ was revealed to be the hardest cluster to articulate among children.

Malayalam

Maya (1990) reported that, cluster acquisition began by 4;7 years and continued till 7;0 years. /nd̪r/, /pr/, /kr/, / ʈr/ were the earlier acquired clusters (by 5;0 years), children acquired /st̪/ and /sk/ by 6;0 years, /st̪r/ by 6;5 years and /kʃ/ was the last cluster acquired by 7;0 years.

Divya and Sreedevi (2010) examined cluster acquisition in children aged 2;0-3;0 years, and found only one boy in the age range of 2;9-3;0 years produced /tr/, /st/,/sk/ in the medial position. At 2;9 years, children begin to produce clusters but they have substitution errors.

The acquisition of initial and medial consonant clusters in typically developing children as part of revalidation of the Malayalam diagnostic articulation test was carried out. Three investigators carried out cross-sectional study independently for 15 word-initial and 15 word-medial clusters were tested in children age 3;0–6;0 years. The acquisition of these clusters is summarized in Table 2.10

Table 2.10

Acquisition of consonant clusters for different age groups in Malayalam

Position	Neenu and Sreedevi (2011) 3;0-4;0 years	Vipina and Sreedevi (2011) 4;0-5;0 years	Vrinda and Sreedevi (2011) 5;0- 6;0 years
Initial clusters	No cluster acquired	/kl/, /tr/, /bl/, /s̪t̪/, /sk/, /gl/, /kj/, /pr/	/kl/, /tr/, /bl/, /s̪t̪/, /sk/, /gl/, /kj/, /pr/,/pl/, /sl/
Medial clusters	/nt/, /n̪t̪/, /nj/,/lj/, /nk/, /nd/, /tj/	/nt/, /n̪t̪/, /nj/,/lj/, /nk/, /nd/, /tj//ndz/, /sk/, /s̪t̪/, /dj/	/nt/, /n̪t̪/, /nj/,/lj/, /nk/, /nd/,/tj/,/ndz/, /sk/, /s̪t̪/, /dj//n̪d̪r/, /s̪t̪r/, /kʃ/

Neenu and Sreedevi (2011) investigated cluster acquisition in 3;0-4;0 years old Malayalam speaking children. By 4;0 years of age, 7 out of 15 medial clusters /nt/, /n̪t̪/, /nj/,/lj/, /nk/, /nd/, and /tj/ were mastered (90%). Errors found in this group are cluster simplification like coalescence and metathesis. Gender difference for the performance was reported only for younger age group 3;0- 3;3 but not in children in the age range of 3;3- 4; 0 years. Girls performed better in the younger age group over boys.

Vipina and Sreedevi (2011) carried out similar study in 4;0-5;0 years. By 5;0 years, 8 out of 15 initial clusters /kl/, /tr/, /bl/, /s̪t̪/, /sk/, /gl/, /kj/, and /pr/and 10 out of 15 medial clusters /ndz/, /sk/, /s̪t̪/, /dj/ and seven clusters mentioned in 3;0-4;0 years group met the 90% criteria. Common cluster errors found were cluster reduction, followed by cluster simplification (epenthesis and coalescence). Errors such as metathesis were rare. There was no significant difference in the performance of males and females.

Vrinda and Sreedevi (2011) studied cluster acquisition in 5;0-6;0 years old Malayalam speaking children. By six years of age 14 out of the 15 clusters met 90% criteria in both the initial (/pl/, /sl/ and clusters acquired in the previous age group)and medial (/nd̪r/, /st̪r/, /kʃ/ and clusters acquired in the previous age group) positions of words. Medial clusters were acquired earlier than initial clusters in general. The common cluster errors found were cluster reduction followed by epenthesis and cluster substitution.

Bengali

Banik (1988) tested 18 consonant clusters (e.g. /kr/, /kʃ/, /sr/, /gl/, /br/ /st/, /skr/) in 165 typically developing children in the age range of 2;0 to 8;0 years as a part of the Articulation test in Bengali. Results indicate that the acquisition of clusters emerged by the age of 3;5 years on an average. However, few clusters which were acquired later /br/-4;5 years, /st/- 4.0 years, /kr/- 4;5 years.

Hindi

Santhosh (2001) examined the clusters as a part of development of phonological processes in 3;0-4;0 years old typically developing Hindi speaking children. Cluster reduction and epenthesis persisted beyond 4;0 years. Pyata and Banik (2016) studied phonological development of native Hindi speaking children of age range 2 ½ to 6 ½ years. Findings show that clusters /ʧʧʰ//, /lh/and /vj/ were acquired by 3 ½ years of age in 80% of the participants. Blends /br/, /tr/,/dr/, /kr/, /gr/, /rtʃh/ were acquired by 4 ½ years of age ~~in 80% of participants~~ and /mr/ was acquired by the age of 5 ½ years in 80% of participants. By 6 ½ years, all blends were found to be acquired except /ʤr/ which was acquired by only 60% of the participants.

Tamil

Barathy (2001) studied phonological processes in 30, typically developing Tamil speaking children age 3;0- 4;0 years. Tamil articulation test was administered and the findings reveal that cluster reduction process was frequently occurring and persistent in 3;0- 4;0 years old children.

Kannada

Jayashree (1999) studied phonological development in 4;0-5;0 old typically developing Kannada speaking children. She found that even by five years of age cluster reduction persisted in child's phonology.

Rupela and Manjula(2006) studied the phonotactic development in Kannada speaking children in the age range of 0-5 years using spontaneous speech samples and found that,

- Medial geminated clusters were first to be acquired and were present in the age range of 12- to 18- months
- Medial non-geminate clusters appeared at 18- to 24- months; then occurred more frequently by 30- to 36- months and remained stable until 48 months. Again predominate by 48-to 60- months.
- Initial clusters were stabilized by 24- to 30- months. However, the frequency of initial clusters was found to be limited.
- Three sound clusters in the medial position were found to stabilize from 42- to 48- months onwards. These clusters were also noted to have a low frequency of occurrence.

- The rare occurrence of final clusters was also seen only for borrowed English words (e.g. *elepha<u>nt</u>*).

Prathima and Sreedevi (2009) researched articulatory acquisition in 3;0– 4;0 years old typically developing Kannada speaking children and as a part of the same, tested 10 non-geminate consonant clusters- /st-/, /sk-/, /dr-/, /rc/, /kr/, /-ksh-/, /bl-/,/skr-/ (four in initial and six in medial word position). Results revealed that only /ski/ and /kra/ were acquired by 90% of the children by the age of four years.

Re-standardization of Kannada Articulation Test was done by Deepa and Savitri (2010), the target acquisition criteria were kept at 90%. Eleven clusters /st/,/sk/, /sk/, /dr/, /rʧ/, /kr/, /kʃ/, /bl/ and /skr/ were tested. Clusters /st/ and /dr/ were assessed both in the initial and medial positions. Clusters /st/ and /sk/ were acquired by 4;0– 4;6 years in boys and by 3;6 – 4;0 years in girls; /skr/ by 4;0 – 4;6 years and /dr/ by 5;0 – 5;6 in both girls and boys. Cluster /dr/ was acquired in medial position earlier to initial position. The cluster /rʧ/ was not mastered even by 6;0 years.

As noted, there is limited research extensively related to the acquisition of clusters in the Indian context. Kannada is one of the major languages of South Indian Dravidian family. There is a gap in literature with respect to the acquisition of clusters in Kannada. Thus, this study was conducted to obtain norms on acquisition of consonant clusters in Kannada.

A systematic understanding of structure and phonotactics of the Kannada language facilitates better designing of the study. Thus, a brief outlook about linguistic structure of Kannada is described below.

Linguistic structure of Kannada: Consonant repertoire and phonotactics of cluster occurrence in Kannada

The speech sound in the inventory of Kannada constitutes eleven vowels are /a, ā, i, ī, u, ū, e, ē, o, ō, æ/, two diphthongs /ai, au/ and thirty-four consonants are represented in the Table 2.11. The speech sounds /æ/, /f/ and /z/ occur only in loanwords. Differences witnessed in the repertoire of modern Kannada could be influenced by modern trends such as propagation of universal education, and changes in social dialect (Sridhar, 1990).

Table 2.11

The consonant repertoire in the Kannada language (Sridhar, 1990)

	Labial	**Dental**	**Retroflex**	**Palatal**	**Velar**
Stops					
Voiceless	p	t	ṭ	c	k
Aspirated	ph	th	ṭh	ch	kh
Voiced	b	d	ḍ	j	g
Breathy voiced	bh	dh	ḍh	jh	gh
Fricatives					
Voiceless	f	s	ṣ	ś	h
Voiced		z			
Nasal	m	n	ṇ		
Lateral		l	ḷ		
Glide	v			y	
Tap		r			

Hiremath (1961) studied the structure of Kannada language in Dharwad dialect. The following are few of the observations about the consonant clusters in Kannada:

- Possible combinations in two element clusters are: voiceless stop+ voiceless stop (e.g. /utpanna/- ‘income’), voiced stop+ voiced stop (e.g. /śabda/- ‘sound’), the occurrence of voice+ voiceless stop (/aḍke/- ‘betel nut’) is less frequent
- Nasals, laterals, sibilants, trills, and semivowels may occur either as the first or second member of a cluster with voiced or voiceless stops or affricates
- But, /ś/ and /h/ cannot be the first member of the cluster two-element and three-element clusters.
- /ḷ/ does not form a second member of the cluster with /y/, /l/, dental or retroflex stops and nasals.
- /ṇ/ does not form a second member of the cluster with / ḷ /, dental stops and nasals.
- The vowels preceding geminate clusters are always short. However, in case of non-geminate clusters, they can be short or long.
- Three element clusters occur predominantly occur inter-vocalically.
- Retroflex sounds rarely occur in three element clusters.
- Frequent combination of three element clusters:
- Nasal+ homorganic stop+ sonorant: e.g. /bandru/- ‘they came’, /ganṭlu/- ‘throat’
- Nasal+ homorganic+ stop: e.g. / manṭpa/- ‘a pandal’
- Nasal+ homorganic+ spirant: /kunṭsu/- ‘make him walk one-legged'
- In colloquial usage four-member cluster could also occur sometime in rapid conversation (e.g. /tingḷge/- ‘for one month’

- In Kannada, word-initial consonant clusters occur less frequently although many loan words from English with word-initial clusters are present in the educated persons.

The above described observations were given on the basis of colloquial language use for Dharwad dialect. It can be noted that Kannada speakers may incorporate many possible combinations of non-geminate consonant clusters. They are based on position in the word: initial (mostly loan words), predominantly medial and based on the number of elements in the cluster: Two to four element clusters can occur in Kannada colloquial language.

To summarize, the literature reveals that cluster acquisition is a complex process and takes a longer time to complete. Children go through a series of stages from non-adult productions like cluster reduction to finally the target adult like productions. Thus, the acquisition of clusters can continue till 9;0-12;0 years. Cluster acquisition is influenced by the position of the cluster (final clusters are acquired earlier to initial clusters) and constituent elements of the consonant clusters. It is also different across the language, as the phonotactic structure specific and different to each language. The studies in Kannada exclusively investigating cluster acquisition have not been reported. Thus, this study intended to explore the development of consonant clusters in typically developing Kannada speaking children.

CHAPTER III

METHOD

Phonological development in children follows a specific pattern of acquisition with age for a given language. Acquisition of cluster production is a part of the phonological development. The norms established for the mastery in the acquisition of cluster production can provide important inputs for differentiating normal children from children with speech sound disorders and also to determine goals for therapy.

Aim of the study

The aim of the study was to develop norms for the acquisition of non-geminate consonant clusters in native Kannada speaking children in the age range of 3;0 to 6;0 years.

The specific objectives of the study were

1. To obtain norms for non-geminate cluster acquisition in typically developing Kannada speaking children.
2. To compare the non-geminate consonant cluster acquisition skills across age and gender.
3. To determine the positional variations in the acquisition of non-geminate consonant clusters.

Participants

Typically developing native Kannada speaking children in the age range of 3;0 to 6;0 years were randomly recruited for the study from kindergarten, primary schools and different localities in Mysore city. The age range was divided into six subgroups with an age interval of six months (>3;0 to ≤3;6,>3;6 to ≤ 4;0, >4;0 to ≤ 4;6, >4;6 to ≤ 5;0, >5;0 to ≤5;6 &>5;6 to ≤6;0 years). Each subgroup included a total of 30 children with an equal number of boys and girls. Thus, a total of 180 children

participated in the study. As a part of the regular ethical procedure, before recruiting participants for the study, a written consent was obtained from parents, caregiver or concerned school authorities (Appendix A).

Subject selection criteria: Participants were selected based on the following criteria:

1. A native speaker of Kannada with everyday exposure to the Kannada language. The participants were also exposed to some amount of English language in the school set up.
2. Reared in an ambient environment of Kannada
3. Belonging to Urban middle socioeconomic status (The Socioeconomic Status Scales, Venkateshan, 2011)
4. No history of speech, language, hearing, visual, cognitive, motor or any neurological deficits associated based on parent/ teacher report, informal observations and screening for language age using screening checklist (developed in Department of Prevention of Communication Disorders, AIISH,2008).

Material

A list of 54 frequently used meaningful Kannada words which can be depicted by pictures, incorporating non-geminate consonant clusters in the initial and medial positions were considered for the study. Initial consonant cluster words were considered from frequently used English loan words as Kannada initial cluster words are less frequently used.

Material preparation

A total of 100 meaningful and frequently used Kannada words that were represented through picture included, non-geminate two element clusters in both initial and medial position along with few three element clusters. These words were pooled from age-appropriate children's textbooks, storybooks, the corpus of familiar words listed in the Post-Doctoral thesis by Mahalakshmi (2012), and words from children's spontaneous speech during the informal conversation carried out by the investigator for collecting commonly used words in spontaneous speech. As the word-initial two element clusters are less frequently occurring in Kannada, frequently used English borrowed words were also selected. Few initial three element clusters were also the English borrowed words, as they have rare occurrence in Kannada language (Rupela & Manjula, 2006).

Familiarity test

For the data pooled, a familiarity test was carried out. Five native Kannada speaking Speech-Language Pathologists served as judges for rating the familiarity of words and the ambiguity of pictures used.

Familiarity test for word selection

Each word selected was rated on a three-point rating scale (Most familiar- 2, Familiar- 1, and Unfamiliar- 0). The judges were instructed to score the familiarity of the word in children for each age group based on the appropriateness for vocabulary, the frequency of usage, culture, and picturability of the word. Totally 54 words were selected which were rated as most appropriate by four out of the five judges (80% agreement between the judges).

Picture familiarity

Further, three pictures were collected from internet sources (e.g. Google) for each selected word and the judges rated the pictures based on familiarity, ambiguity and clarity on a three-point rating scale (Most appropriate- 2, Appropriate- 1, and Unrelated- 1). Care was taken to keep the pictures colourful, interesting, unambiguous and appropriate for the Indian context. The pictures rated as appropriate and most appropriate by four out of the five judges (80% agreement) were selected as stimuli for the present study. All the words selected were represented through pictures without ambiguity.

Procedure

Data collection and recording procedure

Instrumentation

The following instruments were used for recording and analysis purposes:

- Sony Vaio PCG-71811W, Core i3 laptop system for displaying the pictures
- Sony full HD 1080 Handycam a digital audio-video recorder for audio recording the verbal response of each participant.

Materials

Fifty-four colour pictures were used as stimulus. They were presented using Sony Vaio PCG-71811W laptop system. The pictures were randomly arranged in a power point presentation with a neutral white background. Care was taken to maintain the similar proportion and size of all the pictures.

Recording Procedure

Each participant was tested individually in a noise free room with minimal distractions, seated comfortably next to the examiner. The participants were presented with the pictures for each word using the Sony Vaio PCG-71811W laptop system one after the other. Each participant was instructed as follows.

"I will show you some pictures; you have to name the pictures one after the other. If you are not able to name the pictures, I will help you to name it". However, in case of difficulty or unfamiliarity, cues were given to elicit the response. Despite providing the cues if failed to name, then the participants was encouraged to repeat after the examiner. All samples were recorded using a digital AV recorder (Sony full HD 1080 Handycam) placed on a tripod stand at an approximate distance of 1 feet from the child. The recording for each participant was approximately10 to 20 minutes.

Picture naming task was employed in the present study for elicitation of the target consonant clusters in a word. If the child had difficulty in producing the target, a prompt followed by imitation was encouraged for one trial. It was noted that children of younger age (3;0- 5;0) required greater number of prompts and the response was elicited through imitation. Pictures used for the study is provided in Appendix E.

Elicitation of some of the words like /baʈru/, /vaɻra/, /ra:ɟja/, /dʋaɻa/, /sʈra:/, /spre:/ and /skru:/ was by imitation or required more prompts for children across all the age groups. This could possibly be due to relatively less frequent usage of these words than other words in colloquial language even by adults. Also the parent education level could be a factor influencing this variability.

Data transcription and Scoring

The data of 180 participants were transferred to the computer and transcribed using IPA broad phonetic transcription (2015) (see Appendix B and C), by the investigator. Each word was transcribed on a response sheet and scoring was done. Based on Greenlee's (1974) and Elbert and McReynolds (1979) stages of cluster development scoring was assigned to each type of error as follows;

1. If the entire cluster is deleted a score of '0' was given
2. In the present study, some of the participants presented errors, where only one element of the cluster was produced with a substitution error. In stages of cluster development described by Greenlee's (1974) and Elbert and McReynolds (1979), this type of error was not explained. Thus, for the ease of scoring in the present study, the investigator used a score of '0.25' for the error where one of the elements of cluster is preserved however, it has some substitution error.
3. A score of '0.50' was assigned when number of elements in the cluster is preserved.
4. Substitution of one or more consonants in a cluster was scored '0.75'
5. For the correct production of clusters a score of '1' was assigned (see Table 3.1)

Table 3.1
An example for scoring of two-element cluster (e.g. /kr/ in/kræ:k/)

Score	**Production**	**Example crack- /kræ:k/**
0	If the entire cluster is deleted	/æ:k/
0.25	If one of the elements of cluster is preserved with some substitution error	/tæ:k/
0.50	If one element is preserved and the other is deleted	/kæ:k/
0.75	If one consonant is preserved and other is substitured	/klæ:k/
1	Correct production of complete cluster	/kræ:k/

Correct production of a two-element cluster was given a score of 1 and for a three-element cluster; a score of 1.5 was given for correct production (see Table 3.2). Similar to the description of scoring as mentioned above, three element cluster scoring is as follows: Each element preserved was scored ‘0.5' and if substituted ‘0.25' and ‘0' for the omitted element, then the total of each element score was calculated out of ‘1.5'. This total was given as the score for three element cluster.

Table 3.2
An example for scoring of three-element cluster (e.g./spr/ in /spre:/)

Score	**Production**	**Example** spray- /spre:/
0	If the entire cluster is deleted	/e:/
0.25	If one of the elements of cluster is preserved with some substitution error	/fe:/
0.50	For the errors where one element is deleted and the other is preserved	/se: /
1	Substitution of one consonant in a cluster with the other two consonants correctly produced	/spe: /
1 .5	Correct production of complete cluster	/spre:/

A criterion of 90% correct response was considered in the present study. A score sheet was prepared and used for entering the scores for the transcribed data (Appendix D).

Reliability

Test-retest reliability

Reliability of response was measured by test-retest reliability. 10% of the data were tested with three children from each age group within a span of one week from the time of initial recording.

Inter-Judge Reliability

Three Speech-Language Pathologists including the investigator served as judges for determining inter-judge reliability. 18 participants' (10% of the sample)

recording samples were randomly selected and were used for inter-judge reliability. The judges listened to the audio recordings individually in a quiet room set-up using headphones and were instructed to transcribe the response on the score sheet.

Intra Judge Reliability

The investigator transcribed the responses of the participants after listening to the audio recordings for the second time.18 participants' (10% of the sample) recording sample were randomly selected for intra judge reliability

Data analyses

For each age group clusters produced correctly at least by 90% of the children was identified and the order of acquisition of consonant clusters was determined for different positions of cluster in the word. A criterion of 90% correct response was considered as mastery for each cluster.

Statistical analysis

A commercially available SSPS (Statistical Package for Social Sciences) version 21.0 was used for all statistical analyses. The mean and SD of raw scores and percent scores were calculated. Test of normality was carried out. Non-parametric tests were carried for further analyses as normality was not satisfied. Mann-Whitney test was used for comparison between the scores across gender for all the age groups. Kruskal-Wallis test was run to compare total score, Initial and medial clusters across all age groups. Further Mann-Whitney test was used for post hoc analysis, where pair wise comparison was done between all age groups to find the significant difference. Wilcoxon Signed Ranks Test was employed for comparison between the percentage of the Initial cluster and medial cluster total for each age group. Cronbach's reliability test was administered to measure inter-judge, intra-judge and test-retest reliability.

CHAPTER IV

RESULTS

The aim of the study was to develop norms for the acquisition of non-geminate consonant clusters in native Kannada speaking children in the age range of 3;0 to 6;0 years. One-eighty children participated in the present study. They were equally assigned to six subgroups of age with an inter-age-interval of six months. Picture naming task was used to elicit responses

In the present study, a total of 52 non-geminate consonant clusters were considered, including 22 initial clusters and 30 medial clusters (Table 4.1).

Table 4.1

List of the consonant clusters investigated in the present study

	/l/ cluster	**/bl/, / kl//pl/**
Initial Clusters	/ʋ/ cluster	/dʋ/, /ɟʋ/*
	/s/ cluster	/ sl/, /sʈ/, /sp/,/ sk/,/sʋ/, /sn/*, / skʋ/, /skr/, /spr/, / sʈr/
	/r/ cluster	/gr/, /ɖr/, /kr/,/br/, /dr/, /ʈr/, /pr/*
Medial Clusters	/l/ cluster	/pl/,/ kl/, /ɖl/,/ʈl/
	/s/ cluster	/sk/, /st/, /sl/
	Arka (r+consonant)	/ rk/,/rd/, /rc/, /rj/, /rt/
	/j/ cluster	/lj/,/dj/, /ɟj/
	/k/ cluster	/kʂ/,/kt/, /ks/
	/r/ cluster	/dr/, /sr/, /kr/, /gr/, /tr/,/ʈr/, /ɟr/
	Others	/lp/, /bd/, /ʈn/, /ʂn/,/çʋ/

Note: * indicates the clusters which are not considered for analysis.

For the analyses, 3 initial clusters- sn, pr, ɟʋ were not considered due to high variability across the age groups influenced by colloquial production (see Table 4.6). Therefore the total number of clusters considered for statistical analyses were 49 (19 initial clusters and 30 medial clusters). Out of 19 initial clusters 15 were two-element clusters and four were three-element clusters. Due to removal of three clusters, the

final total score is 51 instead of 54.The results are discussed under following headings: effect of gender, age and positions of the cluster.

Normality Test

The Shapiro-Wilk test for normality was administered. The data of the present study did not satisfy normality due to the presence of outliers across all the age groups and ceiling effect of the raw scores in higher age group. Normality could not be achieved even with the removal of outliers. Thus, for further statistical analyses, non-parametric tests were used and discussed with respect to effect of gender, age and positions of the cluster.

Although non-parametric tests were administered, the mean and median score were very similar across all the age groups, since the standard deviation was very low, with some variability only in younger age groups. Therefore, for the descriptive statistics mean values were considered for representing the data.

Comparison across gender within each age group

Descriptive statistical analysis was carried out to obtain the mean, median and standard deviation for the three parameters: total raw scores, initial cluster total and medial cluster total across gender within each age group. The mean scores and standard deviation across the gender for all the age groups are presented in Table 4.2.

The mean initial cluster total for the male and female group were 18.53 and 18.88 respectively and mean scores of medial cluster total for the boys and girls were 27.67 and 28.15 respectively, the mean total score for the boys and girls group were 46.21 and 47.03 respectively. Girls had a marginal edge over the boys group for scores in all the three conditions.

Table 4.2
Mean raw scores and SD across gender for all the age groups

Age groups (years)	Gender	>3;0 to ≤3;6	>3;6 to ≤4;0	>4;0 to ≤4;6	>4;6 to ≤5;0	>5;0 to ≤5;6	>5;6 to ≤6;0	Overall total
Initial cluster total score (21)	Boys Mean (SD)	12.9 (3.19)	18.05 (1.34)	19.21 (1.73)	19.93 (0.84)	20.31 (0.63)	20.8 (0.31)	18.53 (3.12)
	Girls Mean (SD)	14.83 (3.01)	17.56 (1.70)	19.08 (1.47)	20.28 (0.66)	20.7 (0.42)	20.81 (0.24)	18.88 (2.62)
Medial cluster total score (30)	Boys Mean (SD)	22.08 (3.39)	26.6 (1.63)	28.36 (1.49)	29.36 (0.51)	29.76 (0.40)	29.88 (0.18)	27.67 (3.20)
	Girls Mean (SD)	24.6 (3.55)	26.68 (2.09)	28.53 (1.00)	29.35 (0.44)	29.78 (0.26)	29.96 (0.12)	28.15 (2.57)
Total Score (51)	Boys Mean (SD)	34.98 (6.40)	44.65 (2.79)	47.58 (2.84)	49.3 (1.00)	50.08 (0.74)	50.68 (0.43)	46.21 (6.22)
	Girls Mean (SD)	39.43 (6.42)	44.25 (3.47)	47.61 (2.17)	49.63 (0.78)	50.48 (0.46)	50.78 (0.24)	47.03 (5.08)

The percentage was calculated for a total score of 51, initial cluster total 19 and medial cluster total for 30 for the respective mean scores obtained in each age group. The mean percentage values for all the scores across the gender for each age group and positions of the cluster are given in the Figure 4.1.

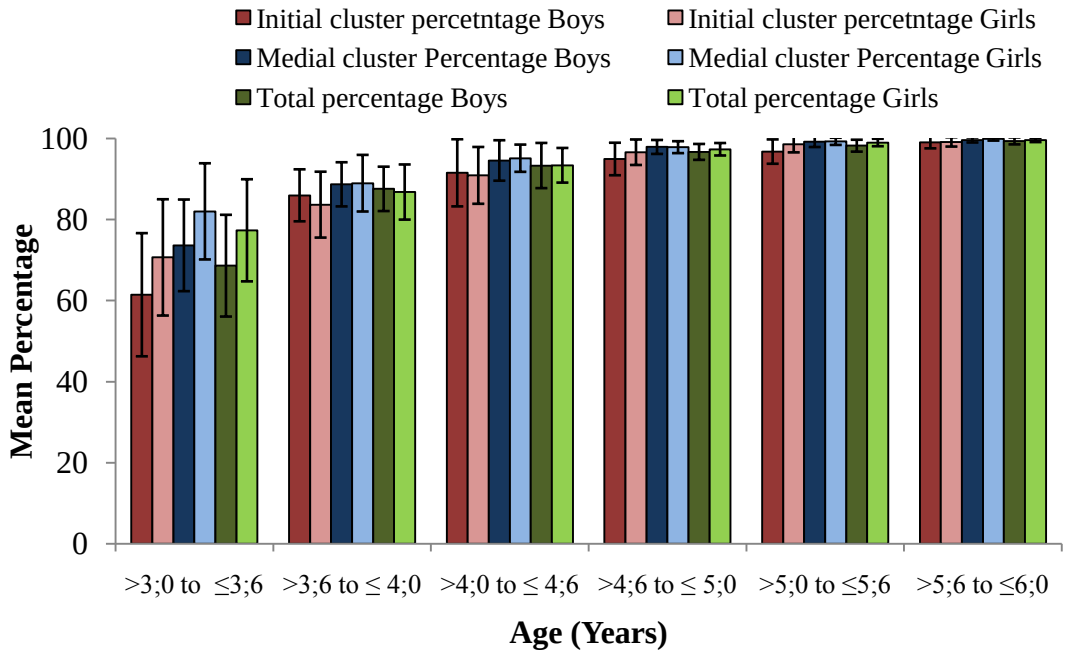

*Figure 4.1.*Comparing Mean percentage and SD across the gender for all the age groups and position of cluster

Thus, from the graph it is observed that girls performed better than boys in lower age groups. This difference in the performance of boys and girls was observed to reduce as the age increased.

Further, Mann-Whitney test was employed to verify for any significant difference between boys and girls across all the age group. Results indicated no significant effect ($p>0.05$) of gender for the acquisition of cluster production in all the age groups and positions of clusters. Thus, the data of boys and girls were combined for further statistical analyses.

Comparison between age groups

The mean values of the raw scores were compared across different age groups. The mean raw scores and SD for total, initial cluster total and medial cluster total are given in Table 4.3

Table 4.3
Mean raw scores and SD across the age groups

Age (Years)	**Initial cluster total score (21)**	**Medial cluster total score (30)**	**Total Score (51)**
	Mean (SD)	Mean (SD)	Mean (SD)
>3;0 to ≤3;6	13.86 (3.20)	23.34 (3.64)	37.20 (6.69)
>3;6 to ≤ 4;0	17.80 (1.53)	26.64 (1.84)	44.45 (3.10)
>4;0 to ≤ 4;6	19.15 (1.58)	28.45 (1.25)	47.6 (2.48)
>4;6 to ≤ 5;0	20.10 (0.76)	29.35 (0.47)	49.46 (0.89)
>5;0 to ≤5;6	20.50 (0.56)	29.77 (0.33)	50.28 (0.64)
>5;6 to ≤6;0	20.80 (0.27)	29.92 (0.16)	50.73 (0.35)
Overall Total	18.70 (2.88)	27.91 (2.90)	46.62 (5.68)

It can be observed from Table 4.3 across all age groups in all three conditions scores show a gradual improvement. The mean percentage for total scores is depicted in the Figure 4.2.

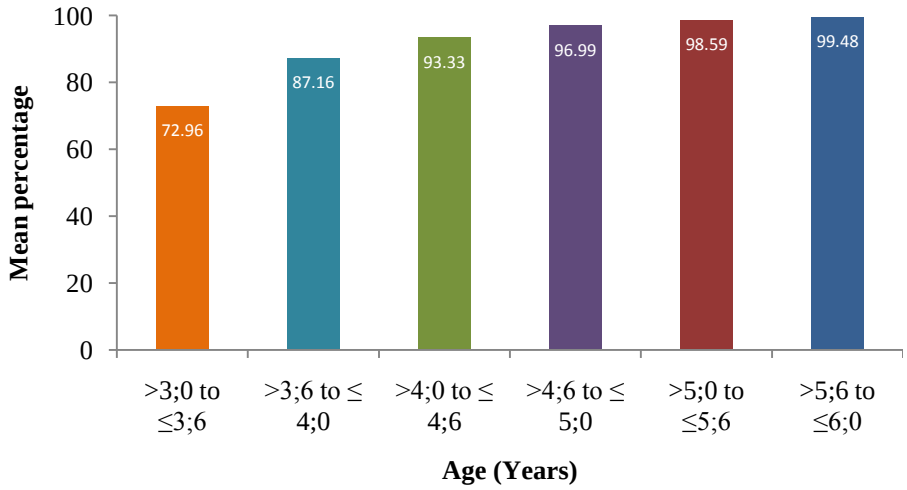

Figure 4.2. Comparison of mean total percentage across the age groups

From the Figure 4.2, a linear increase in the scores for all the three parameters with increase in age was observed. Thus, cluster acquisition in children demonstrate developing trend.

Subsequently, Kruskal-Wallis test was employed to estimate the overall, significant difference across all the age groups. The results indicated significant difference ($p < 0.05$) for all the three conditions across all the age groups. The following Table 4.4 depicts results of Kruskal-Wallis test.

Table 4.4

Results of Kruskal-Wallis test for comparison across the age groups

	Initial cluster total	**Medial cluster total**	**Total Score**
Chi-Square	127.744	135.102	140.044
'p' value	0.00	0.00	0.00

Since there was significant effect of age observed in all the conditions, post-hoc analysis was run using Mann-Whitney test for pair wise comparison across all the age groups (Table 4.5). There was significant difference ($p < 0.05$) across all the age groups for all the three conditions.

Table 4.5

Results of post hoc analysis using Mann-Whitney test for pair wise comparison across the age groups

Pairs of age groups	**Initial cluster total**		**Medial cluster total**		**Total scores**	
	|Z|	'p' value	|Z|	'p' value	|Z|	'p' value
G1-G2	4.952	.000	4.415	.000	-3.706	.000
G1-G3	5.914	.000	6.109	.000	5.839	.000
G1-G4	6.620	.000	6.657	.000	6.564	.000
G1-G5	6.695	.000	6.670	.000	6.707	.000
G1-G6	6.773	.000	6.729	.000	6.878	.000
G2-G3	3.276	.000	3.825	.000	3.991	.000
G2-G4	5.957	.000	6.319	.000	5.885	.000
G2-G5	6.494	.000	6.649	.000	6.500	.000
G2-G6	6.778	.000	6.729	.000	6.811	.000
G3-G4	2.364	.018	2.898	.004	3.332	.001
G3-G5	3.966	.000	4.972	.000	5.260	.000
G3-G6	5.593	.000	6.213	.000	6.034	.000
G4-G5	2.167	.000	3.577	.000	3.606	.000
G4-G6	4.251	.000	5.503	.000	5.045	.000
G5-G6	2.265	.023	2.991	.003	2.079	.038

Note: G1is >3;0 to ≤3;6 years, G2 is >3;6 to ≤ 4;0 years, G3 is >4;0 to ≤ 4;6 years, G4 is >4;6 to ≤ 5;0 years, G5 is >5;0 to ≤5;6 years and G6 is >5;6 to ≤6;0 years (where, G= group)

Thus, from the results it was noted that there is increase in the total, initial cluster total and medial cluster total scores with the increase in age indicating a visible developmental trend in the acquisition of clusters.

Comparison between medial and initial percentage within each age group

The non-geminate consonant clusters were analysed, out of which 19 were initial and 30 were non-geminate consonant clusters. Since the number of initial and medial clusters was not equal, the raw scores were converted into percentage and represented in Figure 4.3.

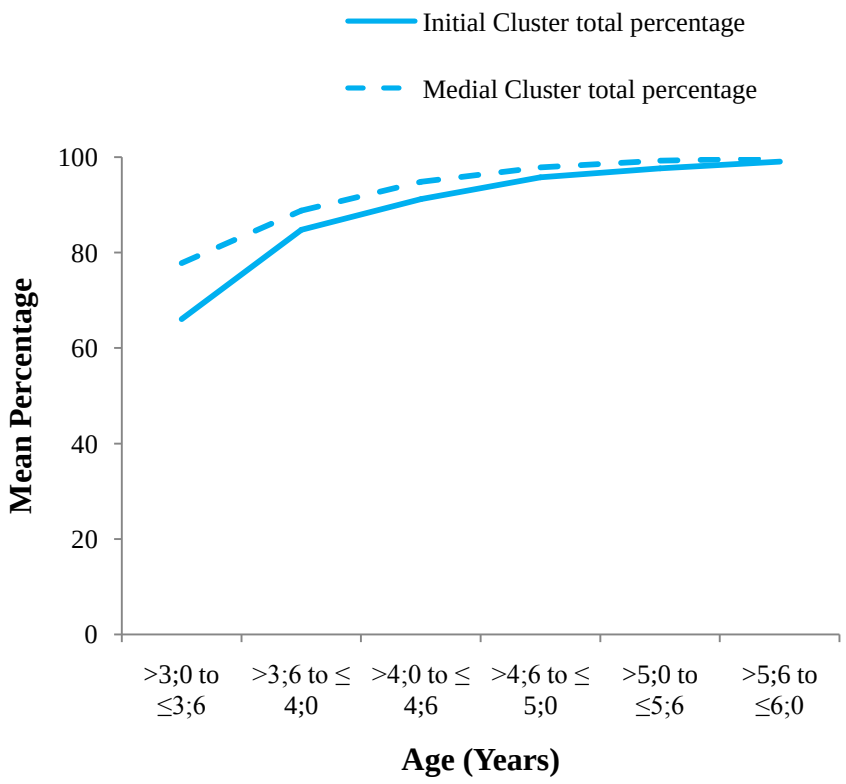

Figure 4.3. Comparison of mean percentage across the positions of the cluster

The Figure 4.3 indicates that mean percentage for medial cluster total is higher than the initial cluster total for all the age groups. With increase in, the age this difference with respect to positional variation is gradually reducing. To note if this difference was significant, Wilcoxon Signed Ranks Test was carried out. There was significant difference ($p<0.005$) within each age group across the positions of cluster. The results of Wilcoxon Signed Ranks Test are presented in Table 4.6.

Table 4.6

Results of Wilcoxon Signed Ranks Test for comparison across the positions of the cluster

Age groups (Years)	**>3;0 to ≤3;6**	**>3;6 to ≤ 4;0**	**>4;0 to ≤ 4;6**	**>4;6 to ≤ 5;0**	**>5;0 to ≤5;6**	**>5;6 to ≤6;0**
|Z|	4.731	3.446	3.446	2.495	2.649	2.580
'p' value	.000	.001	.001	.013	.008	.010

Hence, in all age groups there was a positive effect of position on acquisition of the cluster. The medial clusters exhibit higher scores compared to initial clusters across all age groups. Although this difference is reducing with increase a in age, significant difference ($p<0.05$) (Table 4.6) was still pertinent (Table 4.3).

Acquisition sequence of consonant clusters

For each word, percentage of children acquiring the consonant cluster in each age group was analyzed and the sequence of acquisition was plotted (Table 4.7). The 'mastery' of non-geminate clusters was considered to be achieved when 90% criteria was satisfied at a particular age.

It can be observed that as age increases the percentage of children acquiring the consonant cluster is increasing. Also out of 49 clusters considered for the analysis all the clusters achieved 90% acquisition by 6;0 years.

Table 4.7

75%, 90% and 100% acquisition of initial and medial clusters across all the age groups

Position	Sl No.	Cluster	Word	>3;0 to ≤3;6 years	>3;6 to ≤ 4;0 years	>4;0 to ≤ 4;6 years	>4;6 to ≤ 5;0 years	>5;0 to ≤5.6 years	>5;6 to ≤6.0 years
Initial clusters	1	/sk/	/skeːl/						
	2	/sl/	/sleːʈ/						
	3	/sʈ/	/sʈaːr/						
	4	/kl/	/klæːs/						
	5	/sp/	/spuːn/						
	6	/bl/	/bleːɖ/						
	7	/pl/	/pleːʈ/						
	8	/gr/	/griːn/						
	9	/skʊ/	/skʊeːr/						
	10	/skr/	/skruː/						
	11	/spr/	/spreː/						
	12	/ ɖr/	/ɖram/						
	13	/kr/	/kriketʈ/						
	14	/br/	/breɖ/						
	15	/sʈr/	/sʈraː/						
	16	/ dʊ/	/dʊaɻa/						
	17	/sʊ/	/sʊeʈar/						
	18	/dr/	/draːkʂi/						
	19	/ʈr/	/ʈrækʈar/						
Medial clusters	20	/sk/	/namaskaːra/						
	21	/pl/	/capli/						
	22	/lp/	/sʊalpa/						
	23	/ks/	/sɔːksu/						
	24	/st/	/ɻaːsti/						
	25	/kl/	/cakli/						
	26	/dj/	/madja/						
	27	/lj/	/palja/						
	28	/dr/	/candra/						
	29	/rk/	/tarkaːri/						
	30	/sʈ/	/basʈæːnɖ/						
	31	/ɖl/	/iɖli/						
	32	/ʂn/	/krišna/						
	33	/bd/	/çabda/						
	34	/gr/	/puḷijoːgre/						
	35	/rd/	/arda/						
	36	/rt/	/puːrti/						
	37	/çʊ/	/iːçʊara/						
	38	/ʈl/	/baʈlu/						
	39	/tr/	/catri/						
	40	/kʂ/	/pakʂi/						
	41	/rc/	/kircu/						
	42	/ʈn/	/caʈni/						
	43	/kr/	/aiskriːm/						
	44	/sr/	/mosranna/						
	45	/rj/	/suːrja/						
	46	/ɻj/	/raːɻja/						
	47	/kt/	/rakta/						
	48	/ʈr/	/baʈru/						
	49	/ɻr/	/vaɻra/						
Not Considered in analysis	50	/pr/	/praiz/						
	51	/sn/	/snaːna/						
	52	/ɻʊ/	/ɻʊara/						

Note: ▭ represents 100% of the children have acquired the cluster, ▭ >90% of the children have acquired the cluster, ▭ > 75% of the children have acquired ▭ indicates the region which is indicates the clusters are emerging in <75% of the children where total number of children in each group, n= 30.

Group 1 (>3;0 to ≤3;6 years): In the first group, none of the words met 100% or 90% criteria of acquisition for both initial and medial position of the consonant clusters. However, few of the clusters like /sk/ and /dj/ were in the emerging stage (75%).

Group 2 (>3;6 to ≤ 4;0 years): In initial position clusters, /l/ clusters- /bl/, /kl/; /s/ cluster- /sl/, /sʈ/, /sp/, /sk/; in medial clusters, /l/ cluster- /pl/, /kl/; /s/ cluster- /sk/,/ st/; 'arka'- /rk/, and /lp/ met 90% criteria. Thus, six initial and six medial clusters were mastered by Group 2 children.

Group 3 (>4;0 to ≤ 4;6 years): 90% criteria was met for 11 clusters including 1 initial /l/ cluster- /pl/ in initial position and ten medial position clusters, /s/ cluster-/sl/; 'arka'(/r/+Consonant clusters in Kannada is termed as 'arka') - /rd/, /rc/, /rj/, /rt/; /j/ cluster- /lj/, /ʂ/ cluster- /ʂn/; /r/ cluster- /dr/; others- /bd/ and /ks/. From this age /r/ clusters began to occur. 'Arka' was mastered by this age.

Group 4 (>4;6 to ≤ 5;0 years): This group mastered sixteen clusters, including six initial clusters, /r/ cluster-/gr/, /ɖr/, /kr/;/s/ cluster- /skʊ/, /skr/, /spr/ and ten medial clusters/l/ cluster-/ʈl/ /j/ cluster- / dj /, /ɟj/; /r/ cluster- /sr/, /kr/, /gr/, /tr/; others- /ʈn/, /çʊ/ and /kʂ/. Few three element initial consonant clusters were mastered by this age.

Group 5 (>5;0 to ≤5;6 years): The 3 initial clusters,/r/ cluster-/br/; /s/ cluster- /sʈr/; /ʊ/ cluster- /dʊ/ and three medial cluster, /r/ cluster- /ʈr/, /ɟr/; others- /kt/ were mastered by Group 5. Almost all the medial clusters were mastered by the age >5;0 to ≤5;6 years

Group 6 (>5;6 to ≤6;0 years): Initial /ʊ/ cluster- /sʊ/; /r/ cluster- /dr/ and /ʈr/ are mastered by Group 6. On observation, /r/ clusters continue to master till the last age group. By >5;6 to ≤6;0 years most of the consonant clusters are mastered. From Table

4.6 it is clear that production of consonant clusters emerge between >3;0 to ≤3;6 years and most of the clusters master by age >5;6 to ≤6;0 years in Kannada

Three initial consonant clusters (Table 4.7) were not considered for the statistical analyses, as they exhibited high variability and did not show linear pattern in development. This was speculated to be because of the influence of colloquial usage of the specific word. Even in repetition mode for elicitation of response, correct production was not achieved in many of the participants. The percentage of children producing these words is given in Table 4.8

Table le 4.8

List of words not considered for cluster analysis

Cluster	**>3;0 to ≤3;6 Years**	**>3;6 to ≤ 4;0 Years**	**>4;0 to ≤ 4;6 Years**	**>4;6 to ≤ 5;0 Years**	**>5;0 to ≤5;6 Years**	**>5;6 to ≤6;0 Years**	**Colloquial usage**
/pr/	23.33%	63.33%	60%	90%	56.66%	76.66%	/fraiz/ for /praiz/
/sn/	26.67%	43.33%	46.66%	66.66%	53.33%	66.66%	/sa:na/ for /sna:na/
/ɟʊ/	3.33%	16.66%	10%	16.66%	0.0%	13.33%	/ɟora/ for /ɟʊara/

The percentage of acquisition depicted (see Table 4.8) shows contrasting performance across the age groups. Thus, the three clusters /pr/, /sn/ and /ɟʊ/ were not considered for the analysis.

The clusters show developmental pattern based on the constituent members in the cluster. In the present study major combination of clusters investigated were stop+ /l/, stop+ /ʊ/, stop+ /r/, stop+ /j/,/s/+ C , /ʂ/+ C, /k/+C (where 'C' is consonant), and few other combinations. The clusters showing 90% acquisition are categorized based on the constituents and placed in the respective age groups in Table 4.9.

Table 4.9

Acquisition sequence of initial and medial consonant clusters grouped based on sound class for 90% acquisition

Position	Age (years)	>3;0 to ≤3;6	>3;6 to ≤ 4;0	>4;0 to ≤ 4;6	>4;6 to ≤ 5;0	>5;0 to ≤5;6	>5;6 to ≤6;0
Initial Clusters	/l/ cluster	-	/bl/, / kl/	/pl/			
	/ʊ/ cluster					/dʊ/	
	/s/ cluster	-	/ sl/, /sʈ/, /sp/,/ sk/		/ skʊ/, /skr/, /spr/	/ sʈr/	/sʊ/
	/r/ cluster	-			/gr/, /ɖr/, /kr/	/br/	/dr/, /ʈr/
Medial Clusters	/l/ cluster	-	/pl/,/ kl/	/ɖl/	/ʈl/		
	/s/ cluster	-	/sk/, /st/	/sl/			
	Arka (/r/+C)	-	/ rk/	/rd/, /rtʃ/, /rj/, /rt/			
	/j/ cluster	-		/lj/	/dj/, /ɟj/		
	/r/ cluster	-		/dr/	/sr/, /kr/, /gr/, /tr/	/ʈr/, /ɟr/	
	/k/ cluster			/ks/	/kʂ/	/kt/	
	Others	-	/lp/	/bd/, /ʂn/	/ʈn/, /çʊ/		

Thus, from Table 4.9, it can be noted that younger group (>3;0 to ≤3;6 years) children have not mastered any clusters. Further, stop+ /l/ and arka clusters are mastered earlier than others, and Stop + /r/ clusters continue to master till>5;6 to ≤6.0 Years. Thus, cluster acquisition is affected by the constituents of the cluster. The two element clusters begin to master early compared to the three element clusters. Medial cluster show earlier mastery over initial consonant clusters. With increase in age more number of clusters are mastered.

Non Adult productions of clusters during acquisition

During the development of cluster acquisition, children have non adult production of the target clusters. In Table 4.10, the non-adult realizations present in a majority of children are reported for initial consonant clusters. Similarly, for medial consonant clusters, it is depicted in Table 4.11.

Table 4.10
Summary of non adult production for initial clusters

Scoring	**1**	**0.75**	**0.5**	**0.25**
Description	Correct production	Cluster simplification	Cluster reduction Epenthesis (e.g. /pallet/ for plate) Metathesis (e.g. /aks/ for ask)	Coalescence (e.g. /fim/ for swim)
Greenlee stages	Fourth Stage	Third Stage	Second Stage	
Target Example: /kr/	/kræːk/	/klæːk/	/kæːk/	/tæːk/
Cluster	Word		Errors	
/kl/	/klæːs/		/kæːs/	
/bl/	/bleːɖ/		/beːɖ/	
/pl/	/pleːʈ/		/peːʈ/	
/dʋ/	/dʋaɟa/		/doɟa/, /ʋaɟa/	
/sk/	/skeːl/		/seːl/, /keːl/	
/sʈ/	/sʈaːr/	/staːr/	/ʈaːr/, /saːr/	
/sl/	/sleːʈ/		/seːʈ/	
/sp/	/spuːn/		/suːn/	/fuːn/
/sʋ/	/sʋeʈar/			/feʈar/
/gr/	/griːn/		/giːn/	
/ɖr/	/ɖram/		/ɖam/	
/kr/	/kriketʈ/		/kiketʈ/	
/br/	/breɖ/		/beɖ/	
/dr/	/draːkʂi/		/daːkʂi/	
/ʈr/	/ʈrækʈar/		/ʈækʈar/	/tækʈar/
Scoring	1.5	1.25	1	
/skʋ/	/skʋeːr/		/skeːr/, /sʋeːr/	
/skr/	/skruː/	/struː/	/skuː/	
/spr/	/spreː/		/speː/	
/sʈr/	/sʈraː/	/straː/	/sʈaː/	

Table 4.11

Summary of non adult production for medial clusters

Scoring	**1**	**0.75**	**0.5**	**0.25**
Description	Correct production	Cluster simplification	Cluster reduction Epenthesis (e.g. /pallet/ for plate) Metathesis (e.g. /aks/ for ask)	Coalescence (e.g. /fim/ for swim)
Greenlee's stages	Fourth Stage	Third Stage	Second Stage	
Target Example: /ʈr/	/baʈru/	/batru/	/baʈu/	/batu/
Cluster	Word		Errors	
/pl/	/capli/		/capi/	
/kl/	/cakli/		/caki/	
/ɖl/	/iɖli/	Igli	/iɖi/	
/ʈl/	/baʈlu/		/baʈu/	/batu/
/dr/	/candra/		/canda/	
/gr/	/puɭijoːgre/		/puɭijoːge/, /puɭijoːrge/	
/tr/	/catri/		/cati/	
/kr/	/aiskriːm/		/aiskiːm/	
/ʈr/	/baʈru/	/batru/	/baʈu/	/batu/
/ɟr/	/vaɟra/		/vaɟa/	/vada/
/sk/	/namaskaːra/	/namatkaːra/	/namakaːra/	
/st/	/ɟaːsti/		/daːti/	
/sʈ/	/basʈæːnɖ/	/bastæːnɖ/	/baʈæːnɖ/	
/sr/	/mosranna/		/mosanna/	
/ʂn/	/kriʂna/	/krisna/		
/çw/	/iːçwara/	/iːswara/		
/dj/	/madja/		/madija/	
/lj/	/palja/		/palija/	
/ɟj/	/raːɟja/		/raːɟa/	/raːda/
/rk/	/tarkaːri/		/takaːri/	
/rt/	/puːrti/		/puːti/	
/rd/	/arda/		/arda/	
/rj/	/suːrja/		/ suːja/	
/rc/	/kircu/		/kicu/	
/kʂ/	/pakʂi/		/paçi/	/paci/
/kt/	/rakta/		/rata/	
/ks/	/sɔːksu/		/sɔːsu/	
/lp/	/sʊalpa/		/soppa/	
/bd/	/çabda/		/çada/	
/ʈn/	/caʈni/	/catni/	/caʈi/, /cani/	/caci/

In the present study, the children majorly exhibited cluster reduction (one element was preserved and the other was omitted) there were some more type of non-adult realizations which had lesser frequency such as cluster simplification(e.g /sʈa:r/ for /sʈa:r/, etc.); Metathesis (e.g. /pulɻijo:rge/ for /pulɻijo:rge/, /kirkeʈ/ for /kriketʈ/; Epenthesis (e.g. /palija/ for /palja/, /madija/); Coalescence (e.g. /fu:n/ for /spu:n/, /feʈar for /sʋeʈar/).

Among two-element clusters, reduction pattern predominantly observed were stop+ /w/ reduced to stop in word-initial clusters; stop+ /l/ clusters reduced to stop and stop+ /r/ reduced to stop in both word- initial and medial clusters , /s/+ C reduced to /s/ in word initial position. /s/+ C reduced to C, /k/+C reduced to C, /r/+ C reduced to C in word-medial position (C=Consonant).Three- element clusters were reduced to two-element clusters /skʋ/→/sʋ/, /skr/→ /sk/, /spr/→/sp/, /sʈr/→ /sʈ/.

From the results obtained, it could be noted that there is a developing trend in acquisition of initial and medial clusters with age. Medial consonant clusters are acquired earlier to the initial consonant clusters across all the age groups. Two-element clusters begin to master prior to three-element clusters. The acquisition sequence is also achieved based on the phonetic composition of the cluster. The cluster reduction in the non-adult realization of the cluster is determined by the consonants it constitutes. By age >5;6 to ≤6.0 years most of the consonant clusters of Kannada are mastered with 90% mastery criteria.

Reliability test

Intra-Judge, inter judge and test retest reliability was measured using Cronbach's co-efficient reliability test. The results of the test is provided in Table 4.12

Table 4.12

Results of Cronbach's co-efficient reliability test

Reliability test	**Cronbach's co-efficient α**
Intra-judge reliability	0.990
Inter judge reliability	0.995
Test retest reliability	0.989

Overall, the reliability is noted to be good for intra and inter- judge demonstrating good agreement for transcription. In addition the test-retest reliability is also noted to be good for examination of cluster production in children within a span of one week from the time of initial recording.

CHAPTER V

DISCUSSION

The current study was conducted to obtain norms for the acquisition of non-geminate consonant clusters in 3;0- 6;0 years old native Kannada speaking children. Some of the significant observations in the results of the study are discussed below.

Results from the present study indicate, overall the performance of girls was superior to age matched boys with a relatively greater difference for younger age group (3;0 -3;6years); however, the difference was not significant. The finding from the present study is supported by several studies indicating no significant gender effect for cluster acquisition (Templin; 1957; Padmaja, 1988; Prathima & Sreedevi, 2009; Vipina & Sreedevi, 2011the ; Vrinda & Sreedevi, 2011; Sneha & Sreedevi, 2012).However, some of the studies report of difference in acquisition of clusters between boys and girls the (Smit et al., 1990; Deepa & Savitri, 2010). Thus, studies in the literature indicate contrastive evidence on effect of gender on cluster acquisition.

Based on the position of the consonant cluster, a general trend demonstrates earlier acquisition of medial clusters over the initial clusters across all the ages. In line with this finding, several authors have noted also similar pattern in different Indian languages such as; Malayalam (Neenu & Sreedevi, 2011; Vipina & Sreedevi, 2011); Telugu (Neethipriya & Manjula, 2011); Sneha & Sreedevi, 2011); and Kannada (Rupela & Manjula, 2006; Deepa & Savitri, 2010). Researchers attribute such asymmetries in cluster acquisition to the position, and the frequency with which clusters occur in the ambient language (Krik & Demuth, 2003; Reynolds, 2011).Thus, high frequency occurrence of word-medial clusters in Kannada (Hiremath, 1961; Rupela & Manjula, 2006) reports earlier acquisition of medial clusters over initial

clusters in Kannada. Another possible reason for such pattern could also be explained as a result of articulatory difficulty in producing word-initial consonant clusters than word-final clusters in English, possibly because some sequence of consonant clusters are easier to produce than others because of their phonetic context.(Kent, 1982; Kirk & Demuth, 2005).

Further, observation on the acquisition of the consonant clusters revealed that, mastery of the clusters began to occur as early as 3;6-4;0 years and continued till 5;6-6;0 years of age. However, the inventory of children in younger age group (3;0-3;6 years) contained few consonant clusters. The beginning of mastery between 3;6- 4;0 years is reported in several others studies.(Smit et al., 1990; Templin, 1957; Maya, 1990; Prathima & Sreedevi, 2009).

In the younger age groups, the standard deviation was noted to be higher(see Table 4.2) and as the age increased standard deviation gradually reduced. The number of outliers present was also more in younger age groups. From this, we can infer that, younger children tend to have higher variability in production of the non-geminate consonant clusters, trying various productions to approximate adult targets. Various studies have reported high variability in cluster acquisition, around 2;0- to 3;0- years of age. (Dyson & Paden, 1983; McLoed & Hewett, 2008)

The study by Smit et al.,(1990), Templin (1957), Mcloed et al.,(2001a) suggest that clusters constituting stops are acquired earlier to fricative clusters in English. In line with the same, stop+ /l/ clusters (e.g. /kl æ:s/, /capli/) demonstrate earlier mastery over /s/+ C cluster (e.g. / spuːn /, /ɟaːsti /) in the present study. However, stop+ /w/ does not exhibit this trend. The word /dʋaɟa/ is usually used as a literary term rather than frequent usage in colloquial language. Children use /flæ:g/ or /baːʋuʈaː/ more

frequently, thus less frequency of usage and absence of the target word in most of the children's vocabulary could possibly explain later acquisition of /dʊ/.

Further, /s/+ C (e.g. /ske:l/) and stop+/r/ (e.g. /dra:kʂi/)are the clusters which continue to master till 5;6-6;0 years of age. The development of few initial two-element /s/+ C and stop+/r/ clusters were reported to continue mastery till the age of 5;0-8;0 years, (McLeod & Arciuli 2009). All the 49 clusters examined in the present study reached 90% mastery by 6;0 years of age. However, 100% of the children aged between 5;6-6;0 did not master all the clusters. Thus, even after 6;0 years there is advancement in mastery and addition of new clusters in the inventory.

In addition, the mastery of three-element clusters began later to the two-element cluster. However, few two-element clusters still continue to master even after the three-element clusters complete mastery. In the present study only few three-element clusters were considered as a preliminary attempt to differentiate cluster acquisition based on number of elements. Thus, the results should be carefully inferred. In the present study all the 4 three element clusters were mastered around the age of 5;0-5;6 years. On the other hand, McLeod and Arciuli (2009) non-adult acquisition of three-elements continued till 9;0-12;0 years of age.

Children produce various non-adult production forms which eventually develop into the target adult productions by the age of 6;0 years. In the listed out error productions based on Greenlee's stages, most of the children exhibited deletion of one element with the other preserved (Cluster reduction). The error patterns described in other stages were exhibited only for few words and by fewer children.

The cluster reduction process was observed for most of the consonant clusters in the present study; two-element cluster reduction follows a Sonority specific pattern

(SSP) for majority of them (Except for asymmetries in initial /s/+C cluster) (see Table 5.1). As explained according to the SSP (Fikkert, 1994; Chin & Powell, 1996; Gierut 1999, Ohala, 1999, Pater & Barlow, 2003; Gnanadesikan, 2004; Barlow 2005),the least sonorant member will be preserved based on the hierarchy [most sonorant to least sonorant: vowel > high vowels > glides >, liquids > nasals> voiced fricative > voiceless fricatives > voiced stops > voiceless stops]. However, for initial /s/+C cluster in some children, head pattern is observed where head of the onset is preserved. Thus, there is asymmetry for initial two-the element /s/+C cluster reduction. Similar pattern of asymmetries and individual variability has been reported in literature on head pattern of cluster reduction (Goad & Rose, 2004). Also stop+ /ʋ/ cluster in the word /dʋaɟa/ exhibited asymmetrical reduction pattern (see Table 5.1) of either sonority or head pattern across individual child.

Table 5.1

Cluster reduction pattern in two-element clusters

Cluster	Preserved member	Example
Initial (Sonority pattern)		
stop+ /l/ clusters	Stop	/pleːt/→ /peːt/
stop+ /r/	Stop	/griːn/→/giːn/
Medial (Sonority pattern)		
stop+ /l/ clusters	Stop	/ capli/→/ccpi/
stop+ /r/	Stop	/catri/→/cati/
/s/+ C→ C	C	/mosranna/→ /mosranna/
/k/+C→ C	C	/pakʂi/→/paʂi/
/r/+ C → C	C	/arda/→ /ada/
Initial		
/s/+ C(Head pattern)	/s/	/skeːl/→ /seːl/, /sʈaːr/→ /saːr/
/s/+ C (Sonority pattern)	/c/	/skeːl/→ /keːl/, /sʈaːr/→ / ʈaːr/
stop+ /w/ (Head pattern)	/w/	/dʋaɟa/→ /doɟa/
stop+ /w/ (Sonority pattern)	Stop	/dʋaɟa/→ /ʋaɟa/

Thus, some of the two-element clusters in the present study exhibit sonority pattern for cluster reduction. Sonority pattern of cluster reduction was also reported in

Telugu for some of the two- element clusters (Sneha & Sreedevi, 2012). However, the results should be carefully generalized, as this study only report of pattern seen in a majority of the participants. Furthermore, individual variability and numerous other simplification patterns have been noted.

Some other forms of non-adult expressions are cluster simplification (e.g /sʈa:r/ for /sʈa:r/, etc.); Metathesis (e.g. /pulļijo:rge/ for /pulļijo:rge/, /kirkeʈ/ for /kriketʈ/; Epenthesis (e.g. /palija/ for /palja/, /madija/); Coalescence (e.g. /fu:n/ for /spu:n/, /feʈar for /sʋeʈar/). These were less frequently observed than cluster reduction process.

The three-element clusters were reduced to two elements /skʊ/→ /sk/, /skr/→ /sk/, /spr/→/sp/, /sʈr/→ /st/ in older children (4;6-5;6 years); however, other variations in three-element cluster reductions were also noted(e.g. /sʈr/→ /sr/, /skʊ/→ /sʊ/, etc.). McLeod and Arciuli (2009) also found similar pattern of reduction in three-element /s/ clusters. In younger children, the three-element clusters are produced as singletons. The reduction to singletons is highly inconsistent across age and individual child with respect to which member of the cluster is preserved. (e.g. some children show /spr/→/s/, or /spr/→/p/, /sku/→ /k/, /sku/→ /s /, /skʊ/→/f/, etc.)

In general, a trend was observed from non-adult realizations towards development of adult target (e.g. /catʃi/→/cati/→/catni/→/caʈni/) for some of the words. Thus, gradually from coalescence (simultaneous reduction and simplification occurs together), cluster reduction (one element is omitted and the other is preserved similar cluster simplification (one element is correct and other is substituted) and finally correct realization. Similar developmental trend in suppression of processes during cluster acquisition was recognized by Sneha and Sreedevi (2012) in Telugu

speaking children. These stages were also explained (Greenlee, 1974; Elbert & McReynolds, 1979) based on the number of elements preserved as Greenlee's stages; however, coalescence errors are not explained in these stages. For most of the clusters, cluster reduction is seen in younger age groups later directly followed by correct productions in older groups. Thus, a varied pattern is present during the development of clusters in children aged 3;0-6;0 years.

CHAPTER V

SUMMARY AND CONCLUSIONS

The aim of the study was to develop norms for the acquisition of non-geminate consonant clusters in native Kannada speaking children in the age range of 3;0 to 6;0 years. The criteria of acquisition considered in the present study were 90% and 100%.

Totally 180 participants were randomly selected for the study; they were sub-divided under six age groups (>3;0 to ≤3;6,>3;6 to ≤ 4;0, >4;0 to ≤ 4;6, >4;6 to ≤ 5;0, >5;0 to ≤5;6 &>5;6 to ≤6;0 years) with equal inter-age interval. Each sub-group included 15 boys and 15 girls. Word and Picture familiarity check was done by three judges to pick the most appropriate words and pictures for the given age range, thus the wordlist and picture stimuli were carefully selected for further examination. Finally, 52 words were chosen for the study; among them 30 words incorporated medial consonant clusters, 22 words incorporated initial consonant clusters. There was high variation in performances of the children for three words, incorporating initial consonant clusters /sn/, /pr/, /ɟʊ/, due to the influence of colloquial usage. Therefore, only 49 clusters were examined in present study, with 30 medial consonant clusters and 19 initial consonant clusters. The children were asked to name the pictures presented using a laptop system. The responses were recorder, transcribed and scored for a maximum score of 51. Each cluster was scored based on the number of element preserved (1- correct; 0.75- one element of the cluster preserved but substituted and the other element preserved, 0.5- omission of one element, 0.25- omission of one element and substitution of the preserved element, 0- complete cluster deletion). The intra- judge reliability of 0.990, inter-judge reliability of 0.995 and test-retest reliability of 0.989 was obtained for the data recorded.

Descriptive and inferential statistical analysis was carried out for the data. Normality was not satisfied due to the presence of outliers in younger group and ceiling effect in older group. Thus, non-parametric tests were carried out at a confidence level of 0.05 to obtain the presence of any significant difference across age, gender and the position of cluster in the word. The results indicated that, the effect of gender was not significant for cluster acquisition across the age groups (3;0-6;0 years). However, a significant difference was observed in the performance across the age groups and position. A developmental trend of increase in scores was exhibited with increase in age, indicating maturation of neuro-musculature for the control of complex articulatory productions. Further, Medial clusters demonstrate earlier acquisition than initial clusters, possibly due to higher frequency of medial clusters in Kannada.

The acquisition sequence in cluster development shows interesting patterns of reductions, affected by aspects like, number of elements in the cluster, constituents of the clusters and position of the cluster. Some of the important findings associated with developmental changes in cluster acquisition are listed below

- Mastery of clusters begin to occur by >3;6 to ≤ 4;0 years. However, the younger age group also show some clusters emerging in their inventories.
- The mastery is persisting even in the last group (>5;6 to ≤6;0 years). Even by this age, 100% of the children may not acquire all the clusters. Thus, development might still continue for longer period (>6;0 years).
- Stop+/l/ clusters are the earlier ones to be mastered and the stop+ /r/ clusters are later ones to be mastered.
- Stop+/c/ clusters are mastered earlier to fricative+ consonant cluster

- Two element clusters show an earlier acquisition than three element clusters.
- The cluster reduction occurring as a part of cluster acquisition shows various pattern in the reduction. Most of the clusters show sonority pattern, however some show head pattern.
- Several processes like, Cluster reduction, cluster simplification, metathesis, epenthesis and coalescence errors are observed in the non-adult realizations of the target cluster.

Therefore, there are various factors contributing to the cluster acquisition in children such as age, position of the cluster, consonants in the cluster, etc. The summary of the mean scores across the age groups is presented in Table 6.1.

Table 6.1

Mean scores and SD across the age groups

Age (Years)		**>3;0 to ≤3;6**	**>3;6 to ≤ 4;0**	**>4;0 to ≤ 4;6**	**>4;6 to ≤ 5;0**	**>5;0 to ≤5;6**	**>5;6 to ≤6;0**
Initial cluster total score (21)	Mean (SD)	13.86 (3.20)	17.80 (1.53)	19.15 (1.58)	20.10 (0.76)	20.50 (0.56)	20.80 (0.27)
Medial cluster total score(30)	Mean (SD)	23.34 (3.64)	26.64 (1.84)	28.45 (1.25)	29.35 (0.47)	29.77 (0.33)	29.92 (0.16)
Total Score (51)	Mean (SD)	37.20 (6.69)	44.45 (3.10)	47.6 (2.48)	49.46 (0.89)	50.28 (0.64)	50.73 (0.35)

Thus, cluster acquisition is a complex gradual process undergoing numerous developmental stages from the non-adult realization to toward the target productions. Although acquisition of clusters emerge in young children it continues to develop and master in children until >5;6 to ≤6.0 years. To conclude, most of the clusters (49 clusters with a total score of 51, in the present study) are acquired by 6;0 in native Kannada speaking children.

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Appendix A

Informed consent letter

ALL INDIA INSITTUTE OF SPEECH AND HEARING: MYSORE-06

Title: "***Acquisition of clusters in typically developing Kannada speaking children: 3-6 years*"**

Guide: Dr. N. Sreedevi, Professor & Head, Department of Clinical Services, AIISH, Mysore

Student: Ms. Divyashree. K. N., II M.Sc, AIISH, Mysore

Description of the study: The study aims to test the acquisition of clusters in typically developing native Kannada speaking children between the age range of 3;0 to 6;0 years and to develop norms for the same. The participants are involved in picture naming task presented using a laptop system and the responses will be audio recorded and analyzed later. The approximate time for testing will be around 20 minutes per individual. This data will be helpful to find the developmental pattern for cluster acquisition in typically developing children. The data confidentiality will be maintained for the data collected.

Informed Consent [Consent for participation]

I [Parent/Guardian/Teacher] have been informed about the aims, objectives and the procedure of the study. The possible risks-benefits of my participation as human subject in the study are clearly understood by me. I understand that I have a right to refuse participation of my daughter/son/student as subject or withdraw my consent at any time without adversely affecting my/my ward's treatment at AIISH. I am also aware that by subjecting to this investigation, I will have to give more time for assessments by the investigating team and that these assessments may not result in any benefits to me. I have the freedom to write to Chairman, AEC, in case of any violation of these provisions without the danger of my being denied any rights to secure the clinical services at this institute.

I [Parent/ Guardian/Teacher], _____, the undersigned, give my consent that my daughter/son/Student can be participant of this investigation/study/program.

(AGREE/DISAGREE)

Signature of Parent: Name:

Parent of:

Signature of Investigator: Date :

Appendix B

THE INTERNATIONAL PHONETIC ALPHABET (2015) for Kannada consonant phones

IPA for Kannada consonants (Based on place and manner of articulation)

	Labial	**Dental**	**Retroflex**	**Palatal**	**Velar**
Stops					
Voiceless	p	t	ʈ		k
Aspirated	p^h	t^h	$ʈ^h$		k^h
Voiced	b	d	ɖ		g
Breathy voiced	b^h	d^h	$ɖ^h$		$g^ɦ$
Affricate					
Voiceless				c	
Aspirated				c^h	
Voiced				ɟ	
Breathy voiced				$ɟ^h$	
Fricatives					
Voiceless	f	s	ʂ	ç	h
Voiced		z			
Nasal	m	n	ɳ		
Lateral		l	ɭ		
Glide	ʋ			j	
Trill		r			

Appendix C

THE INTERNATIONAL PHONETIC ALPHABET (2015) for Kannada consonant phones

IPA for Kannada consonants (Based on varnamala)

Gloss	ಕ	ಖ	ಗ	ಘ	ಙ
IPA	[k]	[k^h]	[g]	[$g^ɦ$]	[ŋ]
Gloss	ಚ	ಛ	ಜ	ಝ	ಞ
IPA	[c]	[c^h]	[ɟ]	[$ɟ^h$]	[ɲ]
Gloss	ಟ	ಠ	ಡ	ಢ	ಣ
IPA	[ʈ]	[$ʈ^h$]	[ɖ]	[$ɖ^ɦ$]	[ɳ]
Gloss	ತ	ಥ	ದ	ಧ	ನ
IPA	[t]	[t^h]	[d]	[d^h]	[n]
Gloss	ಪ	ಫ	ಬ	ಭ	ಮ
IPA	[p]	[p^h]	[b]	[$b^ɦ$]	[m]

Gloss	ಯ	ರ	ಲ	ವ	ಶ	ಷ	ಸ	ಹ	ಳ
IPA	[j]	[r]	[l]	[ʋ]	[ç]	[ʂ]	[s]	[h]	[ɭ]

Appendix D

SCORE SHEET

Name:	Language☐ Phonology☐
Age: _____Years_____Months	Socioeconomic status:
Date of birth:	Any exposure to second language:
Education:	Date:

*An example for scoring oftwo-element cluster (e.g. /sk/ in*namaska:ra/*)*

Score	**Production**	**Example /namaska:ra/**
0	If the entire cluster is deleted	/nama:ra/
0.25	If one of the elements of cluster is preserved with some substitution error	/namata:ra/
0.50	If one element is preserved and the other is deleted	/namaka:ra/
0.75	If one consonant is preserved and other is substitured	/namatka:ra/
1	Correct production of complete cluster	/namaska:ra/

An example for scoring ofthree-element cluster (e.g./spr/ in /spre:/)

Score	**Production**	**Example** spray- /spre:/
0	If the entire cluster is deleted	/e:/
0.25	If one of the elements of cluster is preserved with some substitution error	/fe:/
0.50	For the errors where one element is deleted and the other is preserved	/se: /
1	Substitution of one consonant in a cluster with the other two consonants correctly produced	/spe: /
1 .5	Correct production of complete cluster	/spre:/

Age	Position	Gloss	Word	Cluster	Transcription	Scoring
>3;6 to ≤ 4;0 years	Initial	ಬ್ಲೇಡ್	/ble:ɖ/	/bl/		
		ಕ್ಲಾಸ್	/kl æ:s/	/kl/		
		ಸ್ಲೇಟ್	/sle:ʈ/	/sl/		
		ಸ್ಕೇಲ್	/ske:l/	/sk/		
		ಸ್ಟಾರ್	/sʈa:r/	/sʈ/		
		ಸ್ಪೂನ್	/spu:n/	/sp/		
	Medial	ಚಪ್ಲಿ	/capli/	/pl/		
		ಚಕ್ಲಿ	/cakli/	/kl/		

		ನಮಸ್ಕಾರ	/namaska:ra/	/sk/		
		ಜಾಸ್ತಿ	/ɟa:sti/	/st/		
		ಸ್ವಲ್ಪ	/sʋalpa/	/lp/		
		ತರ್ಕಾರಿ	/tarka:ri/	/rk/		
>4;0 to ≤ 4;6 years	Initial	ಪ್ಲೇಟ್	/ple:ʈ/	/pl/		
	Medial	ಇಡ್ಲಿ	/iɖli/	/ɖl/		
		ಬಸ್ಟಾಂಡ್	/basʈæ:nɖ/	/sʈ/		
		ಅರ್ಧ	/arda/	/rd/		
		ಪೂರ್ತಿ	/pu:rti/	/rt/		
		ಕಿರ್ಚು	/kircu/	/rc/		
		ಸೂರ್ಯ	/su:rja/	/rj/		
		ಪಲ್ಯ	/palja/	/lj/		
		ಕೃಷ್ಣ	/kriʂna/	/ʂn/		
		ಚಂದ್ರ	/candra/	/dr/		
		ಶಬ್ದ	/ʂabda/	/bd/		
		ಸಾಕ್ಸ್	/sɔ:ks/	/ks/		
>4;6 to ≤ 5;0 years	Initial	ಸ್ಕ್ವೇರ್	/skʋe:r/	/skʋ/		
		ಸ್ಕ್ರೂ	/skru:/	/skr/		
		ಸ್ಪ್ರೇ	/spre:/	/spr/		
		ಗ್ರೀನ್	/gri:n/	/gr/		
		ಡ್ರಮ್	/ɖram/	/ɖr/		
		ಕ್ರಿಕೆಟ್	/kriketʈ/	/kr/		
	Medial	ಬಟ್ಲು	/batʟu/	/tʟ/		
		ಮದ್ಯ	/madja/	/dj/		
		ರಾಜ್ಯ	/ra:ɟja/	/ɟj/		
		ಈಶ್ವರ್	/i:çʋara/	/ çʋ/		
		ಪಕ್ಷಿ	/pakʂi/	/kʂ/		
		ಪುಳಿಯೋಗ್ರೆ	/puɭijo:gre/	/gr/		
		ಛತ್ರಿ	/catri/	/tr/		
		ಐಸ್ಕ್ರೀಮ್	/aiskri:m/	/kr/		
		ಮೊಸ್ರನ್ನ	/mosranna/	/sr/		

		ಚಟ್ನಿ	/caʈni/	/ʈn/		
>5;0 to ≤5;6 Years	Initial	ಬ್ರೆಡ್	/breɖ/	/br/		
		ಧ್ವಜ	/dʋaɻa/	/dʋ/		
		ಸ್ಟ್ರಾ	/sʈra:/	/sʈr/		
	Medial	ರಕ್ತ	/rakta/	/kt/		
		ಭಟ್ರು	/baʈru/	/ʈr/		
		ವಜ್ರ	/vaɻra/	/ɻr/		
>5;6 to ≤6;0 years	Initial	ಸ್ವೆಟರ್	/sʋeʈar/	/sʋ/		
		ದ್ರಾಕ್ಷಿ	/dra:kʂi/	/dr/		
		ಟ್ರಾಕ್ಟರ್	/ʈrækʈar/	/ʈr/		

Maximum Score= 51

Obtained Score=_____

Appendix E

Picture stimuli

/ble:ɖ/

/kl æ:s/

/sle:ʈ/

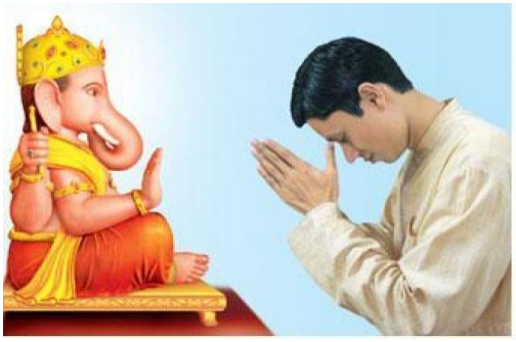
/ske:l/

/sʈa:r/

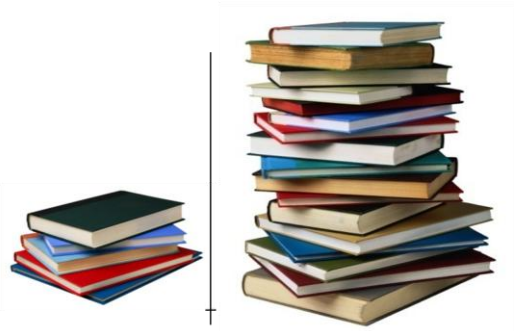
/spu:n/

/capli/

/cakli/



/namaska:ra/



/sʋalpa/ and /ɟa:sti/

/tarka:ri/

/ple:ʈ/

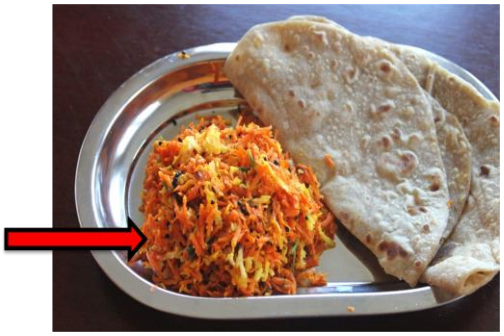
/iɖli/

/basʈæ:nɖ/

/arda/ and /pu:rti/

/kircu/

/su:rja/



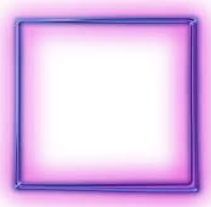
/palja/

/krişna/

/candra/

/şabda/

/sɔ:ks/



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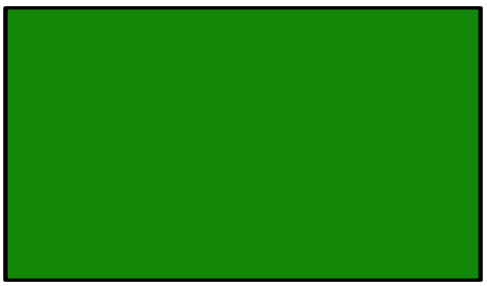

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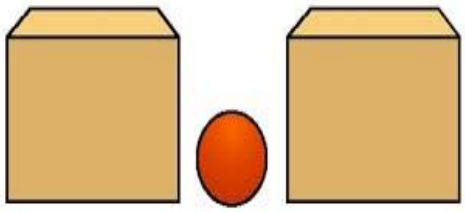

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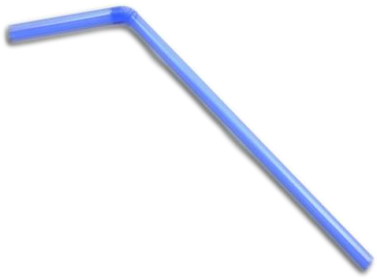

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Appendix F

Mean scores for correct cluster production in 3;0-6;0 years old Kannada speaking children

Age (Years)	>3;0 to ≤3;6	>3;6 to ≤ 4;0	>4;0 to ≤ 4;6	>4;6 to ≤ 5;0	>5;0 to ≤5;6	>5;6 to ≤6;0
Initial cluster total score (21)	13.86	17.80	19.15	20.10	20.50	20.80
Medial cluster total score(30)	23.34	26.64	28.45	29.35	29.77	29.92
Total Score (51)	37.20	44.45	47.6	49.46	50.28	50.73