PHONOTACTIC DEVELOPMENT IN 3-4 YEARS OLD NATIVE HINDI SPEAKING CHILDREN

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April, 2018

CERTIFICATE

This is to certify that this dissertation entitled **"Phonotactic Development in 3-4 Years old Native Hindi Speaking Children"** is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 16SLP001. 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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This is to certify that this dissertation entitled "**Phonotactic Development in 3-4 Years old Native Hindi Speaking Children**" has been prepared under my supervision and guidance. It is also been certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Phonotactic Development in 3-4 Years old Native Hindi Speaking Children"** 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.

Mysore,
April, 2018

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Dedicated to Flt Lt KK Sundaram!!!

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CHAPTER I

Introduction

Sounds, especially linguistic sounds, have an effect on any listener. Descriptive linguistic methods have long been used to describe the fully developed primary language of an individual. Similar methods are applied to study the language development in children's speech sound systems. To study the characteristics of speech sound system, the descriptive methods are preferred as an analytic tool, because they give good evidence independent of the theoretical orientation, age, or population of the study. Phonetic inventory, phonemic inventory, distribution of sounds, rule-governed alterations are a few of the properties of such analytic methods (Kent, 2004).

All possible sequences or types of sounds and morphemes do not occur in any single language. These restrictions are called 'phonotactics' or 'distributional constraints' by the structuralists and morpheme structure rules (Halle, 1968) or morpheme structure conditions (Stanley, 1967) by the generative phonologists. Words derive their structure not only from the sounds they include, but also from the organization of those sounds within the word. This organization is nothing but the phonotactic rules of the word, which describe the shape and sequence of its elements (Velleman, 1998). Languages spoken all over the world have their own phonotactic structure. Every language in the world has certain preferred word and syllable pattern, as well as patterns that are not preferred or even allowed. In generative phonology, two main functions are assigned to a morpheme structure: the 'possible' and 'impossible'. This explains why specific redundant patterns are seen in the lexicon of languages with regard to their segments and sequences of segments.

A phonetic inventory comprises of all speech sounds produced by a child, regardless of the intended target sound. Children's phonetic inventory reflect the range of individual variability expected in development. The rate and pattern of speech and language development are highly variable among young children (Bernthal, Bankson, & Flipsen, 2013; Sotto, Redle, Bandaranayake, Neil-Strunjas & Creaghead, 2014). The speech sound acquisition follows a pattern across various stages of development. There are 4 phases of speech acquisition (Bleile, 2004):

- Phase 1: Laying the foundations for speech (birth to 1 year)
- Phase 2: Transitioning from words to speech (1 to 2 years)
- Phase 3: The growth of the inventory (2 to 5 years)
- Phase 4: Mastery of speech and literacy (5 + years)

Typically developing children implicitly learn the rules of their language including phonotactic patterns as they develop. The most interesting and fascinating aspect of language development is the rapidity and apparent ease with which children acquire adult like form and rules of their native language. On the other hand, many children with disordered phonologies experience phonotactic as well as phonetic limitations. While dealing with individuals with disordered phonology, major focus has been on individual sounds and not on how these sounds interact in the word i.e. phonotactic patterns. Edwards and Shriberg (1983) defined phonotactic as the rules for how sounds can be combined to formulate syllables and words; and how these sounds can be distributed in a given language. Phonotactic rules increase the ease of production. The phonotactic rules reflect a variety of different factors in a language, including the following:

- The number of syllables that tend to occur in each word
- The numbers, types and locations of consonants in clusters
- The presence or absence of final consonants
- The presence or absence of diphthongs or long vowels
- Harmony patterns in which consonants or vowels become more similar to each other.
- Phrase-level effects which change the pronunciations of sounds in phrases and sentences.

On the basis of data drawn from children speaking different western languages including English, Ingram (1986) reported some common tendencies in phonological acquisition in children between ages of 1.6 and 4.0 years. It was observed that children often resort to phonological processes, with simple syllable structures and in most of the children, the direction of such simplification was towards a basic CV syllable. Schwartz et al. (1980) postulated reduplication as a strategy for avoiding the use of final consonants.

Many investigators (Bernhardt, 1994; Bernhardt & Stoel- Gammon, 1994; Velleman, 1998, and Velleman, 2002) have stressed the importance of addressing assessment and treatment of phonotactic errors in children with disordered phonologies. Ingram (1978) stressed the need to focus on syllable and word structures while correcting the phonological process errors in children, as the errors observed in such children is basically a reflection of errors in the syllable or word structures. For example, simplification of syllable structure gives rise to consonant cluster reduction and final consonant omission, deletion of unstressed syllable and reduplication suggests poor word integrity. Ingram

(1978) further stated that the segmental complexity experienced as difficulty in executing a variety of speech sounds within the word interacts very closely with the complexity of the given syllable in terms of its shape and this in turn could harm the word processes that are evidenced as harmony patterns. As segmental complexity increases, syllable complexity may decrease and vice versa.

Many investigators have observed that phonological development in early years of a child is exclusively word or syllable based and does not refer to the segmental level. Velleman (1998) cites that many speech language clinicians observe that children of any age are able to generalize much better when sounds are targeted at syllable and / or word level rather than in isolation. As children grow older, they learn more complex syllable and word shapes. It is often seen that children with disordered phonology show developmentally inappropriate or unusual phonotactic constraints. Hence, it is essential to know how these patterns are developed in typically developing children in order to facilitate comparison between normal and disordered population. Thus, before initiating a speech remediation program for children with impaired phonology it is essential to have a sound knowledge about the phonotactic constraints in a given language and how it develops in typically developing children. Since phonotactic is language specific, studies on limited languages acts as a constraint on the diagnostic and therapeutic ability of a clinician. India is a country with a population of more than 132.42 crores, and diverse in terms of its culture, tradition and language experiences.

India is a multilingual country with 114 languages belonging to four distinct linguistic families: Indo-Aryan, Dravidian, Tibeto-Burman and Austro-Asiatic (Mallikarjun, 2004). The phonotactic structure of most of these languages is not

known. Addressing this issue is especially relevant when it comes to the question of rehabilitation of children exhibiting phonological impairments.

Need For the Study

There is some amount of literature on the phonotactic rules used by children in major south Indian languages, however native Hindi speaking children have not been explored extensively. As there is linguistic variability of rules, the findings of one language cannot be generalized to the other. Therefore, it is essential for Speech Language Pathologists to have sound knowledge of the typical phonotactic development in a particular language, so that the pattern established can serve as a benchmark for assessment of disordered phonologies. The findings augment our understanding of a child's phonology and serve as a preliminary data for improving the speech and language diagnostic and therapeutic services.

Aim of the study

To investigate the phonotactic development in 3-4 year old native Hindi speaking children.

Objectives of the Study

1. To obtain the phonetic repertoire, various syllable structures and word shapes
2. To analyze the type and frequency of consonant clusters
3. To compare the findings across gender

Clinical implications

i. The study will augment our understanding on the phonotactic rules used by typically developing young Hindi speaking children.

ii. It will serve as a preliminary data for Speech Language Pathologists in improving the data base for diagnostic and therapeutic purposes.

CHAPTER II

Review of Literature

Language refers to a rule based system of symbolic communication involving set of small units (syllables or words) that can be combined to yield an infinite number of larger language forms (Hoff & Naigles, 2002). Phonology refers to the speech sound systems of a language. It involves the study of classification and organization of speech sounds in a language (Vihman, 1996). Phonology encompasses all aspects of the sound system including the speech production and perception. Phonological structure has two components, a limited repertoire of sounds (phonemes) representing various classes (based on physiological and acoustic characteristics) and a set of phonotactic rules defining how these phonemes can be arranged into syllables (Hodson & Paden, 1991).

Stoel-Gammon and Dunn (1985) reported that phonology includes all aspects of the speech system and the production of speech sounds. They described two levels of analysis viz. phonetic and phonological analysis, which allows for complete understanding of the phonology of the given language. Phonetic analysis of the sound system of a language would include:

- Analysis of articulatory dynamics or the way sounds are formed by the speech mechanism
- Analysis of acoustic or physical component of speech sounds
- Analysis of psychological perspective or the way sounds are perceived by the listener.

Phonological analysis of a sound system encompasses:

- Inventory of the phonemes of a particular language
- Description of patterns and the use of these phonemes
- Description of the phonemes as pronounced in various phonetic contexts or allophonic variations
- Description of morpho-phonemic alterations in sound patterns.

As children expand their vocabulary of words, they also demonstrate an emerging phonological system. The development of phonology is not an immediate process. Children cannot immediately learn the entire array of phonemes instead they progress gradually from mastery of the simpler sounds and then arrangement to these sounds into more complex ones. Developmental phonologists have observed that a young child usually makes these substitutions and omissions in predictable ways. Thus, even the child's technique for coping with speech inadequacies is systematic (Markman, Wasow & Hansen, 2003).

Over the years, the study of phonological development has shifted from the analysis of individual speech sound errors toward the analyses of phonological processes that are rule governed simplifications of adult speech. The phonological process analyses is fast emerging as a popular technique to meet the demand for a more comprehensive means of assessing children who exhibit multiple speech sound production. The concept of phonological process was first introduced by Stampe (1973), according to him learning of sound system requires suppression of a number of innate simplifying processes and simultaneously increasing number of contact sounds.

According to Hodson and Paden (1981) phonological processes are defined as regularly occurring deviations from standard adult speech patterns that may occur across a class of sounds, a syllable shape or syllable sequence. In short, processes are description of regularly occurring patterns observed in child's speech, which operate to simplify adult targets. The literature reports that there are more than 40 such different processes operating during children's phonological development (Hodson, 1980).

Having a sound knowledge of phonotactic of a particular language gives a good basis for understanding such phonological processes that occur during the developmental ages. As stated by Tesar and Prince in 2003, phonotactic based analysis of these phonological processes helps one get the positives and negatives of the acquisition process, i.e., the analysis can reveal about the pattern of syllable shapes, word types, phrase–level patterns that occur in the child's repertoire and the ones that are difficult to produce. The authors have also suggested a 'back and forth' analysis process in which the child maps various combinations based on the morphemic structures based on the phonotactic of the syllable. This mapping occurs due to repeated exposure to the plausible combinations in a particular language, thus suggesting that phonotactic is a useful tool in updating the phonological processes occurring in a language.

Majority of the children of the world's languages begin phonological acquisition with CV syllable as the preferred basic unit (core syllable) of speech articulation. However the preference of this pattern of syllables with consonant onset is not a universal phenomenon. For instance in Portuguese language, Freitas (1996) reported that children in their early stages of word acquisition produced vowel-initial syllables. In comparison with open syllables (CV and V)

closed syllables (CVC) is not reported to emerge until the child has acquired 8-11 different consonants at approximately 2.5 years (Grunwell, 1982). During later babbling periods, open syllables are still the most frequent type of syllables. Phonotactic constraints on clusters are common among young children belonging to any linguistic environment. In English-speaking children of 24-months, Stoel-Gammon (1985) reported that 58% use 2 element clusters in initial position, 48% in final position and 30% in medial position. Children's phonology may be less systematic in early stages of word learning. It could become more systematic as the mastery of syllable and word shapes takes place through an extensive period of Prelinguistic speech practice (babbling) and then by the use of their best-learned shapes as the basis for words.

Jacobson (1968) postulated a universal order of syllable acquisition. He indicated that the first syllable structure to develop was consonant vowel (CV) or CV reduplicated, followed by CVC and CVCV (differentiated). The CV syllable, occurring in virtually all of the world's languages, has long been recognized as a preferred basic unit of speech articulation (Bernthal & Bankson, 1993). This syllable form is one of the earliest syllables to be identified in infant vocalizations. The vocalizations of 1-year-olds are predominantly, simple V or CV syllables and their elaborations like VCV, CVCV (Kent & Bauer, 1985). Branigan (1976) regarded the CV syllable as a training ground for consonant formation. Most consonants are produced first in the initial position of CV syllables and then, later, in postvocalic (e.g., VC) position. There is also evidence to suggest that early CV syllable production is linked in a developmental chain to early word production and to the articulation of word-final consonants (Menyuk, Liebergott & Schultz, 1986).

Mc Leod and Bleile (2003) analysed phonology in 2-year-olds and reported that phonemes missing usually included /ŋ, v, z, ʃ, ʒ, θ, ð, tʃ, dʒ, r, l/. The error patterns noted were: cluster reduction, fronting of velars and fricatives, stopping of fricatives and affricates, gliding, context sensitive voicing and final consonant deletion. Complex syllable structures and polysyllabic words are also commonly seen at this stage of a child. Indian languages have also been studied on similar lines, but they are not widely explored in younger population.

Indian studies

Phonotactic patterns in spoken language of children in Indian languages are not well reported. In Telugu language (Telangana dialect), Nirmala (1981) studied four children in the age range 1.6-3.0 years over a period of six months. Controlled elicitation and free conversation were used to collect data from the children. Results revealed that in the order of acquisition among consonants, nasals appeared first, followed by stops affricates and semi-vowels. Voiceless phonemes were acquired earlier than voiced ones. Contrasts among the voiceless stops and nasals were established before the voiced stops affricates and semivowels. Aspirated phonemes were acquired by 3.5 years at which point the distinction between retroflex versus non-retroflex sounds was still emerging. Glottal fricative /h/ had no substitutes and it was deleted in the speech of all four children until the age of 3.5 years. There were many substitutions among medial consonantal clusters produced by 2.6 to 3.5 year-olds. Geminate and homorganic clusters were acquired earlier than the others. Telugu words typically ended in open syllables. Two syllable words were more common than three or tetrasyllabic words. Syllable reduction was observed mainly with respect to three syllable words.

Rupela and Manjula (2006) studied the phonotactic development in 30 Kannada speaking children in the age range of 0-5 years. Results showed that CV syllables were the most commonly occurring syllable shapes compared to VC and CVC. CVC syllables were reported to occur at 12 months and increasing in frequency by 54-60 months.

Anjana and Sreedevi (2008) established a quantitative and qualitative database on babbling in Kannada and the syllable shapes found were V, CV, CVC, VC and VCV and the mean occurrence of multi-syllabic words increased with age. This is in accord with the finding by Neeti Priya and Manjula (2007), wherein children from 3-6years were studied and CV was the most predominant syllable form followed by CVC and then VC and V. Cluster analysis revealed medial geminate clusters were predominant compared to other types. Among word shapes disyllabic were the most pre dominant followed by multi-syllabic in younger age, which reformed to more multisyllabic words as age increased.

In a cross linguistic comparison, reported by Shailaja, Manjula and Praveen (2011), the syllable shapes evident in 3-5 year old typically developing Hindi speaking children were CV, CVC, VC, V, CCV, CVCC and VCC. Monosyllabic structures were found to be more frequent when compared to disyllabic structures and tri-syllabic words. Very few consonant clusters were produced (like CCV, VCC and CCVC) by the age of 5 years, which implies that these were yet to mature / or were emerging structures in the developmental sequence.

Analysis of phonotactic repertoire forms an important aspect in understanding the development of phonological abilities in typically developing children. It helps to gain insight regarding the actual phonological capabilities and limitations of a given child. There is a need to establish normative data of phonotactic repertoire in order to compare deviant phonological pattern in children with various communication disorders.

Hindi Phonology

Hindi and Urdu languages have their origins in Khariboli spoken in areas around Delhi. Khariboli was adopted by the Afghans, Persians, and Turks as a common language of interaction with the local population during the period of Islamic invasions and the establishment of Muslim rule in the north of India between the eighth and tenth centuries AD. In time, it developed a variety called Urdu with significant borrowings from Arabic and Persian and that uses a Persian script. It was also known as rexta "mixed language." As Urdu gained patronage in the Muslim courts and developed into a literature language, the variety used by the general population gradually replaced Sanskrit, literary Prakrits, and Apabhramsas as the literary language. This latter variety looked to Sanskrit for linguistic borrowings and Sanskrit, Prakrits, and Apabhramsas for literary conventions. It is this variety that became known as Hindi (Koul, 2008).

Hindi has a special status in India. It is spoken by the largest population in India. Hindi is an Indo-Aryan language (a branch of the-Indo-European family of languages), spoken primarily in the states of Bihar, Chhattisgarh, Delhi, Haryana, Himachal Pradesh, Jharkhand, Madhya Pradesh, Rajasthan, Uttarakhand, and Uttar Pradesh in India. Besides being the official language of these states it is also the official language of government of India along with

English. According to the 2001 census, it is spoken by 422,048,642 speakers which include the speakers of its various dialects and variations of speech grouped under Hindi. It is taught as a second language in all the non-Hindi speaking states under the three-language formula. Under this formula, a child is supposed to learn his mother tongue, Hindi, and English. If a child's mother tongue is Hindi, (s) he is expected to learn an additional modern Indian language or a foreign language. Hindi is taught as a foreign language in a large number of countries throughout the world. Dialectal variations provide vital cues to both synchronic and diachronic changes in sounds of a language. There has been no comparative phonological study of the dialects of Hindi in the last several decades. The present study has taken Khariboli as the major dialect across all its participants, however a comparative study is not taken up.

Hindi shares major linguistic characteristics with other Indo-Aryan languages. It has ten vowels. The length of vowels is phonemic. All vowels can be nasalized and nasalization is phonemic. The Hindi syllable contains a vowel as its nucleus, followed or preceded by consonants. Words usually have two or three syllables.

Distinctive Segments

The inventory of the distinctive segments of Hindi are as follows:

Table 2.1

Inventory of various vowels in Hindi (Koul, 2008)

Vowels

	Front	Central	Back
High	i:		u:
Lower High	i		u
Mid	e		o
Lower Mid	ɛ		ɔ
Low		a a:	

Note: Examples are stated in Appendix I

The nasalization is phonemic in Hindi as shown in the table below. Stating a few examples for the mid, front and back vowels, a clear comparison can be made such as, /kaha/ - said versus /kahãn/- where; /i:d/- Eid versus /îc^{h}/- inch; /u:n/- wool versus /û:t^{h}/-camel.

Table 2.2

Inventory of various nasalised vowels in Hindi (Koul, 2008)

	Front	Central	Back
High	ĩ:		ũ:
Lower High	ĩ		ũ
Mid	ẽ		õ
Lower Mid	ɛ̃		ɔ̃
Low		ã ã:	

Note: Examples are stated in Appendix I

Consonants

Table 2.3

Inventory of various consonants in Hindi (Koul, 2008)

	Bilabial	Labio-dental	Alveolar	Dental	Retroflex	Palatal	velar	Glottal Stops
vl.unasp	p			t	ṭ		k	
vl.asp	ph			th	ṭh		kh	
vd.unsap	b			d	ḍ		g	
vd.asp	bh			dh	ḍh		gh	
Affricates								
vl.unas						c		
vl.asp						ch		
Vd.unas						j		
vd.asp						jh		
Nasal	m			n	ṇ		ŋ	
Trill				r				
Flap								
unasp					ṛ			
asp					ṛh			
Lateral				l				
Fricative								
vl		f	s			š	x	
vd			z					h
Semivowel		v				y		

Note: Examples are stated in Appendix II

In Hindi only two vowel sequences are permissible as shown in table 2.4

Table 2.4

Inventory of various diphthongs in Hindi (Koul, 2008).

ai:	नाई	nai:	new
ia:	दिआ	dia:	lamp
ie	चलिए	calie	let's go
ui:	सुई	sui:	needle
uã:	कुँआ	kuã:	well
oi:	रोई	roi:	wept
oe	खोए	khoe	lost

Note: Examples are stated in Appendix III

Consonant Clusters

Word-initial consonant clusters are not as frequent as the word-medial consonant clusters. Consonant clusters occur frequently in the medial position. Most of these clusters are formed across syllable or morpheme boundaries. There are some restrictions in the formation of consonant clusters as follows: (i) two aspirated consonants do not combine to form a consonant cluster, (ii) /ch/ is not combined to form a consonant cluster, (iii) /d,/ does not occur as the second member of a consonant cluster. Consonant clusters occur less frequently in the word-final position.

No studies till date have reported syllable patterns in native Hindi speaking children in early years of life along with tracking the developmental trend with small time intervals (3months). Thus, there arises a need for studying the various phonotactic patterns arising in native Hindi speaking children at the early stages of development; and to tap these changes by keenly observing the

patterns in smaller age intervals. Hence present study was planned to obtain a preliminary database for phonotactic pattern seen in typically developing native Hindi speaking children between the age ranges 3 to 4 years; with an age interval of 3 months (>3;0 ≥ 3;3years ;> 3;3 ≥ 3;6years ;> 3;6 ≥ 3;9years; >3;9 ≥ 4;0 years). The focus of the study was to obtain the phonetic repertoire, various syllable structures and word shapes, the type and frequency of consonant clusters and to compare the findings across gender from a 100 word spontaneous speech sample from native Hindi speaking children in the age range of 3 – 4 years.

CHAPTER III

Method

The present study aimed at investigating the phonotactic development in 3-4 year old native Hindi speaking children.

3.1 Participants

A total of 40 typically developing participants in the age range of 3 to 4 years, with native language as Hindi were recruited in the study. The participants, were included in a 3 months age interval, thus a total of 4 age groups were considered (>3;0 ≥ 3;3years ;> 3;3 ≥ 3;6years ;> 3;6 ≥ 3;9years; >3;9 ≥ 4;0 years). Each of the four age intervals included ten participants including five boys and five girls. The participants were randomly selected from the Defence Colony nursery and pre-primary schools, from cities of Telangana and Karnataka. The study was briefed to the concerned authorities and a written consent was obtained from them for involving the participation of the children (Appendix IV).

3.1.1 Inclusion Criteria for participants

- ✓ Native speakers of Hindi, with minimal exposure to other languages and using majorly Hindi to communicate at home.
- ✓ Typically developing children with normal speech and language skills, ensured using screening checklist (developed in Department of Prevention of Communication Disorders, AIISH, 2008).
- ✓ Middle Socioeconomic Status (The Socioeconomic Status Scales, Venkatesan, 2011).

- ✓ Normal hearing, vision, oro-motor skills and no structural anomalies or middle ear infections based on informal observation and screening/ and no neurological disorders.

3.2 Procedure

3.2.1 Data collection and recording procedure

3.2.1.1 Instrumentation

The following instruments were used for recording and analysis purposes:

- Sony Vaio Core i3 laptop system: For displaying the story videos; and
- Digital Audio-Video recorder - Sony full HD 1080 Handycam for recording the verbal interaction with each participant.

3.2.1.2 Materials

To elicit natural speech sample the following materials were used as conversation generators, reinforces, and theme based controls:

- Story videos in Hindi taken from Youtube (Rabbit and the Tortoise, Thirsty Crow, Fox and the Grapes, Chota Bheem, Motu aur Patlu).
- Toy Kit for 2-4 year olds (Venkatesan, 2004)

3.2.1.3 Procedure

A spontaneous speech sample was elicited from the participants one at a time, in a fairly quiet school room set up, with minimal distractions, by the investigator in the presence of the parent/teacher/caregiver. Prior to the data recording a written consent was obtained from parents/teachers. A minimum of 10-15 minutes speech sample was elicited from each participant, which included a conversation on daily living, playing with toys and story narration. As supported by Dufour, Estève, and Deléglise, (2014) and Luzzati (2014) spontaneous speech is considered as unprepared speech which is conceived and perceived during its utterance, in opposition to prepared speech where utterances contain well-formed sentences. 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.

3.2.2 Data Analysis

Data analysis was carried out in the following two stages:

Stage 1: Transcription and data reduction

Stage 2: Data quantification of the phonotactic measures considered

Stage 1: The recorded sample was transferred to the computer and transcribed using International Phonetic Alphabet (2015) broad phonetic transcription, by the investigator. The transcribed data was then written in a CV-structure for each transcribed word. Consonants were marked as –C and vowels as –V, diphthongs were marked as –VV and open and closed clusters as –CC-,

depending on the number of clusters which occurred together in a sequence (Ohala, 1983).

Stage 2: The data was analysed for the following phonotactic measures:

- Syllable shapes (CV, VC, CVC, V and C),
- Word shapes (Mono-, Di-, Poly-),
- Position of clusters (initial, medial, final),
- Type and frequency of clusters (CC, CCC, geminates, non-geminate).

NOTE: Frequently occurring loan words from English were considered for analysis of speech sample

For calculation of the percentage of occurrence of the syllable structure and word level pattern, Velleman's (1998) formula was used:

- Percentage of CV/VC/CVC/V/C syllables -

$$\frac{\text{Number of CV/VC/CVC/V/C syllables}}{\text{Total number of syllables}} \times 100$$

- Percentage of mono/bi/polysyllabic words –

$$\frac{\text{Number of mono-/di-/polysyllabic words}}{\text{Total number of words}} \times 100$$

- Percentage of initial/medial/final consonant clusters -

$$\frac{\text{Number of Initial/medial/final consonant clusters}}{\text{Total number of words}} \times 100$$

- Percentage of type of clusters (CC/ CCC/ geminates/ non-geminate) -

$$\frac{\text{Number of CC/ CCC/ geminates/ non-geminate cluster}}{\text{Total number of words}} \times 100$$

3.3 Reliability

3.3.1 Inter and Intra Judge Reliability

Three (post graduates) speech language pathologists including the investigator served as judges for determining inter (included the investigator and two other SLPs) and intra (included only the primary investigator) judge reliability. The judges listened to the sample individually in a quiet room set-up using headphones. They, then transcribed 10% utterances of two participant in each age interval. Measure of agreement was calculated using Kappa-Coefficient since it is a qualitative data. Thus, a total of twenty responses for each age interval was transcribed and a significant agreement was observed between the three judges, as indicated in table 3.1.

Table 3.1

Measure of Agreement using Kappa-Coefficient ($p<0.05$)

	Inter Judge Reliability			**Intra Judge Reliability**
	JUDGE 1-2	**JUDGE 2-3**	**JUDGE 3-1**	**JUDGE 1-1**
Group 1 (3;0-3;3yrs)	0.67	0.83	0.60	1.0
Group 2 (3;3-3;6yrs)	0.82	0.88	0.82	1.0
Group 3 (3;6-3;9yrs)	0.77	0.94	0.82	1.0
Group 4 (3;9-4;0yrs)	0.80	1.00	0.82	1.0

3.4 Statistical analysis

Statistical methods were employed using SPSS (Statistical Package for Social Sciences) version 21.0. The transcribed data was not assessed for normality as the standard deviation was high and thus non-parametric tests and mean scores were computed.

CHAPTER IV

Results and Discussion

The present study aimed at investigating the phonotactic development in 3-4 year old native Hindi speaking children.

The main objectives of the study were:

1. To obtain the phonetic repertoire, various syllable structures and word shapes in native Hindi speaking children
2. To analyze the type and frequency of consonant clusters in native Hindi speaking children
3. To compare the findings across gender

The recorded data of 10-15 min duration of the 40 participants was phonetically transcribed using International Phonetic Alphabet (2015) which yielded a total of 4000 utterances in the entire spontaneous speech corpus of 40 participants. The types of phonotactic measures extracted and analysed from the spontaneous speech sample are represented elaborately in the flow chart 4.1.

The results are discussed under three sections and they are as follows:

Section1: Syllable Structures

Section 2: Word Types

Section3: Consonantal Clusters

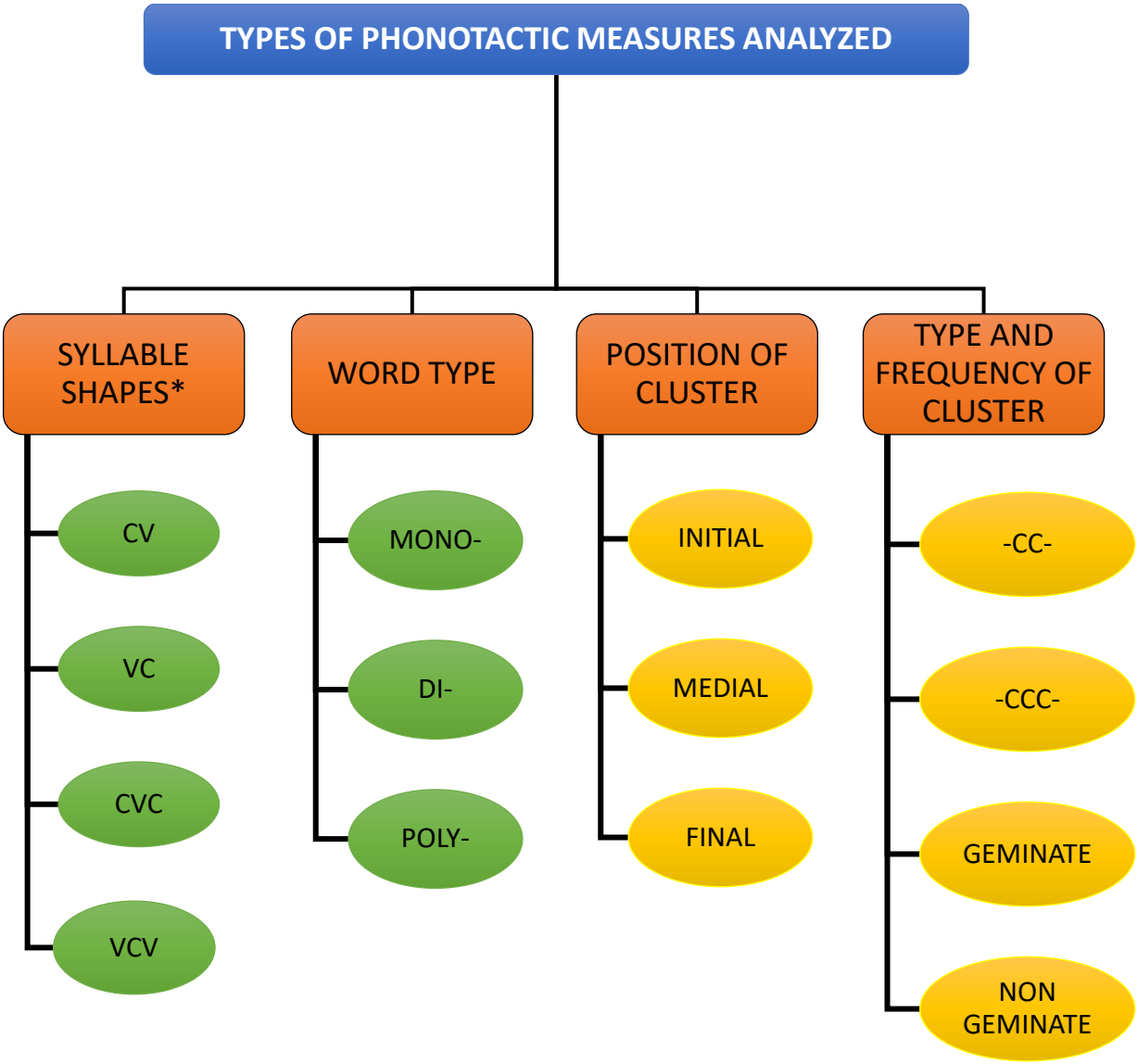

Figure 4.1. Flow chart representation of the types of phonotactic measures analysed in the native Hindi speaking children in the age range 3-4 years', spontaneous speech in the present study

NOTES: CV- Consonant-Vowel, VC- Vowel-Consonant, CVC- Consonant–Vowel-Consonant, VCV- Vowel-Consonant-Vowel, CVV- Consonant-Vowel-Vowel, CCV- Consonant-Consonant-Vowel, CC- Consonant-Consonant, CCC- Consonant-Consonant-Consonant

*- Although there were 55 total syllable shapes that were identified across the age intervals, syllable shapes considered for analyses were only four, which showed significant difference across the age intervals/occurred more than 60%.

The transcribed spontaneous speech sample of the participants consisted majorly of the following phonotactic measures as described in the figure 4.1:

Syllable shapes extracted were plenty, including diphthongs and consonant-vowel permutations and combinations all within the phonotactic rules of the Hindi language, concurring with the measures suggested by Ohala (1983). The word types were extracted from within the transcribed syllable structure and were categorised as monosyllables, disyllables and polysyllables depending on the occurrence of consonants-vowel combination in a particular word. Thus, a total of 55 various syllable structures were identified from the transcribed data set, out of which 11 types of monosyllable, 20 types of disyllable and 24 types of polysyllable word type occurred in the entire repertoire of the 40 participants (Appendix VI).

The frequency of occurrence of syllable structure and word types were calculated for each age group, which presented a constant growth line from the age 3;0 to 3;6 years, after which a slight decline in the overall frequency of occurrence of the words types was observed. An increase in the number of production of words is again observed in the final age group, i.e., 3;9 to 4;0 years, as indicated in table 4.1.

Table 4.1

Frequency of occurrence of Syllable Structures (CV/VC combinations) and Word Types (monosyllables, disyllables, polysyllables) across Age Groups

Word Type	Syllable Structure	Group 1 (3;0-3;3yrs)	Group 2 (3;3-3;6yrs)	Group 3 (3;6-3;9yrs)	Group 4 (3;9-4;0yrs)
MONO-	14	597	718	684	786
DI-	25	531	531	535	530
POLY-	27	64	77	70	69

4.1 Descriptive Statistics

Descriptive statistics was carried out for all types of phonotactic measures observed. Since the data presented a non-normal distribution and high standard deviations in many of the utterance types, median based scores are used for descriptions and comparisons. To consider a phonotactic measure as most frequently occurring, a 60% criteria was adopted, i.e., 6 or more participants out of 10 had to produce the specific phonotactic measure. Similarly a 40% -60% criteria was adopted for less frequently occurring phonotactic measure, i.e., 4 or more and lesser than 6 participants out of 10 had to produce the specific phonotactic measure; and a <40% criteria for rarely occurring phonotactic measure, i.e., lesser than 4 participants out of 10 had to produce the specific phonotactic measure. The same is indicated in table 4.2.

Table 4.2

Criteria for Frequency of occurrence of the Phonotactic Measure

Percentage of occurrence	**Category**
≥ 60%	Most Frequently Occurring
≥40% < 60%	Less Frequently Occurring
<40%	Rarely Occurring

4.2 Non- parametric tests

As data points are small and they displayed high standard deviation, non-parametric statistics were carried out for comparisons of types of phonetic measures across gender and age. A flow chart of the statistical analysis carried out in the study is shown in figure 4.2. Non parametric Mann Whitney U test was applied to examine the significant difference across gender in the 4 age intervals. Kruskal Wallis test was employed for the comparison of phonotactic measure types across age intervals. For the phonotactic measures with significant difference, Mann-Whitney-U test was employed for pair wise comparison across age intervals.

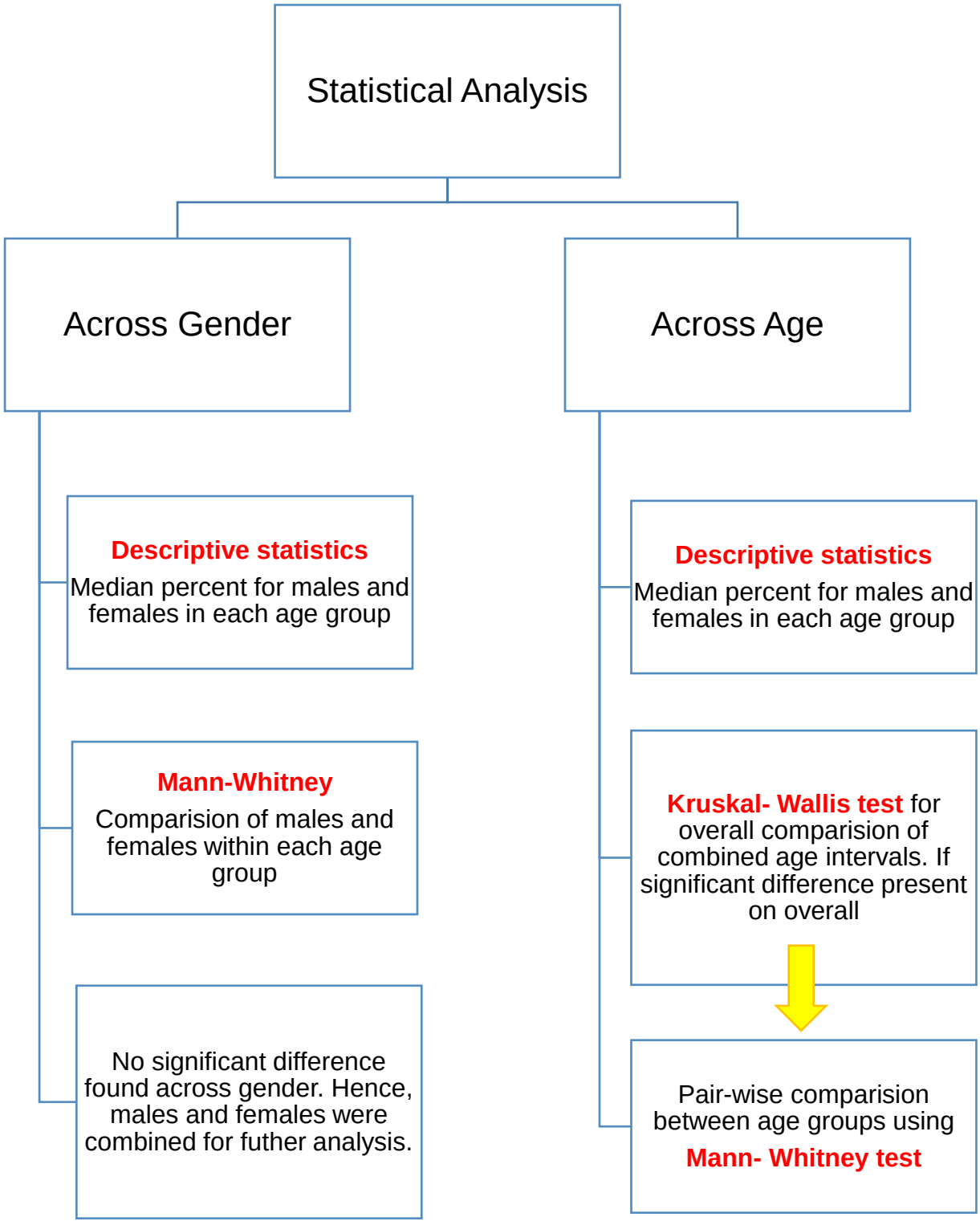

Figure 4.2. Flow chart of the statistical analyses

Section1: Syllable Shapes

A total of 55 various syllable shape patterns were observed, which were then reduced to 19 syllable structures which occurred 'most frequently' based on the >60% criteria. Thus, various syllable shapes found in the samples were CV, VC, CVC, VCV, CVV, CVCC, CCVC, CVCV, CVCCVC, CVCVC, CVCCV, VCCV, CVVCV, CVVC, VCVC, VCVCV, CVCVCVC, CVCCVCV and CVCVCV. However, as recommended by Velleman (1998), patterns with clusters were considered as a single consonant syllable and they were analysed separately. Thus various syllable shapes found in the samples comprised of 14 syllable shapes, including, CV, VC, CVC, VCV, CVCV, CVCVC, VCVC, VCVCV, CVCVCVC, VCVCVC, VCVCVCV, CVCVCV, CVCVCVCV, and CVCVCVCVC, excluding clusters.

- CV and CVC, CVCV syllables were the 'most frequently' occurring phonotactic measures, having 100% occurrence in all four age groups.
- Consonants and Vowels did not occur as singletons
- The frequency of occurrence of VC syllable was 60% in age group I (3;0 – 3;3 years) and 100% in all other age groups making it the 'most frequently' occurring phonetic measure.
- VCV syllable had an occurrence of 80-90% across the four age groups, making them 'most frequently' occurring syllable shape.
- CVCVC, CVCVCV syllable had 90 - 100% occurrence in all age groups, thus falling under the 'most frequently' occurring syllable shape.
- The frequency of occurrence of VCVC was between 40-60% across the four age groups, hence is categorised as the 'less frequently' occurring phonotactic measure.

- The syllable shapes VCVCV, CVCVCVC and CVCVCVCV were considered under the 'rarely' occurring category as their frequency of occurrence was limited to 20-30% across the four age groups.
- There was no significant change in the percentage occurrence of syllable shapes across ages 3;0-4;0 years. The above results are summarized in tables 4.3 and 4.4.

Table 4.3

Frequency of occurrence of various Syllable Shapes

Category	Syllable shapes*
Most frequently occurring	CV, CVC, CVCV,VC, VCV, CVCVC, CVCVCV
Less frequently occurring	VCVC
Rarely occurring	VCVCV, CVCVCVC, CVCVCVCV

Note: There was no significant change in the percentage occurrence of syllable shapes across the the four age groups studied

Table 4.4

Mean and Standard Deviation of various Syllable Shapes

Age (years)		**3;0-3;3**	**3;3-3;6**	**3;6-3;9**	**3;9-4;0**
CV	Mean	26.3	30.7	33.1	35.2
	SD	13.46642	8.71844	15.3221	11.08352
CVC	Mean	20.3	25.6	21.1	25.5
	SD	8.42021	8.11309	6.5904	9.3244
CVCV	Mean	24	28.9	31.7	29
	SD	7.70281	7.26407	12.35628	8.76863
VC	Mean	5.5	4.6	6.9	6.7
	SD	6.8678	4.27395	2.18327	2.45176
VCV	Mean	2.4	2.9	2.3	3.4
	SD	1.89737	3.78447	1.05935	2.59058

CVCVC	Mean	3.4	7.2	6.3	6.7
	SD	2.59058	3.96653	2.16282	4.11096
CVCVCV	Mean	4.1	5.1	4.7	4.6
	SD	2.37814	3.98469	1.76698	2.83627
VCVC	Mean	1	0.9	0.3	2.1
	SD	1.63299	0.8756	0.67495	2.23358
VCVCV	Mean	0.2	0.9	0.2	0.4
	SD	0.42164	0.99443	0.63246	0.96609
CVCVCVC	Mean	0.5	0.1	0.6	0.2
	SD	0.84984	0.31623	0.96609	0.42164
CVCVCVCV	Mean	0.2	0.1	0.6	0.1
	SD	0.42164	0.31623	0.84327	0.31623

Note: Colour coding is in correspondence with table 4.3. Green – Most frequently occurring, Purple- Less frequently occurring, red- Rarely occurring

Kruskal Wallis test was employed for the comparison of phonotactic measure types across age intervals. The statistical result revealed that syllable shapes CVV, CCVC and VCCV were significantly different across the four age intervals ($p < 0.05$). Further, Pair-wise Man Whitney test was run to verify significant difference across age groups. Results are as indicated in the subsequent tables 4.5, 4.6 and 4.7 below.

Table 4.5

Pair-wise Comparison of CVV Syllable Structure across Age Groups

	Group I	Group II	Group III	Group IV
Group I		✖	✖	✓
Group II			✖	✖
Group III				✖
Group IV				

Note: ✖ depicts no significant difference between the two groups taken for comparison; and ✓ depicts there is significant difference between the two groups compared.

Table 4.6

Pair-wise Comparison of CCVC Syllable Structure across age groups

	Group I	Group II	Group III	Group IV
Group I		✓	✖	✖
Group II			✓	✓
Group III				✖
Group IV				

Note: ✖ depicts no significant difference between the two groups taken for comparison; and ✓ depicts there is significant difference between the two groups compared.

Table 4.7

Pair-wise Comparison of VCCV Syllable Structure across age groups

	Group I	Group II	Group III	Group IV
Group I		✓	✖	✓
Group II			✖	✖
Group III				✖
Group IV				

Note: ✖ depicts no significant difference between the two groups taken for comparison; and ✓ depicts there is significant difference between the two groups compared.

Even though, Kruskal Wallis test revealed that syllable shape CVV, CCVC and VCCV were significantly different across the four age intervals ($p < 0.05$), from the results of Pair-wise Man Whitney test (table 4.5, 4.6 and 4.7) it is concluded that there was no apparent developmental trend seen for any of the syllable shapes. CVV showed a slight increment when compared across group I and Group IV, indicating that CVV syllable structures do increase with age, but there was no apparent pattern which was observed. On the other hand, CCVC and VCCV showed increment across the age groups, and a gradient granular growth across the age groups was observed.

Section 2: Word Types

When analysed for word shapes monosyllables, disyllables and polysyllables were found in the samples. A total of 11 monosyllables were observed, out of which 7 were considered as most frequently occurring; 20 disyllabic word types were observed of which 9 were considered for analysis; and of the 24 polysyllabic words only 3 had an occurrence more than 60% of the times, making a total of 19 syllable structures which were identified and categorised into 3 word types as indicated in the figure 4.3. Only these 19 structures were then analysed further for mean rank scores, standard deviation and median analysis and to compare across age and gender. These word types were analysed from the various syllable structures.

- Around 7 types of monosyllables were analysed from the sample, which included CV, VC, VCV, CVC, CCVC, CVCC and CVV as the most frequently occurring word types. Among these only CVV and CCVC had a significant difference across age groups as indicated in table 4.5 and 4.6 (CVV (diphthong) is considered as a monosyllable based on the classification given by Ohala, 1983).
- Out of the 55 phonotactic measures which were extracted, 20 of them were disyllabic words in which the 'most frequently' occurring ones were 9 word types, including CVCV, CVCCVC, CVCVC, CVCCV, VCCV, CVVCV, CVVC, VCVC and VCVCV. However there was no developmental pattern that was observed, these disyllabic words were all scattered in their occurrence across the age intervals, except VCCV, which was observed as 'most frequently' occurring word type with a difference across age intervals, as indicated in table 4.7.

- Even though polysyllabic words comprised of 24 various types out of the 55 phonotactic measures, only 3 patterns were recognised as 'most frequently' occurring word types, including CVCVCVC, CVCCVCV and CVCVCV. All of them they showed no specific increment pattern across age intervals and the frequency of their occurrence was also scattered.

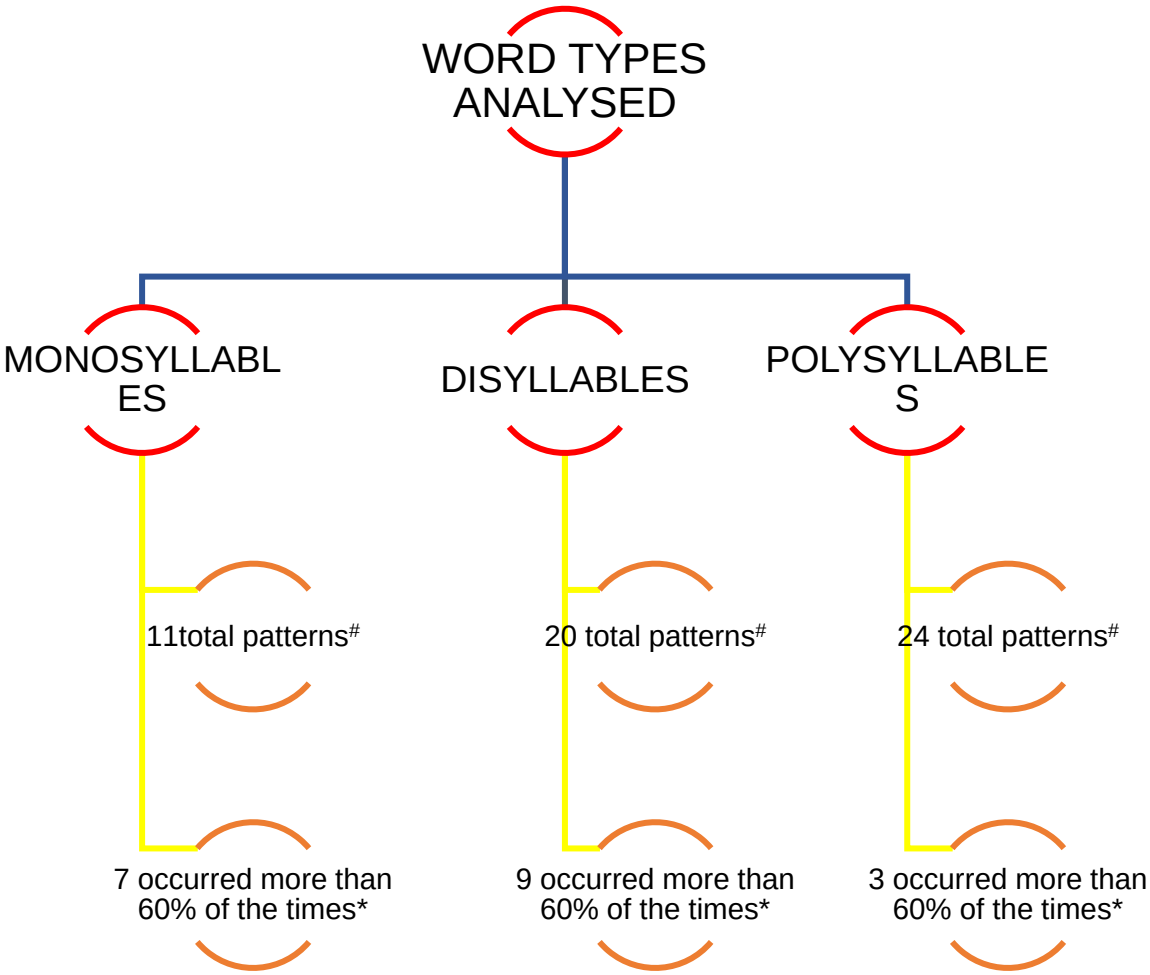

Figure 4.3. Flow chart representation of the word types analysed in the spontaneous speech of native Hindi speaking children in the age range 3-4 years'

NOTES: #- indicates all patterns that were observed in the spontaneous speech sample. *- indicates the filtered word types that occurred more than 60% of the times and thus were considered for further analysis.

Table 4.8

Mean, Standard Deviation and Median scores of various word types

AGE		TOTAL			
		N	**MEAN**	**SD**	**MEDIAN**
TOTAL MONO-	3;0-3;3	10	58.7	24.55855	66.5
	3;3-3;6	10	71.1	12.8966	74
	3;6-3;9	10	67.8	21.89267	76
	3;9-4;0	10	77.5	9.24061	78
TOTAL DI-	3;0-3;3	10	40.1	13.81183	43
	3;3-3;6	10	51	9.38083	49.5
	3;6-3;9	10	51	13.02135	50
	3;9-4;0	10	50.7	9.21412	51.5
TOTAL POLY-	3;0-3;3	10	4.8	2.97396	4
	3;3-3;6	10	5.3	4.27005	4.5
	3;6-3;9	10	5.9	2.46982	6
	3;9-4;0	10	4.9	2.96086	3.5

Note: N- indicates total number of participants in the particular age range.
S.D- indicates standard deviation

Kruskal Wallis test was employed for the overall comparison of word types across age intervals. Although the frequency of occurrence of the monosyllables and disyllables did increase across the age interval, results of statistical analysis indicated that there is no significant developmental pattern for the various word types. The statistical result revealed that the only disyllable, VCCV was significantly different across the four age intervals ($p < 0.05$). Further, Pair-wise Man Whitney test was run to check for difference across age groups. Results are as indicated in tables 4.5, 4.6 and 4.7.

Section 3: Consonantal Clusters

Various consonant clusters found in the children's speech were initial clusters (CC-), medial clusters (-CC-), final clusters (-CC) and three sound clusters in the medial position. Medial clusters included geminated (-CCg-) and non-geminated clusters (-CCng-). A total of 32 various cluster types were observed across the 40 participants. However only 6 of them were taken for cluster analysis, as they occurred more than 60% of the times across the age group.

- The 6 consonantal cluster with higher frequency of occurrence were CVCC, CCVC CVCCVC, CVCCV, VCCV and CVCCVCV, which were categorised as 'most frequently' occurring cluster pattern. The mean rank occurrence scores are as indicated in table 4.9.
- Among the cluster types, medial clusters were the 'most frequently' occurring clusters with 60-70% frequency in all age intervals. Within these medial clusters, non-geminated clusters were the majorly occurring combinations, across all age groups. This is seen as Hindi majorly has higher occurrence rate of non-geminate clusters than geminate clusters (Koul, 2008). The cluster types included both open and close clusters, including combinations of laterals+nasals (/ln/- khelna), stops+nasals (/pn/-apna), nasal+fricative (/mdz/-samjhi), velar+glide (/kj/- kya), velar+dental (/kt, nasal+velar (/nk/-pink, /ng/-ring), glottal+dental (/ht/-khatm), nasal+dental (/nd/-pasand), laterals+dentals (/lt/-ulti), retroflex+velar (/rg/-khargosh) [Appendix VI].
- Initial, final and three consonant clusters occurred 'rarely' in the speech samples of all age groups with < 20% frequency in all age groups.

Table 4.9

Mean, Standard Deviation and Median scores of Various Consonantal Clusters

CLUSTER TYPE	AGE	TOTAL			
		N	Mean	S.D	Median
CVCCVC	3;0-3;3	10	1.7	1.70294	1.5
	3;3-3;6	10	1.4	1.50555	1
	3;6-3;9	10	1.6	1.42984	1.5
	3;9-4;0	10	1.7	1.94651	1
CVCCV	3;0-3;3	10	7.4	4.42719	7
	3;3-3;6	10	8.2	3.11983	8.5
	3;6-3;9	10	8.2	3.25918	8
	3;9-4;0	10	5.2	2.39444	6
VCCV	3;0-3;3	10	0.4	0.5164	0
	3;3-3;6	10	2.1	2.18327	2
	3;6-3;9	10	1.5	1.71594	1
	3;9-4;0	10	3.2	3.19026	3
CVCCVCV	3;0-3;3	10	0.2	0.42164	0
	3;3-3;6	10	0.1	0.31623	0
	3;6-3;9	10	0.6	0.84327	0
	3;9-4;0	10	0.1	0.31623	0
CVCC	3;0-3;3	10	1.6	1.77639	1.5
	3;3-3;6	10	1.2	1.93218	0.5
	3;6-3;9	10	0.8	0.78881	1
	3;9-4;0	10	1	1.05409	1
CCVC	3;0-3;3	10	0.4	0.69921	0
	3;3-3;6	10	1.5	1.2693	2
	3;6-3;9	10	0.2	0.42164	0
	3;9-4;0	10	0.5	0.52705	0.5

Note: N- indicates total number of participants in the particular age range.
S.D- indicates standard deviation

The cluster sample were very rarely occurring in and across all age groups and thus no specific statistical test could be employed for analysis. The sample set was qualitatively analysed and it was found that the clusters though rare, depicted varied combinations and occurred across all age groups, thus

indicating that simple and complex cluster acquisition does occur in this age range (3;0-4;0 years). However, as children less than 3 years are not considered in the present study, it is difficult to comment on the emergence of the same.

The results of the study suggest that there is no significant developmental trend noticed in native Hindi speaking children between 3-4 years age range in terms of the phonotactic measures of syllable shapes, word shapes, and type and frequency of clusters. However, the mean rank scores are indicative of high occurrence of a few phonotactic patterns, such as monosyllabic CV, VC, CVC, VCV, CVV, CVCC, CCVC; disyllabic CVCV, CVCCVC, CVCVC, CVCCV, VCCV, CVVCV, CVVC, VCVC and VCVCV; and polysyllabic CVCVCVC, CVCCVCV and CVCVCV, which were observed to occur across the four age intervals with >60% frequency, thus indicative of their acquisition much before the age range of 3-4 years, as they are completely mastered utterances.

Among these, CV and CVC patterns of syllable shape have highest frequency of occurrence, which is indicative of both closed and open set syllable shape, and is in agreement with the study by Shailaja and Manjula (2011) which is suggestive of prominence of these patterns in the language. The result also seems to suggest that Hindi speaking children are following universal order of syllable acquisition where CV type is reported to be acquired earlier by children of all languages (Jackobson, 1968; Bernthal & Bankson, 1993; Shailaja & Manjula, 2011). According to Mishra and Bali, 2011, Hindi predominantly has CVC syllable shape, thus making the occurrence of closed syllable shape in children more likely and justifiable. Another reason for this frequent occurrence of CVC could be due to the increased frequency of medial clusters in Hindi. As stated by Ohala (1983), the syllabification of the medial cluster leads to CVC-

CV, pattern thus making it more prominent even in a child's repertoire. Also, like in majority of the languages, Hindi allows vowel-initial syllables, evidenced by the presence of VC, VCV, VCCV and VCVC type of word-initial productions. The results in this study is different from the observation of Vani and Manjula, (2006) in Kannada speaking children and Neethipriya and Manjula (2007) in Telugu speaking children, who commonly observed that in monosyllable word shapes CV followed by VC and CVC occurred in that order. In the Hindi speaking children of only CV and CVC were majorly seen.

Among word shapes, high occurrence of monosyllables were followed by disyllables. Further, in monosyllables CV and CVC were predominantly observed. In disyllables, CVCV, CVCVC and CVCCV were most frequently occurring with a slight increment across age groups, which is also supported by the observation of Shailaja and Majula (2011) in Hindi, where they report of majorly CV, and CV chains in the disyllables. Also in polysyllables, they report of CV, CV, CV and CVC, CVC, CVC, chains which were evident even in the present study in CVCVCV, CVCVCVC and CVCCVCV type of syllable structures. This trend observed up to 5 years in the study by Shailaja and Majula (2011), was similar to that reported in Kannada speaking children (Vani & Manjula, 2006) and Telugu speaking children (Neethipriya & Manjula, 2007).

Cluster analysis of samples revealed predominance of medial non-geminated clusters. Two consonantal combinations (-CC-) showed a higher percentage of occurrence than three consonantal clusters (-CCC-). Word- initial and word-final clusters were rare in occurrence and were majorly found in lone words from English. Native language does contain word-initial and word-final clusters, but they were not observed in the repertoire of the samples considered

in the present study. The variety in the occurrence of consonantal clusters across age intervals is varied, however, they did not occur consistently across in samples due to which no conclusions on their developmental trend could be drawn from the study. However, it can be concluded that various patterns of consonantal clusters are emerging at a very early age in Hindi, suggesting a need for detailed study on the cluster acquisition in the language in children less than 3 years of age.

CHAPTER V

Summary and Conclusions

The present study aimed at investigating the phonotactic development in 3-4 year old native Hindi speaking children. The main objectives of the study were:

1. To obtain the phonetic repertoire, various syllable structures and word shapes in native Hindi speaking children
2. To analyze the type and frequency of consonant clusters in native Hindi speaking children
3. To compare the findings across gender

Across sectional population of Hindi children from 3 to 4 years in a 3months age interval (>3;0 ≥ 3;3years ;> 3;3 ≥ 3;6years ;> 3;6 ≥ 3;9years; >3;9 ≥ 4;0 years) were enrolled in the present study. A total of 40 participants comprised of 10 children in each age interval with 5 males and 5 females were considered. The participants were randomly selected from the Defence Colony nursery and pre-primary schools, from cities of Telangana and Karnataka. A general history of child's development, details of speech and language, hearing, vision, oro-motor, articulatory and cognitive skills were obtained through interview method using the screening checklist developed at the department of Prevention of Communication Disorders (2008) in AIISH. The Socioeconomic Status Scales, Venkatesan (2011), was used to ensure that all the participants were from middle socio-economic background and were exposed predominantly to Hindi.

An Audio-Video recording of 10-15 minutes duration of spontaneous speech, of the 40 participants was elicited using story videos, toy kit and general conversation. This was then phonetically transcribed using International Phonetic Alphabet (2015) which yielded a total of 4000 utterances in the entire

spontaneous speech corpus of 40 participants. The types of phonotactic measures extracted from the spontaneous speech sample were:

- Syllable shapes (CV, VC, CVC, V and C),
- Word shapes (Mono-, Di-, Poly-),
- Position of clusters (initial, medial, final),
- Type and frequency of clusters (CC, CCC, geminates, non-geminate).

For calculation of percentage of occurrence of these phonotactic measures, the formulae given by Velleman (1998) were used. Inter and intra judge reliability were also carried out to check the reliability of transcription and syllabification.

The results discussed under three sections (Syllable Structures, Word Types, Consonantal Clusters), revealed that the major syllable structures which occurred most frequently were CV, VC, CVC, VCV, CVV, CVCC, CCVC, CVCV, CVCCVC, CVCVC, CVCCV, VCCV, CVVCV, CVCVCVC, CVCCVCV and CVCVCV, of which only CVV, CCVC, VCCV showed a significant difference across age intervals. However on comparisons between the groups there was no evident developmental pattern seen for any of the syllable structures obtained. A total of 19 most frequently occurring word types were elicited, of which monosyllables and the disyllables were the majorly occurring word types. With increase in age no statistically significant increment in the word types were observed. However, the frequency of occurrence of the various word types did show slight increment with increase in age. Consonant clusters were analysed and it was observed that medial non-geminate clusters

occurred most frequently, followed by initial clusters and final clusters, majorly seen for loan words of English.

This study promoted the importance of developing language based normative data as each language differs from others in terms of phonotactics. It would aid in accurate assessment and also useful in setting therapy goals according to developmental patterns. Future research should be planned to make detailed analysis on interaction between Phonetic and phonotactic development with wide range of age is required in formulating comprehensive assessment tools.

Limitations of the present study:

- Dialect of the participants were ignored
- Sample size and the corpus are small.

Future Directions:

- The study could be used as a normative database to facilitate a probable diagnostic tool for speech and language assessment purposes
- The study could be repeated with a larger population, wider age range and dialectal variations in Hindi.

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APPENDIX I

1) Inventory of various oral vowels in Hindi (Koul, 2008)

/i:/	(high front unrounded long vowel):		
	ईद	i:d	Eid
	नीर	ni:r	water
	जल्दी	jaldi:	hurry

/i/	(high front unrounded short vowel):		
	इमारत	ima:rat	building
	गिरना	girna:	to fall
	पति	pati	husband
/e/	(mid front unrounded long vowel):		
	एक	ek	one
	रेत	ret	sand
	जूते	ju:te	shoes
/a/	(low central unrounded short vowel):		
	अगर	agar	if
	पर	par	but
	न	na	no
/a:/	(low central unrounded long vowel):		
	आम	a:m	mango
	आराम	a:ra:m	rest
	अच्छा	accha:	good
/u/	(high back rounded short vowel):		
	उठना	uṭhna:	to rise
	पुत्र	putr	son
	किंतु	kintu	but
/u:/	(high back rounded long vowel):		
	ऊन	u:n	wool
	सूद	su:d	interest
	भालू	bha:lu:	bear

/o/	(mid back rounded long vowel):		
	ओस	os	dew
	रोटी	roṭi:	bread
	दो	do	two
/ɛ/	(lower mid unrounded front vowel)		
	ऐनक	ɛnak	mirror
	गैर	gɛr	stranger
	लै	lɛ	tune
/ɔ/	(lower mid rounded back vowel)		
	औरत	ɔrat	woman
	दौलत	dɔlat	wealth
	सौ	sɔ	hundred

2) Inventory of various nasalised vowels in Hindi (Koul, 2008)

/ĩ/	इंच	ĩc	inch
	पिंजरा	pĩjra:	cage
/ĩ:/	ईंट	ĩ:ṭ	brick
	सींचना	sĩ:cna:	to irrigate
	नहीं	nahĩ:	no
/ẽ/	भेंट	bhẽṭ	meeting
	में	mẽ	in
/ã/	अँगूठा	ãgu:ṭha:	thumb
	ठंड	ṭhãḍ	cold
/ã:/	आँगन	ã:gan	courtyard
	माँग	mã:g	demand
	माँ	mã:	mother
/ũ/	उँस	ũs	ounce
	मुँह	mũh	face
/ũ:/	ऊँट	ũ:ṭ	camel
	सूँघना	sũ:ghna:	to smell
	जूँ	jũ:	louse
/õ/	ओंठ	õṭh	lip
	गोंद	gõd	gum
	सरसों	sarsõ	mustard
/ɛ̃/	ऐंठना	ɛ̃ṭhna:	to tighten
	भैंस	bhɛ̃s	buffalo
	मैं	mɛ̃	I

APPENDIX II

1) Inventory of various consonants in Hindi (Koul, 2008).

/p/	(voiceless unaspirated bilabial stop):		
	पल	pal	moment
	कपड़ा	kapṛa:	cloth
	साँप	sã:p	snake
/ph/	(voiceless aspirated bilabial stop):		
	फल	phal	fruit
	सफल	saphal	successful
	साफ	sa:ph	clean
/b/	(voiced unaspirated bilabial stop):		
	बल	bal	strength
	अंबर	ambar	sky
	सब	sab	all
/bh/	(voiced aspirated bilabial stop):		
	भालू	bha:lu:	bear
	सभा	sabha:	meeting
	लाभ	la:bh	profit
/t/	(voiceless unaspirated dental stop):		
	तार	ta:r	wire
	कातना	ka:tna:	to spin
	रात	ra:t	night
/th/	(voiceless aspirated dental stop):		
	थाली	tha:li:	palate
	हाथी	ha:thi:	elephant
	हाथ	ha:th	hand
/d/	(voiced unaspirated dental stop):		
	दरवाज़ा	darva:za:	door
	वर्दी	vardi:	uniform
	बंद	band	closed
/dh/	(voiced aspirated dental stop):		
	धन	dhan	wealth
	आधा	a:dha:	half
	दूध	du:dh	milk
/ṭ/	(voiceless unaspirated retroflex stop):		
	टोकरी	ṭokri:	basket

	काटना	ka:ṭna:	to cut
	कोट	koṭ	coat
/ṭh/	(voiceless aspirated retroflex stop):		
	ठग	ṭhag	cheat
	मिठाई	miṭha:i:	sweets
	आठ	a:ṭh	eight
/ḍ/	(voiced unaspirated retroflex stop):		
	डाली	ḍa:li:	branch
	निडर	niḍar	fearless
	साँड	sã:ḍ	bull
/ḍh/	(voiced aspirated retroflex stop):		
	ढोल	ḍhol	drum
	गढा	gaḍha:	ditch
/k/	(voiceless unaspirated velar stop):		
	कान	ka:n	ear
	लकड़ी	lakṛi:	wood
	नाक	na:k	nose
/kh/	(voiceless aspirated velar stop):		
	खोदना	khodna:	to dig
	देखना	dekhna:	to see
	राख	ra:kh	ashes
/g/	(voiced unaspirated velar stop):		
	गर्दन	gardan	neck
	अगर	agar	if
	आग	a:g	fire
/c/	(voiceless unaspirated palatal stop):		
	चार	ca:r	four
	बच्चा	bacca:	child
	कांच	kã:c	glass
/ch/	(voiceless aspirated palatal affricate):		
	छे	che	six

	मछली	machli:	fish
	कुछ	kuch	some
/j/	(voiced unaspirated palatal affricate):		
	जान	ja:n	life
	गाजर	ga:jar	carrot
	ताज	ta:j	crown
/jh/	(voiced aspirated palatal affricate):		
	झंडा	jhãḍa:	flag
	सुझाव	sujha:v	suggestion
	साँझ	sã:jh	evening

/f/	(voiceless labio-dental fricative)		
	फर्ज़	farz	duty
	नफरत	nafrat	dislike
	सिर्फ	sirf	only
/s/	(voiceless alveolar fricative):		
	सात	sa:t	seven
	सस्ता	sasta:	cheap
	दस	das	ten
/z/	(voiced alveolar fricative):		
	ज़बान	zaba:n	language
	बाज़ार	ba:za:r	market
	गज़	gaz	yard
/š/	(voiceless alveolar fricative):		
	शक	šak	suspicion
	आशा	a:ša:	hope
	नाश	na:š	destruction
/x/	(voiceless velar fricative):		
	ख़बर	xabar	news
	अख़बार	axba:r	newspaper
	शाख़	ša:x	branch
/h/	(voiceless glottal fricative):		
	हाथी	ha:thi:	elephant
	बहार	baha:r	spring
	राह	ra:h	way

/m/	(voiced bilabial nasal):		
	माथा	ma:tha:	forehead
	कमरा	kamra:	room
	आराम	a:ra:m	rest
/n/	(voiced alveolar nasal):		
	नाक	na:k	nose
	लाना	la:na:	to bring
	धान	dha:n	paddy
/ɳ/	(voiced retroflex nasal)		
	अणु	aɳu	atom
	प्राण	pra:ɳ	life
/ŋ/	(voiced velar nasal):		
	रंगना	raŋna:	to dye
	रंग	raŋ	color

/r/	(voiced alveolar trill):		
	रस्सी	rassi:	rope
	नर्म	narm	soft
	तार	ta:r	wire

/v/	(voiced labio-dental semi-vowel):		
	वादा	va:da:	promise
	दवाई	dava:i:	medicine
	नाव	na:v	boat
/y/	(voiced palatal semi-vowel):		
	याद	ya:d	memory
	साया	sa:ya:	shade
	राय	ra:y	opinion

APPENDIX III

1) Inventory of various vowel sequences (diphthongs) in Hindi (Koul, 2008).

ai:	नाई	nai:	new
ia:	दिआ	dia:	lamp
ie	चलिए	calie	let's go
ui:	सुई	sui:	needle
uã:	कुँआ	kuã:	well
oi:	रोई	roi:	wept
oe	खोए	khoe	lost

APPENDIX IV

1) Consent form taken from the caregivers/teachers

Informed Consent

I 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 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, _____, the undersigned, give my consent to be participant of this investigation/study/program.

Signature of Parent/
Guardian
(Name and Address)

Signature of Witness

(Name of Witness)

Signature of Investigator:
Name and Designation:
Date:

APPENDIX VI

1) Exemplars of various syllable structures observed in the repertoire of the 40 participants (International Phonetic Alphabet, 2015).

SYLLABLE STRUCTURE	EXAMPLES	IPA	MEANING (in English)
MONOSYLLABLES			
CV	Main	mɛː	In
VC	Aur	ɔːr	And
CVC	Ram	rɑːm	Pronoun
VCV	Agae	aːgɛː	Front
CVV	Nai	naiː	No
CVCCC	Mantr	mantr	Hymn
CVCC	Chips	ʧips	Chips*(loan word)
CCVCC	Svach	svəcʧ	Clean
CCVC	Star	staːr	(Loan word)
CCV	Kya	kjaː	What
VCC	Arth	əɾtʰ	Meaning
DISYLLABLES			
CVCV	Jata	aːgɛː	Going
CVCCVC	Laptop	lɛːptoːp	Laptop
CVCVC	Chawal	ʧaːwal	Rice
CVCCV	Sabji	səbdziː	Vegetable
CCVCCV	Kyunki	kjunki	Because
VCCV	Uska	uska	His
CVVCV	Bhaiya	bʱaija	Elder Brother
CVVC	White	vaːiʈ	(loan word)
VCVC	Ilaj	ɪlaːdz	Treat
CVCVCC	Blocks	bəloːks	Blocks*(loan word)
VCCVC	Asmaan	aːsmaːn	Sky
CVCCCV	Dhundte	ɖʱuːnd̪teː	Searching
VCCCVC	Ice Cream	aiskriːm	Ice cream
CVCVV	Safai	səfaːi	Cleaning
VCVCC	Orange	ɔːrɛːndz	Orange
VCVCV	Udega	udɛːga	Will fly
CVVCC	Cycle	saːikl	Bicycle
CVCCVCC	Yashwant	jaʃvənt	Pronoun

CVCCCVC	Control	kəntro:l	(Loan word)
CCVCVC	Driver	ɖraivər	Driver*(loan word)
POLYSYLLABLES			
CVCVCVC	Favourite	fɛ:vərɛ:t	(Loan word)
VCVCVC	Abhinesh	əbʱinɛ:ʃ	Pronoun
CVCCV	Samjha	səmdʒʱa	Understood
VCVCVCV	Anuradha	ənura:ɖʱa	Pronoun
VCCVCV	Anjali	əndzali:	Pronoun
CVCCVVC	Tortiose	ʈo:rto:iz	(Loan Word)
CVCCVCV	Macroni	mɛ:kro:ni	Macroni*(loan word)
CVCVCV	Banayi	bəna:yi	Made
CVCVCCV	Paranthe	pəra:nʈʰe	Pronoun
CVVCVC	Cycle- Saikel	sa:ikəl	Bicycle
CVCVCVCV	Chalegaya	ʧəlagəja	Left
CVCVCCVC	Mangalmai	məŋəlməi	Happy
CVCVVCV	Kanaiya	kənaija	Pronoun
CVCVCV	Chalanae	ʧəlanɛ:	To walk
CVCCVCCVC	Badminton	bɛ:dmintən	Badminton*(loan word)
CVCVCVCVC	Pediasure	pi:dijaʃo:r	(Loan word)
CVVCVVCC	Bicycle	baisaikl	(Loan word)
VCVCCV	Anushka	ənu:ʃka	Pronoun
CVVCVCV	Vaibhavi	vaibʱavɪ	Pronoun
CVCCVCCV	Divyanshi	ɖɪvja:nʃɪ	Pronoun
CVCCVCVC	Dhanyavad	ɖʱənjava:ɖ	Thank You
VCCVCVCC	Accident	ɛ:ksɪdɛ:nt	(Loan Word)
CVCCCVCVC	Volkswagen	vo:ksvogən	(Loan word)
VCVCCVC	Arindham	ərindəm	Pronoun

Note- *- are all loan words which are widely accepted and used in Hindi. Whereas, other loan words have their Hindi counterparts as well.

Highlighted words are all consonant clusters.

APPENDIX VII

1) The International Phonetic Alphabet (2015) for Hindi vowels consonants

Vowels

Gloss	अ *a*	आ *aa*	इ *i*	ई *ee*	उ *u*	ऊ *oo*
IPA	**ə**	**a:**	**ɪ**	**i:**	**ʊ**	**u:**
Gloss	ए *e*	ऐ *ai*	ओ *o*	औ *au*	अँ *an*	अ: aha
IPA	**e:**	**ɛ:**	**o:**	**ɔ:**	**ə̃**	◌ः

Main Consonants

Gloss	क *ka*	ख *kha*	ग *ga*	घ *gha*	ङ *na*
IPA	**k**	**kʰ**	**g**	**gʰ**	**ŋ**
Gloss	च *ca*	छ *cha*	ज *ja*	झ *jha*	ञ *na*
IPA	**tʃ**	**tʃʰ**	**dʒ**	**dʒʰ**	**ɲ**
Gloss	ट *ta*	ठ *tha*	ड *da*	ढ *dha*	ण *na*
IPA	**ʈ**	**ʈʰ**	**ɖ**	**ɖʰ**	**ɳ**
Gloss	त *ta*	थ *tha*	द *da*	ध *dha*	न *na*
IPA	**t̪**	**t̪ʰ**	**d̪**	**d̪ʰ**	**n**
Gloss	प *pa*	फ *pha*	ब *ba*	भ *bha*	म *ma*
IPA	**p**	**pʰ**	**b**	**bʰ**	**m**
Gloss	य *ya*	र *ra*	ल *la*	व *va*	श *sha*
IPA	**j**	**ɾ**	**l**	**ʋ**	**ʃ**
Gloss	स *sa*	ष *sha*	ह *ha*	ऋ *ṛ*	
IPA	**s**	**ʃ**	**h**	**ɻ̣**	