Revision and Re-Standardization of the Test of Articulation in Odia

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MANASANGOTHRI

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CERTIFICATE

This is to certify that this dissertation entitled **"Revision and Re-Standardization of the Test of Articulation in Odia"** is a bonafide work in part fulfilment for the degree of Master of Sciences (Speech-Language Pathology) of the student (Registration No. 11SLP017). 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 **"Revision and Re-Standardization of the Test of Articulation in Odia"** is the results of my own study under the guidance of Dr. N. Sreedevi, Reader in Speech Sciences, Department of Speech Language 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

Articulation refers to the totality of motor processes involved in the planning and execution of sequences of overlapping gestures that result in speech (Fey, 1992). Acquisition of articulatory skills is a developmental process of learning to move the articulators specifically and precisely for various speech sounds. Any disturbance in this could be due to a disturbance in the peripheral motor processes responsible for the movement of articulators or due to a disruption in the higher order structures or due to other perceptual disturbances. Speech is considered to be normal as long as it conveys the meaning it intends to convey and is socially acceptable. So, any slight deviations from the normal even though it conveys the meaning can be attention seeking and requires probing in by a professional. But, not all articulatory errors are misarticulations. Few patterns seen in young children are normal and can be thought of as a developmental stage in their normal acquisition of phonemes. Beyond a particular age, when such deviancies in articulatory productions are obvious, they could be called as misarticulations after testing each sound in the sound system of the language using appropriate assessment methods. One of the many methods to test articulation involves administering a standardized diagnostic articulation test. Such tests are language dependant and are periodically revised to incorporate new patterns of words used contemporarily by young children or to delete a few obsolete words absent in the children's repertoire of regularly used words.

Phonological diagnosis involves, not only just labeling the child's problems, but also understanding the child's problems, his/her strengths and weaknesses thoroughly.

Initial evaluation is carried out, mainly to ascertain the reality of the problem, to determine the causative factors, and to streamline focus to potential treatment approaches (Haynes & Pindzola, 2004). Assessment of articulation or phonology accurately involves eliciting various types of speech samples. Obtaining the speech sample, audio/video recording the child's responses, transcribing the sample, scoring and analyzing the sample are the steps involved in speech sound evaluation. The sample to be collected can be in the form of single words, phrases, sentences and conversations, and can be either spontaneous responses to picture stimuli or repetition of the clinician's model.

Formal traditional articulation tests make the use of speech sound production in isolated words mostly elicited using pictures without a model from the tester. In most tests, the singleton consonant sounds are elicited in initial, medial and final word positions, and clusters in initial word position (Gordon-Brannan & Weiss, 2007). The results are compiled in terms of the type of articulatory error (substitution, omission, distortion or addition), the word position in which the error occurs and sometimes, if the speech sample is in the form of discourse, the position of error in the sentence. Usually a norm-based scoring is followed to ascertain if a speech sound is misarticulated or not.

Picture identification tasks with or without semantic or phonetic cues though employed, should not expend much time in eliciting the target word. Instead, if the testee is unable to say the target word with one or two cues, the clinician could provide a delayed model wherein he/she says the target word immediately followed by a comment. If the testee is still not able to produce the target word, a direct or immediate model (repetition task) could be employed, keeping in mind that the ultimate goal is to enable the client to produce the word spontaneously.

The responses must be transcribed online (live) and later, be verified with the tape recording. Transcription of the speech sample can be carried out by using the correct or incorrect method (target utterance is scored to be correct or incorrect), analysis by the type of articulatory error (substitution, omission, distortion, addition) or by whole-word phonetic transcription (mostly employed for phonological process analysis). Traditional articulation tests make use of transcribing only the targeted sounds. In the present scenario, various traditional articulation tests are being used in various set ups. A few of them include the Arizona Articulation Proficiency Scale, Third Revision (AAPS- 3; Fudala, 2000), the Goldman-Fristoe Test of Articulation, Second Edition (G-FTA-2; Goldman & Fristoe, 2000), the Photo Articulation Test, Third Edition (PAT-3; Lippke, Dickey, Selmar & Soder, 1997), and the Weiss Comprehensive Articulation Test (WCAT; Weiss, 1980).

In the Indian context, diagnostic tests of articulation are available in Kannada (Babu, Rathna & Bettagiri, 1972, Tamil (Usha, 1986), Telugu (Padmaja, 1988), Bengali (Arun Banik, 1989), Malayalam (Maya, 1990), Oriya (Panda, 1991), Hindi (Deepa Shankar, 2003) and Marathi (Photo-Articulation Test funded by UNICEF, AYJNIHH, Mumbai). Over the years, there has been an obvious change in the pattern and age of acquisition of speech sounds by children. In the present scenario, children are seen to be acquiring sounds much earlier than the previously established norms (Deepa, 2010, Divya, 2010 & Usha, 2010). This brings about an essential need for revising the norms of the existing tests of articulation.

Usha Rani (2010) obtained norms for Telugu speaking children in the age range of 2-3 years and revalidated the existing norms of the Telugu Test of Articulation and

Discrimination- TTAD (Padmaja, 1988). Deepa (2010) revised and re-standardised the Kannada articulation test (Babu, Rathna & Bettagiri, 1972). The recent version is presently called as called as Kannada Diagnostic- Photo Articulation Test. Neenu (2011), Vipina (2011) and Vrinda (2011) revised and revalidated the articulation test battery in Malayalam (Maya, 1990) in children in the age range of 3-4 years, 4-5 years and 5-6 years respectively. All the studies in Malayalam language mentioned above, revised the obsolete words in the articulation test battery in Malayalam (Maya, 1990) and included more number of naturally occurring clusters in the language. The test of articulation in Oriya (Panda, 1991) consists of 84 words which test 32 consonants and 6 vowels in initial, medial and final position of words (Oriya is officially termed as Odia from November, 2011 onwards after Presidential assent and notification in the official Gazette). This test does not include clusters, nasalized vowels and long vowels which exist in the language.

Odia is the official language of the State of Odisha and is specified in the Schedule VIII of the Constitution of India. It belongs to the Indo-Aryan sub-family of the Indo-European families of languages. It has been said that Odia is reasonably free of random dialect variation and more importantly, it can boast of a fairly well established standard variety, generally spoken and understood by the educated speakers irrespective of caste, creed and location. The standard Odia is based mainly on the variety spoken around the coastal areas of Puri and Cuttack districts. The same variety is also followed in the written language. Among the major dialects of Odia, the main isoglossic divide marks the two regional dialect areas commonly known as western dialect Odia and coastal Odia. The western dialect is called as 'Sambalpuri' or 'Kosali' and is distinctively different from the coastal variety called as 'Kataki'. All other varieties of speech which have been identified as distinct varieties of Odia in the 2003 Linguistic Survey consist of a few varieties spoken largely by small, isolated backward caste and tribal groups.

Odia language consists of a total of 38 phonemes out of which 6 are vowels with their long and nasalized counterparts and the rest 32 are consonants. The phonemes fall into the categories of stops, affricates, fricatives, nasals, laterals and taps. Majority of the clusters appear in inter-syllabic position. A few initial and final clusters occur mostly in words borrowed from English or Sanskrit. The phonemes of Odia are enlisted in table 1.

Table 1

Phonemes of Odia based on Manner and Place of Articulation

Consonants		**Bilabial**	**Dental**	**Alveolar**	**Retroflex**	**Palatal**	**Velar**
Plosives	Unaspirated	**/p/, /b/**	**/t̪/, /d̪/**	--	**/ʈ/, /ɖ/**	--	**/k/, /g/**
	Aspirated	**/p^h/, /b^h/**	**/t̪^{h}/,/d̪^{h}/**	--	**/ʈ^h/, /ɖ^h/**	--	**/k^h/, /g^h/**
Affricates	Unaspirated	--	--	--	--	**/ʧ/, /ʤ/**	--
	Aspirated	--	--	--	--	**/ʧ^h/,/ʤ^h/**	--
Nasals		**/m/**	**/n/**	--	**/ɳ/**	--	--
Laterals		--	--	**/l/**	**/ɭ/**	--	--
Taps		--	--	**/r/**	--	--	--
Fricatives		--	**/s/**	--	--	--	**Glottal /h/**
Semi-vowels		--	--	--	--	**/j/**	--

-- indicates phoneme not present with that articulatory feature

Mahapatra (2007), CIIL Publication.

1.1 Need of the study: The existing test of articulation in Oriya (Panda, 1991) was developed more than two decades back. So there is a dire need to update the norms as present day children are seen to be mastering speech sounds much earlier. Further, there is a scope to include words with clusters of the language to the existing test. Studies by Deepa (2010), Divya (2010) and Usha (2010) and others have indicated that several clusters are acquired by almost 3 years of age. There is also a pressing need to revise the existing test of articulation in Oriya (Panda, 1991) for contemporary usage as a few test

words of the same could have become obsolete over the years. In addition to this, the scoring pattern of the existing test needs to be revised as it scores only the correct or incorrect responses using a "one or zero" rule. All articulatory errors need to be scored as substitution, omission, distortion or addition (SODA), in terms of gradations of error, to ascertain the severity of articulatory impairment, instead of just scoring correct productions as 'one' and incorrect as 'zero'.

1.2 Aim of the study: To revise the existing test of articulation in Oriya (Panda, 1991) and re-standardize the same on typically developing children in the age range of 2-5 years with Odia as their native language.

1.3 Objectives of the study

- To revise the test of articulation in Oriya (Panda, 1991) by including test words with clusters occurring in initial and medial positions.
- To identify and replace the obsolete words in the existing test, if found in the pilot study.
- To standardize the revised test on typically developing Odia speaking children in the age range of 2-5years.
- To delineate the order of acquisition of phonemes with age.
- To delineate the order of acquisition of phonemes according to the Manner and Place of Articulation.

- To compare the acquisition of phonemes across different word positions, age and gender abiding by the 90% criteria.

- To compare the order of acquisition of phonemes in Odia language with other Indian languages and English.

CHAPTER II

REVIEW OF LITERATURE

Articulation is the component of speech which serves as a vehicle to convey a person's thoughts, his/ her language content, what he/ she conceptualizes and his/ her views through sounds, words, phrases and sentences. In simple words, it refers to the act of adjusting and arranging the speech musculature, in addition to modifying the breath stream through the vocal tract, to produce meaningful utterances. The final act of articulation is contributed by many events. First, the vocal tract, the articulators and the intact nervous system enable an individual to execute the sensory (auditory, tactile, kinesthetic, proprioceptive) and the motor functions essential for the controlled movement. Second, the cognitive-linguistic component conceptualizes the need to "say something". This thought is processed linguistically wherein the phonological rules of one's language are applied and based on this; the phonemic elements are selected and ordered depending on the semantic lexicon, the syntax and the pragmatic context. Third, the sensorimotor-acoustic component that involves motor programming and learning of the actual sequences of physical movement of the articulators comes into play, following which, the vocal and oral cavity get activated transferring acoustic vibrations to meaningful utterances achieved by the manipulation of the oral articulatory structures (Gordon- Brannan & Weiss, 2007).

Stoel- Gammon and Dunn (1985) designate that articulatory or phonetic component of the sound system encompass (1) the method or the way of speech sound production, (2) their acoustic and physical components, and (3) their perception by the

listener. Articulation is mostly referred to the motoric movements and the way articulators are placed during the production of a speech sound. Fey (1992) entails articulation as the totality of motor processes involved in the planning and execution of sequences of overlapping gestures that result in speech. This definition of articulation suggests that the learning of articulation skills is a developmental process involving the gradual acquisition of the ability to move the articulators in a precise and rapid manner, suggesting that learning to articulate is a specific kind of motor learning. It also suggests that the errors in articulation result from relatively peripheral disturbances of these articulatory processes. Thus, it indicates that articulatory errors are caused when the peripheral motor processes responsible for the act of articulation are impaired and the central language capabilities of an individual remain intact.

Articulation disorder is a sub-category of a speech disorder characterized by atypical production of speech sounds (substitutions, omissions, additions and distortions) that may interfere with the overall intelligibility of speech. Another category of articulatory errors could happen due to an impaired comprehension of the sound system and the rules that govern the sound combination. Such a class of errors is defined as phonological disorder and is thought to be a sub-category of language disorders as opposed to articulatory errors, a sub-category of speech disorders. Cognitively or linguistically based articulatory errors (production of sound is present but the individual is unable to use the sound in appropriate contexts) are referred to as phonological disorders. Bernthal and Bankson (1998) point out: “although it is convenient to dichotomize the motor and linguistic aspect of phonology for organization purposes, normal phonologic use obviously involves both the production of sound at a motor level

and their use in accordance with the rules of the language. Thus, the two skills are intertwined and may be described as two sides of the same coin".

The effect of an articulatory disorder may not be readily evident to the listener but they could have extensive repercussion on the person's social, emotional, interpersonal, and academic and other such aspects. Because articulation is blatant, so unconcealed visibly and auditorily, a slight disruption provokes judgments and penalties by the listeners, sometimes so severe to a permanent socio-psychological impact on the speaker. Van Riper and Erickson (1996) have clearly pointed out that right from childhood; a person with articulatory disturbances could be victimized with comments, mockery, isolation, labeling, bullying and ultimately, frustration. Over the years, this frustration of not being able to communicate as precisely and as efficiently as the peer group, and as the insight towards the negative attitudes of the society grows, the person goes into a stage where he sees himself inferior to others, sometimes avoiding speaking situations or avoiding to speak that particular word which he misarticulates. Degradation in grades, depletion in personality and emergence of disruptive behaviors may become an everyday issue. Hummel and Prizant (1993) report a 50-70 % co-occurrence of speech, language and communication disorders and emotional and behavioral problems in children and adolescents in various set-ups like schools, community speech and language clinics, and inpatient as well as day treatment psychiatric settings. The exact relation between socio-emotional impairment and communication deviancies might not be clear but, it is evident that many emotional and behavioral disturbances are manifestations of the communication difficulties or disorders. If the emotional- behavioral issues are because of communication disorders, it is the role of an SLP to alleviate such disorders in early

childhood itself, provided the child has access to early intervention programs. If such issues are kept in mind, a child may grow up to a confident and efficient adult rather than growing up as an efficient yet less confident adult living life full of contempt and inhibitions.

A clinician administering and analyzing the articulatory responses of children with articulatory deficits must be aware of the developmental pattern of speech sound acquisition and mastery. The earliest age at which a child is correctly articulating a speech sound holds to be an important milestone in speech sound acquisition. However, it is practically impossible to ascertain when a particular child uttered a particular speech sound for the first time. So the concept of speech acquisition came into play. A child is said to have acquired a particular speech sound if he/ she is uttering the speech sound correctly most of the times. Customary productions refer to that part of developmental process where the child correctly articulates the speech sound more than he/ she misarticulates it (Sander, 1972). However, this concept has become obsolete now. In the recent past, the concept of articulatory acquisition and articulatory mastery are used to describe the speech sound systems.

2.1 Development of articulation

- The most significant development of articulation takes occurs between 1- 3 years of age. The first stage of development begins with birth and ends by one year when the child produces his first word utterance
- The second stage begins at around 12 months of age and continues till 18 months of age wherein the child acquires about 50 words. These toddlers have a developing

cognitive system of the mental representation of speech and produce one word utterances mostly. They may say same words differently at different instances. These toddlers are very selective of the adult like patterns they choose to use. They may also produce words with similar structural complexity differently. In some children, gradual deterioration of accurate productions occurs such that the erroneous speech sound productions are produced as consistently as the other spoken words. The presence of such a pattern of behaviors indicates that the developing child's rules linguistic system is not fully established during this stage.

- The third stage extends from 18 months to 3- 4 years. Children in this age range produce many articulatory errors which follow consistent patterns or processes. For example, at 3 years of age, a child may produce constant stopping of fricatives and/ or final consonant deletions. These processes are nothing but simplification of adult forms of words. This is the stage when children acquire mastery over phonemes in English. A large data is available on the age of mastery of English speech sounds (Poole, 1934; Prather, Hedrick & Kern, 1975; Sander, 1972; Templin, 1957; Wellman, Case, Mengert & Bradbury, 1931). Nasals are the ones to be mastered first, followed by glides and stops, and even more delayed mastery of affricates and fricatives. Attainment of mastery of vowels is achieved by 3 years of age. Children develop the concept that a change in the phonemic contrast can alter the meaning of an utterance during this period.
- The fourth stage extends from 4 to 7 years of age. The remaining phonemes are mastered during this age group. Correct production of polysyllabic words and few rules of English morphosyntax are also mastered during this age. During this last

stage, children continue to combine phonemes in different ways to alter the meaning in different context. There are different viewpoints of different researchers, a few of whose findings are summarized below.

1. Poole (1934) and Templin (1957) concluded that
    - In early years, diphthongs, vowels, consonant elements, double consonant blends and triple consonant blends are learnt and produced with accuracy in the said order.
    - Nasals are acquired first followed by stops, fricatives, combinations and semivowels.
    - The voiceless cognates are produced more accurately than the voiced sounds.
    - By 8 years of age, all sounds are produced accurately.
2. Templin (1957) tested 480 children in the age range of 3-8 years and concluded that at least 75% of the children mastered the speech sounds in initial, medial and final word positions. He tested 176 elements in 3 word positions and reported results in consensus with the findings of Wellman (1931) and Poole (1934).
3. Sander (1972) analyzed Templin (1957)'s data from a different perspective. He argued that it is unrealistic to assign sounds to age levels using three position criteria. He reassigned the sounds to age groups where they were able to correctly produce the said sound in two out of three word positions. His results were reported in two levels: 1) the age at which 90% of the children produced the sounds correctly in two out of three word positions, and 2) the age at which 50% of the children produced the sounds correctly in two out of three word positions.

4. Stoel- Gammon (1985) studied the articulatory inventory of 34 children (19 boys and 15 girls) with their ages ranging from 15 to 24 months. She investigated the range and type of meaningful phonemes elicited using spontaneous speech with 10 meaningful and identifiable words in a one hour speech sample, every 3 months (15, 18, 21 and 24 months) and concluded the following
    - /b/, /d/ and /h/ were in the inventory of 50% of the children in initial word positions by 15 months of age.
    - Along with /b/, /d/ and /h/, nasals /m/ and /n/ were present in the inventory of 50% of the children by 18 months of age. The only phoneme at this age in final word position was /t/ in 50% of the children.
    - In initial position, /b/, /d/, /h/, /m/, /n/ and /t/ were present in the inventories of 50% of the children and in final position, only /t/ and /n/ were present in the inventories of 50% of the children at 21 months of age.
    - /b/, /d/, g/, /t/, /k/, /h/, /m/, /n/, /w/, /f/ and /s/ were in the initial position inventories and /p/, /t/, /k/, /n/, /r/ and /s/ were in the medial position inventories of 50% of children, at 24 months of age.
5. Smit, Hand, Freilinger, Bernthal and Bird (1990) present normative of 1049 children from Iowa and Nebarska in the age range of 2-9 years. Their results were as follows
    - Girls acquired sounds earlier than boys, although this reached statistical significance only by 6 years of age.

- The phonemes /m/, /n/, /h/, /p/, /f/, /w/ and /b/ were acquired by 3 years of age.
- The phonemes /l/, /tʃ/, /k/, /g/, /j/, /d/ and /t/ were acquired by 7 years of age.
- The phonemes /ng/ and /s/ were acquired by 7- 9 years.

6. Watson and Scukanec (1997) profiled the phonological abilities of children in the age range of 2-3 years (3 months interval) and concluded that
    - At 2.0 years, /p/, /t/, /k/, /b/, /d/, /m/, /n/, /s/, /h/, /w/ and /j/ were acquired in initial word position, and /p/, /t/, /k/, /m/, /n/, /s/, /z/ in final word position.
    - By 2.3 years, /f/ and /l/ in initial position and /d/ in final position were also acquired.
    - By 2.6 years, in initial position, /g/, /tʃ/, clusters /pw/ and /bw/, and in final position, /l/, /r/, clusters /nd/ and /ts/ were acquired.
    - By 2.9 years, clusters /pl/ was acquired in initial position. In final position, /nt/ and /nz/ were acquired.
    - By 3.0 years, /ð/ was added up to the existing phonetic repertoire along with clusters /st/ and /sp/.
7. McLeod, Doorn and Reed (2001)

    The authors reviewed studies conducted on acquisition of consonant clusters in English from literature of seven decades and concluded the following
    - Two- year old children can produce consonant clusters but these might not be similar to the ambient language.

- Two-element consonant clusters are acquired and mastered before three-element consonant clusters.
- Consonant clusters containing plosives (e.g., /pl/, /kw/) are acquired earlier than clusters containing fricatives (e.g., /st/).
- Young children typically delete one element of a consonant cluster (cluster reduction).
- Types of erroneous production of clusters are many, and the most common among them is cluster simplification (epenthesis, coalescence). Metathesis is rarely seen.
- The acquisition of consonant clusters is a gradual process and follows a typical developmental sequence. It is not an 'all-or-nothing' process.
- Initially cluster reductions are observed in children. Over time, the number of cluster reductions reduces and the frequency of occurrence of cluster simplification increases.
- Despite developmental trends, individual variations do exist.

8. Dodd, Holm, Hua and Crossbie (2003)- 90% criteria
    - By 3.0-3.5 years, plosives (/pt, /t/, /k/, /b/, /d/, /g/), nasals (/m/, /n/, /ŋ/ and fricatives (/f/, /v/, /s/, /z/, /h/) are acquired.
    - By 3.6-3.11 years, approximants (/w/, /l-/, /j/) are acquired.
    - By 4.0-4.5 years, fricative/z/, affricate /ʧ/ and/dz/ are acquired.
    - By 5.0-5.5 years, fricative /ʃ/ is acquired.
    - By 7 years and above, fricative /Θ/ and /ð/are acquired.

The above mentioned studies cannot, however, be utilized to compare when assessing Indian children for their phonological repertoire as they belong to a multicultural and multilingual locale, and are, and mostly exposed to more than one language right from a very young age. Keeping these issues in mind, several studies have been conducted in the Indian context to study the age of acquisition and the age of mastery of speech sounds. Such studies have been embarked on in Kannada, Telugu, Malayalam, Tamil, Hindi, Bengali, Odia, Marathi, Gujarati and various other languages.

2.2 Articulatory Acquisition Studies in the Indian context

In ***Kannada***, one of the earliest attempts to develop a test of articulation in Indian languages was by Babu, Rathna and Bettagiri (1972) when they developed the test of articulation in Kannada. They, however, did not standardize the test. Sreedevi (1976) tested 4 children (2+years of age) and conducted an observational study where the children were tested four times during the course of the study at equal intervals in terms of their age, between two subsequent recordings. She summarized as follows-

- Voiced voiceless distinction was acquired prior to aspirated unaspirated distinction
- The distinction between short and long vowels was acquired and stabilized by 2.6 years of age
- Stops acquired more fully than sibilants, trills and laterals

- Among nasals, bilabial and alveolar nasals were acquired earlier than other nasals
- Among the sibilants, the alveolar and palatal sibilants were acquired earlier than retroflex ones
- Identical clusters were acquired earlier than non- identical clusters

Following this, Tasneem Banu (1977) made use of the Kannada Articulation Test developed by Babu, Rathna and Bettagiri (1972) and standardized the same on 180 Kannada speaking children in the age range of 3-6.6 years and concluded that

- Articulatory patterns varied significantly across different age groups
- A gradual but definite change from age to age
- Fricative /h/ not acquired even by 6.6 years of age
- No significant gender difference

Various other studies to ponder upon the phonological processes in Kannada speaking children have also been carried upon in the recent past. Sreedevi (2008) studied 8 children in the age range of 1.6 to 2 years and reported retroflex fronting (substitution of retroflex sounds by easier dentals) to be the most dominant phonological process during this age range along with several other processes like initial consonant deletion, vowel lowering, trill deletion, cluster reductions, etc. In another study, Sreedevi & Shilpashree (2008) studied the phonological processes occurring in children in the age range of 2.6 – 3 years and concluded that by this age, retroflex fronting is reduced and children are able to produce most of the phonemes including fricatives and trills by the age of 3

years and draw future researchers the need to revise the existing articulatory norms in Kannada.

Almost after 3 decades that the KAT was standardized, Prathima (2009) studied the articulatory acquisition patterns of urban Kannada speaking children in the age range of 3-4 years. She concluded that

- Vowels and most of the consonants except /r/, /h/, /ʃ/, retroflex /d/ and retroflex /l/ were acquired by 3- 3.6 years of age
- Nasals, semivowels /v/ and /j/, affricates / tʃ/, and /dʒ/ were acquired by 90% of the children by the age of 3- 3.6 years
- Glottal fricative /h/ was not mastered even by 75% of the children by 4 years of age
- Dental /s/ (I and M positions) and palatal /ʃ/, (word initial position) were reported to be acquired by 90% of the children by 4 years of age
- Retroflex /l/ was acquired by the age 3.6- 4 years in 90% of the girls and 84% of boys
- Medial clusters (/ski/ and /kra/) were acquired earlier than initial clusters in accordance with a previous study by Vani Rupela and Manjula (2006) where in, medial clusters were the first to appear by the age of 18- 24 months.

Deepa (2010) revised and re-standardized the earlier Kannada Articulation Test (Babu, Rathna & Bettagiri, 1972) and developed a picture form test which is now called as Kannada Diagnostic- Picture Articulation Test (KD- PAT). She

tested 240 urban Kannada speaking children in the age range of 2- 6 years and concluded that

- All bilabials, labiodentals, dentals and velars were acquired by 2.6- 3 years and palatals by 3.6- 4 years
- Glottal /h/ was not acquired even by 6 years of age
- Retroflex /ḍ/ was acquired much earlier than /ṭ/
- All the vowels and diphthongs were mastered by 90% of the children by 2- 2.6 years and were achieved by 100% of the children by 3 years of age
- All the stops were acquired by the age of 3- 3.6 years
- Fricatives /s/ and /ʃ/ were 4- 4.6 years and 3.6- 4 years respectively
- Most of the clusters were acquired by 4- 4.6 years

In ***Tamil*** language, Thirumalai (1972) studied the articulatory acquisition pattern and concluded that

- All the vowels and consonants (except /s/, /l/ and /r/ were acquired by 3 years of age
- Fricative /s/ was not acquired even by 6 years of age
- All the stops were acquired by 3 years of age and retroflex /t/ was acquired earlier than the established western norms
- All the nasals were acquired by 3 years of age
- Among laterals, /l/ was acquired by 3 years of age, but not consistently produced until 6 years of age
- /r/ occurred in medial and final position by 5 years but not in initial position until 6 years which is late as compared to other languages

Usha (1986) developed the Tamil Articulation Test (TAT) and standardized the same on 180 Tamil speaking children in the age range of 3- 6 years and concluded that

- There was a significant difference between males and females in terms of articulatory skills
- All vowels and most of the consonants except /s/, /l/ and /r/ were acquired by 3 years of age
- Voiceless retroflex /t/ acquired much earlier than the Western norms
- All nasals acquired by 3 years of age
- Flap /r/ was not acquired even by 6 years of age which is significantly late than that indicated in other studies

Such studies in ***Telugu*** include Padmaja (1988) who developed the Test of Articulation and Discrimination in Telugu and studied the articulatory acquisition pattern in 160 Telugu speaking children in the age range of 2.5 to 4.5 years. She concluded that

- There is no significant difference between males and females on articulatory proficiency
- All vowels and most of the consonants except /r/, /s/, /ʃ/, /t/, /d/ and aspirated stops were acquired by 2.5 years of age
- All nasals were acquired by 2.6 years of age
- /s/, /r/, /l/, retroflex /ɭ/ and aspirated consonants were acquired by 3.3 years of age

- Phonemes /ʈ/, /ʃ/ and clusters were acquired by 3.5 years of age

Neethipriya (2007) studied phonotactics and acquisition of clusters in typically developing Telugu speaking children in the age range of 3-6 years. She concluded that

- Medial clusters occurred with a frequency of 60- 70% in this age range and among the medial clusters, 30- 40 % were geminated clusters.
- Medial non- geminate clusters occurred with a frequency of 45- 55%. Nasal plus homorganic stops (/nt/, /nd/, /nk/, /mt/, etc) were predominantly observed in samples following fricatives plus plosives combinations.
- Three consonant clusters were rarest to occur in the age range of 3- 6 years.

Usha Rani (2010) tested four consonant clusters in Telugu in 2-3 year old children and concluded that none of the clusters were acquired with 75% accuracy even by 3 years of age in both the genders. However, all clusters crossed 60% by 3 years of age.

Sneha (2012) studied acquisition of clusters in 120 typically developing Telugu speaking children in the age range of 4-6 years and reported that

- Medial clusters are acquired earlier than initial clusters
- Clusters were produced more correctly in word repetition task when compared to picture description task

- The acquisition of clusters is a gradual process and follows a typical developmental sequence.
- In repetition task, by 6 years of age, 3 initial and 6 medial clusters were mastered whereas in picture description task, 4 initial and 8 medial clusters reached the target criteria and in story telling task, 2 initial and 5 medial clusters reached the target criterion.

In ***Malayalam*** language also a few studies have been conducted to embark on the articulatory acquisition in children. One of such preliminary attempts was undertaken by Maya (1990) who developed and standardized the Malayalam Articulation Test and concluded that

- Articulatory scores increased as age increased, but even at 7 years of age, 100% scores were not achieved
- Females had greater articulatory scores than males
- All the vowels were acquired by 3 years of age
- Most of the consonants except fricative /s/, tap /r/, trill /r/, lateral /l/ and aspirated phonemes, were acquired by 3 years of age
- The acquisition was in the order of unaspirated stops followed by fricatives, affricates and aspirated stops
- Compared to other studies, the articulatory acquisition was earlier in Malayalam speaking children than non- speakers of Malayalam

Divya (2010) studied the acquisition patterns in Malayalam speaking children in the age range of 2- 3 years and concluded that

- All vowels except /u/ and /u:/ were acquired by 2.3 years.

- By 2.6 years, these two vowels reached 90% criteria.
- Unaspirated sounds were acquired earlier than aspirated sounds.
- Bilabials, labiodentals, dentals and velars were acquired earlier than alveolars, palatals, retroflex sounds and glottal.
- None of the clusters reached 90% criteria by 3 years of age.

Neenu (2011), Vipina (2011) and Vrinda (2011) revised and revalidated the Malayalam Diagnostic Articulation Test (Maya, 1990) in the age range of 3-4 years, 4-5 years and 5-6 years respectively. They also added initial and medial clusters to the existing test. The findings of their studies are as follows

Neenu (2011) reported that (3-4 years)

- All vowels are acquired by 3-3.3 years of age
- Most consonants acquired 100 % criteria by 4 years of age.
- None of the clusters reached 90% criteria by 4 years of age but a few medial clusters reached 90% criteria by 3.3 years of age itself
- Children acquired bilabials, labiodentals, dentals and velars earlier when compared to alveolars, palatals, glottal and retroflex sounds.
- Unaspirated sounds were acquired earlier than aspirated sounds.
- Fricatives, trill /R/, lateral /l/, /ɭ/ and aspirated /k^h/, /b^h/, /d^h/ did not reach 100% criteria even by 4 years of age.

Vipina (2011) reported that (4-5 years)

- All aspirated phonemes and a few unaspirated phonemes like /ŋ/, /ɖ / and /h/ were not achieved by this age.

- When compared to subjects of lower age groups (Neenu, 2011), more initial and medial clusters were achieved by children according to the 90% criteria.

Vrinda (2011) reported that (5-6 years)

- The consonants not achieved even by 5.3 years included aspirated phonemes and dental /d̪/ and glottal /h/ in medial position.
- By 6 years of age, most of the initial as well as medial clusters met the 100% criteria.

Among the Indo- Aryan languages, studies have been conducted in Hindi, Marathi, Gujarati, Bengali, Odia, etc, a few of which are summarized below.

In Bengali, Arun Banik (1988) developed the diagnostic test of articulation in Bengali and reported

- Existence of a definite pattern of acquisition of sounds
- Earlier acquisition than English speaking children
- Females superior than males in terms of articulatory abilities
- All the vowels acquired by 2.5 years
- Most of the consonants (except /ʤʰ/, /r/ and few consonant clusters) were acquired by 3 years of age
- Most misarticulations were in terms of substitution or omission; addition and distortion were rarely seen

Animesh Barman (1991) constructed the Deep Test of Articulation in Bengali- Picture Form and concluded that

- Articulation of speech sounds improve with age.

- On task analysis, it was observed that /r/ and /ɖ/ were the most difficult sounds to produce.
- Ease of production was better in an environment of voiced consonants when compared to voiceless consonants. Trills and fricatives were the most difficult to be produced.

In Hindi, Deepa (1998) developed the Deep Test of Articulation in Hindi-Picture Form and administered the same on 120 Hindi speaking typically developing children in the age range of 3-7 years. She summarized that

- Articulation skills increase with age till 5 years.
- The environment with aspiration was most difficult to produce.
- By 5 years of age, children articulated all phonemes correctly.
- On item analysis, it was found that /ɖ/, /ɖ^{h}/ and /ʈ^{h}/ were the most difficult to articulate.

Panda (1991) developed the Test of Articulation in Oriya and administered it on 120 Odia speaking children in the age range of 3-6 years. His findings are summarized below.

- Significant difference between boys and girls in terms of articulatory proficiency
- All vowels and consonants except /s/, /r/ and aspirated stops were acquired by 3 years of age
- Aspirated stops were acquired later (5-6 years) than other languages (except Malayalam)

- Order of acquisition follows the trend unaspirated stops followed by fricatives, aspirated stops and last to develop were affricates

2.3 Assessment of Phonology

Diagnosis of phonological disorders involves, not only labeling the child's problems, but also understanding the child's problems, his/her strengths and weaknesses thoroughly. Initial evaluation is carried out, mainly to ascertain the reality of the problem, to determine the causative factors, and to streamline focus to potential treatment approaches (Haynes & Pindzola, 2004). Several factors must be kept in mind before initiating the process of assessment of articulation and phonological disorders. These can be considered as the critical pre-requisites for performing a diagnostic evaluation.

- Knowledge of the Anatomy and Physiology of the Speech Mechanism
- Knowledge of Phonetics
- Knowledge of Phonological Development
- Knowledge of Factors Related to Articulation Disorders
- Knowledge of Dialectal Variations
- Knowledge of Coarticulation
- Knowledge of Linguistic- Articulatory Connection

The main purpose of an assessment of articulation or phonological disorders include

- Description of the articulatory- phonological development and the current status of the individual

- Determination and careful discretion whether the individual's speech is sufficiently deviant from the normal and requires concern or intervention
- Identification of factors that relate to the presence or maintenance of the speech disorder
- Determination of the course or treatment
- Decision regarding prognostic judgments about an improvement in articulatory-phonological skills with and without intervention
- To monitor changes in the articulatory- phonological performance over time (Bernthal & Bankson, 2009)

Assessment of phonological or articulation disorders usually begins with a detailed case history and ends with the administration of a standardized articulation test, its scoring and interpretation. Earlier versions of the various tests in articulation tested

Skahan, Watson and Lof (2007) inspected the assessment procedures employed by randomly selected SLPs to assess children with **suspected Speech Sound Disorders (**SSDs**)** using survey method. They concluded that most frequently, SLPs used commercially available articulation tests, estimated their intelligibility, assessed their stimulability and conducted an auditory screening to ascertain the intactness of auditory perceptual skills. Among the various types of articulation assessment procedures, the traditional procedure is the most common. It holds that each phoneme of a language must be tested in the initial, medial and final positions of words. Typically, these words are elicited from the client by the help of pictures, word lists, sentences, or conventional sampling. Several studies in the past have indicated that children tend to produce more singleton consonants correctly in single-word sampling contexts than in connected speech

on traditional testing from the viewpoint of articulation as opposed to phonological process analysis where no significant difference was observed between single- word sampling and connected speech analysis. Mostly, in developmental phonology, single word articulation tests are being used since many decades, where responses are elicited as single words, called as citing, more than conversational sampling even though many differences exist in both the methods of data elicitation (Morrison & Shriberg, 1992).

The same authors reviewed literature on methods of articulation sampling as a part of their study "Articulation Testing versus Conversational Speech Sampling" and stated that sample sizes varied from 1 to 240 and the children's age varied from under 3 to above 12 years. Most studies which have used citation as the mode of response elicitation have used spontaneous rather than imitative responses. Since, single word articulation tests use standard picture stimuli for each subject, the variability reduces. However, even the size and color of the picture stimulus is shown to produce more variance in the results (Bernthal, Grossman & Goll, 1989). Wolk and Meisler (1998) compared two methods of phonological assessment: conversation and picture naming. They reported that although both methods of speech sample elicitations are useful clinical tools for SLPs, picture naming taps a child's phonological system more deeply and extensively, and represent the index of phonological abilities in a better way. In the context of severity of involvement, more articulatory errors were observed in talking compared to citing, but severity ratings were similar or lesser when using citation forms (Andrews & Fey, 1986; Dubois & Bernthal, 1978; Faircloth & Faircloth, 1970, Klein, 1984). Although citation form (single word elicitation) testing might not provide overall information about a child's speech sound production system when compared to

connected speech sampling (Andrews & Fey, 1986; Bernhardt & Holdgrafer, 2001a; Morrison & Shriberg, 1992), several disadvantages of connected speech sampling compel the SLPs to rely on single- word articulation tests not only to identify the children having speech sound difficulties (SSDs) but also to analyze productions and to determine goals (Hodson, Scherz & Strattman, 2002; Khan, 2002; Tyler & Tolbert, 2002).

Bernthal and Bankson (2009) pronounce that a clinician employs several assessment instruments and sampling procedures when carrying out a phonological analysis as a single assessment procedure might not provide all that is required to make a diagnosis and, to ascertain the need and direction of effective intervention. A phonological evaluation typically includes collecting speech sample of varying length (e.g., syllables, words, phrases), phonetic contexts, and as a response to various elicitation procedures (e.g., picture naming, imitation, conversation). This assortment of samples is frequently referred to as an assessment battery. The authors suggest a comprehensive phonological evaluation battery which include the following

1. Collection of Phonological Samples (connected/ conversational speech sampling, single- word or citation form sampling, stimulability testing, contextual testing)
2. Selection of Phonological Assessment Instruments
3. Transcription and Scoring Responses
4. Case History, Examination of Oral Cavity, Audiological Screening

2.4 Collection of Phonological Samples for Assessment

2.4.1 Connected/ Conversational Speech Sampling

This method of sampling holds that since the eventual goal of phonological intervention is accurate production of sounds in spontaneous conversation, it is essential for the examiner to observe sound patterns in speaking situations mimicking natural conversations. This allows the tester to observe the sound productions in a variety of phonetic contexts, to observe error patterns and to ascertain severity of the problem and overall intelligibility in discourse.

2.4.2 Single- Word or Citation Form Sampling

Citation forms enable an examiner to obtain discrete, identifiable units of production which they can easily transcribe. These are quicker and have a better ease of transcription as the examiner already has an idea of what the examinee is going to say. When sampling single words, only one or two consonants are targeted and scored in a word in various positions (initial, medial and final). The customary way of elicitation is through single word articulation tests, generally called as speech sound inventory. These, generally, help elicit words with consonants, consonant clusters, vowels and diphthongs.

2.4.3 Stimulability Testing

This process involves the testee's ability to repeat the target utterance correctly when provided with a model. Basically, it tests how well a client imitates, in one or more phonetic contexts (isolation, syllables, words, phrases, etc.), sounds that were produced erroneously during testing. This method is basically used (1) to determine if a sound is liable to be acquired without intervention, (2) to decide the level and/ or type of production at which training might begin, (3) to predict the occurrence and nature of generalization. The sample is elicited by asking the client to look at the examiner's mouth, listen to what he/ she says and imitate the target stimulus.

2.4.4 Contextual Testing

This method helps solving issues of inconsistency of errors as seen, mostly, in children. Knowledge of the consistency of phonological errors is essential to decide which phoneme or sound pattern to work on in therapy or to decide a particular phonetic context that may facilitate accurate sound production. Administering a deep test of articulation is one of the methods of collecting samples in different contexts.

2.5 Selection of Phonological Assessment Instruments

These include formal articulation tests which should be appropriate for the individual being tested and should provide the information desired by the clinician. Few factors like nature of the stimulus material, the scoring system, and the type of analysis facilitated by the test must be considered. The variables which need to be taken into consideration while selecting a test instrument to include in the battery are

2.5.1 Sample Obtained: This depends on the adequacy or representativeness of the speech sample obtained. Variables to consider include the specific consonants, consonant clusters, vowels and diphthongs tested, as well as the units in which sounds are to be produced (i.e., syllables, words, sentences). In addition, stimulus presentation and type of sample elicited (e.g., picture-naming, sentence completion, imitation, delayed imitation and sentence completion) should also be considered)

2.5.2 Material presentation: Size, familiarity, and color of stimulus pictures and appropriateness to the age of the client facilitate the ease with which the test can

be administered and analyzed. Tests with familiar and attractive stimulus items and score sheets that facilitate analysis are desirable.

2.5.3 Types of Analysis: Phonetic and/or phoneme analysis of consonant and vowel sounds of the language, sound productions in initial, medial and final words positions, place, manner, voicing analysis, phonological process analysis, age appropriateness of phonological productions, speech sound stimulability.

2.6 Transcription and Scoring Responses

The recording and scoring systems vary across clinicians and may range from very simple, scoring the phonological productions as correct or incorrect, to giving credits for each type of articulatory or phonologic error (substitution, omission, distortion and addition). The collected sample then has to be transcribed using International Phonetic Alphabet (IPA); referred to as broad transcription system, or supplemented by diacritic markers, referred to as narrow transcription system.

2.7 Analysis and Interpretation of responses

Once the speech samples have been collected and transcribed, the clinician has a pool of data which needs to be analyzed. The information about sound system errors can be analyzed using two ways (Stoel- Gammon & Dunn, 1985) - In **Independent Analysis,** the child's utterances are described without reference to an adult model. Rather, the child's phonetic inventory is examined according to their position of occurrence and articulatory features. In this process, the child's productions are not described in terms of errors. The clinician makes a note of what the child can produce. In **Relational Analysis,** the child's speech sound productions are compared to the adult forms. Through this method, a clinician can perform a traditional sound-by-sound analysis, a manner-place-

voicing (MPV) analysis, a distinctive feature analysis, and a phonological process analysis.

2.7.1 Traditional analysis

This involves examining the occurrence or speech sound errors in different word positions (initial, medial and final), and the type of errors made (SODA). This method is most appropriate for children with lesser number of errors and with a fairly good intelligibility. This deals with phonetic problems rather than phonological problems. Though a traditional approach, clinicians still widely use this method of analysis because of its concise and quick nature.

2.7.2 Error Pattern Identification

Also called as phonological process analysis, is mostly used with clients who present multiple speech sound errors. A few reasons why this process is used are as follows, (1) they provide an overall description of the child's phonological system, (2) it facilitates treatment efficacy by targeting a phonological pattern rather a single speech sound, providing a heightened scope of better generalization.

2.7.3 Distinctive Feature Analysis

Using this method of analysis, children's multiple misarticulations are grouped according to the presence or absence of certain features called as distinctive features. This is generally not employed because of its complexity and disputed clinical relevance. Out of the numerous methods of elicitation of phonological samples, citation forms are mostly used because

- They are more time efficient in enabling elicitation of consonants and vowels in different word positions.

- The clinician knows what the child is going to say, so transcription and comparison with similar adult form become easier (Burnhardt & Holdgrafer, 2001a, Velleman, 1998).
- The availability of norms for single word standardized articulation tests could be one of the most compelling reasons for SLPs to choose citation over spontaneous speech sampling.

As obvious, connected speech sampling is a tedious process and is mostly not used for the following reasons

- Some children may be hesitant to talk and this would lead to loss of time and difficulty in collecting a sample sufficient enough to analyze the speech errors.
- Transcription of conversation sample requires a lot of time which might not be available in many clinical set-ups. Hence, Hodson et al. (2002); Khan (2002); Tyler & Tolbert (2002) advocate the use of single word citation forms for more time efficiency.
- Transcription of speech by children with severe unintelligibility might not be possible because the target word itself might be unidentifiable (Shriberg et al., 1997; Stoel- Gammon & Dunn, 1985).
- Also, as children have the independence to choose 'what to talk' in their spontaneous speech, they might avoid difficult words and this might lead to decreased range of word shapes produced or attempted (Ingram, 1989; Stoel-Gammon & Dunn, 1985).

Formal assessment of an individual's speech sound system includes administration of formal articulation/ phonological tests. Formal tests can be categorized into three types, most of which are standardized on a large pool of data: (1) Traditional articulation tests, (2) Combined articulation and phonological tests, and (3) Phonological tests. Most of these tests are norm- based and standardized on children up to 8-9 years of age, but this doesn't bar an SLP against administering to individuals above this age range. They can still be tested with these tests but instead of comparing with the norms based on children, they should be compared to the adult speech in the respective linguistic community.

Even though the stimulus data for analysis might range from single words to connected speech, a clinician's focus would be towards finding the articulatory errors in terms of substitution, omission, distortion and addition of phonemes in different word positions. Several standardized tests are available for this purpose. A few of the traditional articulation tests in English are the Arizona Articulation Proficiency Scale, Third Revision (AAPS- 3; Fudala, 2000), the Goldman-Fristoe Test of Articulation, Second Edition (G-FTA-2; Goldman & Fristoe, 2000), the Photo Articulation Test, Third Edition (PAT-3; Lippke, Dickey, Selmar & Soder, 1997), the Templin- Darley Test of Articulation; Templin & Darley, 1969) and the Weiss Comprehensive Articulation Test (WCAT; Weiss, 1980). These tests sample utterances in single- words, conversations, contextual testing or stimulability testing. Data is analyzed mostly for SODA errors, phonological processes, etc. Phonemes are tested for accuracy in word initial, medial and final positions. In case of continuous speech sampling, only the target words are transcribed and analyzed for ascertaining the error patterns. These traditional articulation

tests follow a norm based protocol wherein the child tested is compared against his peer group for his articulatory skills. Another similarity of these traditional articulation tests is that all these tests believe in acquiring a phonetic inventory from the child, basically for the purpose of comparison with norms. Most of these normative studies are based on traditional assessment principles and report phoneme productions in initial, medial and final word positions (Poole, 1934; Sander, 1972; Prather, Hedrick & Kern, 1975).

2.8 Salient Features of few Traditional Articulation Tests (Beyond late 90's)

The Arizona Articulation Proficiency Scale, Third Revision (AAPS- 3; Fudala, 2000): It consists of 42 line- drawn picture cards, list of words and optional picture cards for spontaneous speech. The salient features are word reading list for older examinees, language screening task, spontaneous speech task, total score to reflect frequency of occurrence of error sounds (100 minus frequency of occurrence value of misarticulated sounds).

The Goldman-Fristoe Test of Articulation, Second Edition (G-FTA-2; Goldman & Fristoe, 2000): Its stimuli are presented in the form of picture plates and verbal prompts. A striking feature of this test is that the responses in terms of word positions are color coded which allows easy comparison across different word positions, response form allows for easy comparison of three types of samples; story telling task enables informal screening of expressive language.

The Photo Articulation Test, Third Edition (PAT-3; Lippke, Dickey, Selmar & Soder, 1997): It groups sounds by age at which 90% of the sample are correctly

articulates by the testee. It also provides a supplementary word list to check the child's ability to produce similar phonemes in other words.

2.9 Salient Features of Standardized Tests using both Phonetic as well as Phonological Deviation Analysis

Clinical Assessment of Articulation and Phonology (CAAP), Secord and Donohue, (2002): Yields a critical difference score, five foam stimuli figures, checklist for scoring phonological processes

Computerized Articulation and Phonology Evaluation System (CAPES), Materson and Bernhardt, (2001): Dialect filters for African American English and Spanish- influenced English; provides treatment suggestions; can record productions for later review; administered and scored by computer program and yields a wide variety of independent and relational analyses.

Smit- Hand Articulation and Phonology Evaluation (SHAPE), Smit and Hand (1997): Multiple exemplars of frequently used phonemes and clusters; checklist transcription (i.e., response form includes likely substitutions and narrow transcription descriptors); provides information on age of acquisition of consonants, presence or absence of phonological processes, and criterion scores indicating possible speech disorders; generates an independent analysis (phonetic inventory and list of syllable structures) and a relational analysis (phoneme- by- phoneme comparison with adult system and a list of phonological processes used)

Structured Photographic Articulation Tests II (SPAT- D II), Dawson and Tattersall (2001): Provides analysis of errors according to syllabic function and manner of articulation, consonant inventory, percentage of consonant correct, word shapes, sample word repertoire, tables and explanation of dialectal variations; color- coded response from word position.

As clinicians, we rely a lot on the test material that is used. Mullen and Whitehead (1977, 2003) compared the Goldman- Fristoe Test of Articulation (GFTA) and the Arizona Articulation Proficiency Test (AAPT) for the correctness of responses elicited using the picture cards for the target words. On administering the parts of the tests which make use of picture stimuli to elicit consonants and consonant blends, on 20 normal speaking and 20 articulation defective children, they observed that even though GFTA has lesser picture stimuli, it required more time for administration. The authors, in their study "Stimulus Picture Identification in Articulation Testing" attributed the increase in response elicitation time because of ambiguity of test stimuli or pictures which represent the target word which would have led the examinee to keep guessing till he/ she produced the expected word, in agreement to a previous investigators (Shanks et al., 1970; Nichols, 1967) who have also reported ineffectiveness of certain picture stimuli in articulation tests, to elicit initial correct responses.

Owing to this hitch, Shanks, Sharpe and Jackson (1970), in their study "Spontaneous Responses of First Grade Children to Diagnostic Picture Articulation Tests" compared four commonly used diagnostic articulation tests (Look and say, Montgomery, 1958; AAPS, Barber, 1963; TD-DAT, Templin & Darley, 1960; Photo Articulation Test, Pendergast, 1965) for the effectiveness of these tests in terms of the

number of correct responses the pictures could elicit. The common items, 53 in number, were chosen from each test and compiled according to the Milisen's (1954) form. The authors concluded that the pictures of PAT were capable of eliciting more correct spontaneous responses when compared to the other three tests. They attribute this difference to the usage of colored photographs in PAT which the children were better able to correlate with real objects than simple black and white line drawings. So, the authors advocate testing the pictures used in articulation tests for their effectiveness in elicitation of exact target stimulus word for stringent usage of time.

2.10 Construction of Diagnostic Articulation Tests: To serve the purpose of diagnosis, a diagnostic articulation test ought to be brief and precise keeping in mind the patient load and time constraints in routine clinical set-up. So, while constructing a test of articulation, the ease of test administration, scoring and analysis, and the time effectiveness of the test material must be kept in mind. It usually follows two stages

1. Ascertaining the language in which the test of articulation has to be constructed, the inventory of phonemes of the language and the basic phonemic alignment of the language in terms of occurrence in word positions (initial, medial and final)
2. Choosing picturable, unambiguous and familiar words with all the phonemes of the language in all naturally occurring word positions. , Babu, Rathna and Bettagiri (1972) selected 372 words, Padmaja (1988) opted to choose 283 words, Maya (1990) initially selected 350 words, Usha (1986) used 218 words with all naturally occurring phonemes in Kannada, Telugu, and Malayalam and Tamil languages respectively. While restandardizing the test of articulation in Kannada, Deepa (2010) used 485

words. The authors advocate that there be at least 5 words with each phoneme in each natural word position of the language it tends to test.

3. Familiarization of the selected words with a number of adult native speakers of the language to determine the existence of the word in the language and its usage in day to day conversation. The task employed is generally to judge if a word is most-familiar, familiar or unfamiliar in the language. Out of all the words, the words rated as most familiar by more than 50% of the judges (usually odd numbers are preferable for ease) are listed out and among these, the words which are better in terms of picturability, non-ambiguity and familiarity with children or the population the articulation test intends to test are chosen as stimuli words of the test of articulation.
4. The next step is to pictorially represent the stimuli words. In former days, simple line drawings were employed to elicit spontaneous naming of the stimuli words. Shanks, Sharpe and Jackson (1970) and several others support that colored pictures or photographs are better as the 3-Dimensional nature of the same help children correlate better with images of real objects when compared to line drawings of the same. Once the pictures are selected, they are stacked in the form of 3”X4” cards or computer based program modules such as PowerPoint slides, photo gallery, etc depending on whether the test is manual, computerized or semi- computerized.
5. The test is now ready to administer with a pre-decided scoring pattern, way of transcription and analysis.

Various computerized tests of articulation are also available in the present scenario. These are mostly used for phonological analysis purpose and the process is called as computer assisted phonological analysis. Buder (1998) pointed out that such

computer based programs save time and provide greater detail of analysis than one could possibly do manually. Computer phonological analysis (CPA) software involves proving an input of phonetic transcriptions from a computer keyboard and/ or selecting from predetermined stimuli, displaying the data on the screen, and ultimately printing results of an analysis. Analyses often include both relational and independent analyses of consonants and vowels, word position analysis, syllable shapes used, patterns among errors, and calculation of percentage of consonants correct. A few of such computer assisted tools of phonetic/ phonemic analysis are as follows

- Programs to Examine Phonetic and Phonological Evaluation Records (PEP-PER), Shriberg (1986)
- Interactive System of Phonological Analysis (ISPA). Masterson and Pagan (1993)
- The Computerized Articulation and Phonology Evaluation System (CAPES), Masterson and Bernhardt (2001)
- Computerized Profiling (Version CP941.exe.), Long, Fey and Channell (2002)
- Hodson Computer Analysis of Phonological Patterns (HCAPP). Hodson (2003)

Among the various computerized tools to elicit and analyze phonological productions, the Computerized Articulation and Phonology Evaluation System (CAPES) is one. It was developed by Materson and Bernhardt (2001) and elicits 47 single word responses through digitized photographs presented on the computer. Responses can be

recorded by tape or online recording methods. At the end, output is received by the clinician and it reflects the client's misarticulations in terms of substitutions, omissions and distortions for each consonant and consonant sequence in word initial, medial and final positions. Analyses that describe the client's productions in terms of word length, syllable stress, word shape, place- manner- voicing features, and phonological processes/ patterns can also be generated. On the basis of this, the computer program also suggests treatment goals which the clinician may adapt for intervention.

In the Indian context, Ramadevi (2006) developed a phonological profile in Kannada for children with hearing impairment. This module assists in computerized presentation of stimuli. Responses are transcribed manually using broad transcription. Sreedevi and Merin (2011) developed the Computer based Assessment of Phonological Processes in Malayalam (CAPP- M) which uses dotnet framework and can run on any computer which is preloaded with this software. CAPP- M displays the stimulus in the form of colored pictures and the correct target utterance printed in IPA below it and automatically assesses the phonological processes in Malayalam speaking children in the age range of 2- 3.6 years. It also portrays three possible erroneous productions and an extra option to include any unspecified production under the head of "others". This also gives a scope of analysis and at the end, depicts the phonological processes the child manifests along with its frequency of occurrence.

Though computer based phonological assessment has set its roots in clinical assessment procedure, it still has to be popularized and be used on a large scale. As of now, "paper pencil" tests are being used by many SLPs worldwide. The test material of an articulation test is much more than just a stack of picture cards representing the stimuli

to test a phoneme in different word positions. Administering a test requires a lot more than just eliciting the speech sample from the child. Articulatory changes occur so fast and are so transient that a clinician must be careful and fast enough to capture the articulatory changes and must have a very good discretion so as to make judgments regarding the correctness of a particular stimulus. Winitz (1969) advocates that SLPs' judgments are fairly reliable in binary decision making tasks where they just have to predict if an utterance is produced correctly or incorrectly. But the reliability deteriorates while the challenge is to make finer decisions like the nature of articulatory error, the context in which the articulatory errors occur, the consistency with which they are produced and so on. This can be improved if the clinician thrives to practice, develops the habit of rechecking and most important, if the clinician builds on to careful and assertive listening of the client's responses.

As seen above, the tests of articulation have been developed and standardized on a large sample of the targeted age group, and have also been periodically revised to include new features, an updated scoring pattern, contemporary stimulus words and their picture referents and most importantly to revise the norms. The question arises as to why an articulation test needs to be revised when already an old one exists. The reason to this varies depending on validity and reliability of the test material in the current scenario. A few reasons as to why an already existing test of articulation needs to be revised are as follows (1) Children are observed to be acquiring articulatory proficiency much earlier than that indicated before (Roberts, Burchinal & Footo, 1990; Bharathy, 2001; Rahul, 2006; Sreedevi & Shilpashree, 2008, Deepa, 2010) (2) Certain test stimuli in the existing tests of articulation could no longer be in contemporary usage, (3) With the advent of

urbanization, more and more of borrowed words become prevalent in the language, and (4) Simultaneous or successive exposure to more than one language, which has become very common in a country like India, could yield different results.

In the Indian context, diagnostic tests of articulation are available in Kannada (Babu, Rathna & Bettagiri, 1972, Tamil (Usha, 1986), Telugu (Padmaja, 1988), Bengali (Arun Banik, 1989), Malayalam (Maya, 1990), Oriya (Panda, 1991), Hindi (Deepa Shankar, 1998) and Marathi (Photo-Articulation Test funded by UNICEF, AYJNIHH, Mumbai). The Kannada Articulation test was revised by Deepa (2010) and the newly developed test is now called as Kannada Diagnostic-Picture Articulation Test (KD-PAT). The Malayalam Articulation Test (Maya, 1990) tests 11 vowels and 33 consonants in initial, medial and final word positions. Neenu (2011), Vipina (2011) and Vrinda (2011) revised and revalidated the articulation test battery in Malayalam (Maya, 1990) in children in the age range of 3-4 years, 4-5 years and 5-6 years respectively. All the studies in Malayalam language mentioned above, revised the obsolete words in the articulation test battery in Malayalam (Maya, 1990) and included more number of naturally occurring clusters in the language.

The test of articulation in Oriya (Panda, 1991) consists of 84 words which test 32 consonants and 6 vowels in initial, medial and final position of words (Oriya is officially termed as Odia from November, 2011 onwards after Presidential assent and notification in the official Gazette). The stimuli consist of black and white line drawings of the target words. Scoring is in terms of 'correct' and 'incorrect' responses given a credit of '1' and '0' respectively. It has not included long vowels, nasalized vowels and naturally occurring clusters of the language. As indicated before, a few geminated clusters are

acquired as early as 2 years of age. It has been almost 2 decades since the norms of the test were revised. Also, with urbanization and exposure to bilingualism at an early age, changes in articulatory acquisition and usage of words are expected to have changed. A great majority of Odia speaking children are educated in English medium schools in cities, which exposes them to English as early as 2 years of age. Previous research has indicated that bilingual children have a faster articulatory acquisition compared to monolingual children (Kester, Davis & Pena, 2008). So, keeping this in mind the present study was carried out with an aim of revising the existing test of articulation in Oriya (Panda, 1991) and re-standardizing the same on typically developing children in the age range of 2-5 years with Odia as their native language.

CHAPTER III

METHOD

The present study was aimed to revise the existing test of articulation in Oriya (Panda, 1991) and to standardize the revised test on typically developing children in the age range of 2-5 years with Odia. The study was conducted in two phases

1. Preparation of the test material
    - Incorporating words with naturally occurring clusters in initial and medial word positions in Odia language
    - Revising the obsolete words in the existing test of articulation in Oriya (Panda, 1991)
2. Administration of the revised test on typically developing Odia speaking children in the age range of 2-5 years.

3.1 Phase I: Preparation of the test material

3.1.1 Inclusion of words with clusters

150 words with clusters in initial (50 words) and medial (100 words) positions were chosen from Odia text books and story books for children in the age range of 2-5 years. These words were given to 3 native speakers of Odia in the age range of 19-40 years for familiarity. They were instructed to rate the words as ‘very familiar’, ‘familiar’ or ‘unfamiliar’ depending on each word’s usage in daily conversation in the language. The words rated as ‘most familiar’ by two out of three judges were listed out. Out of these words, eight words with medial clusters and seven words with initial clusters were included in the existing test of articulation in Oriya (Panda, 1991).

3.1.2 Revision of the obsolete words from the existing test of articulation in Oriya

Colored pictures of the stimulus words of the existing test of articulation in Oriya were downloaded from the internet and positioned on Microsoft PowerPoint slides. Care was taken that the pictures were simple, non-ambiguous, clearly represented the stimulus word as well as cultural background of the language considered.

A pilot study was conducted on 18 typically developing children in the age range of 2-5 years with Odia as their native language, mainly to ascertain the usage of clusters in the children of this age group and to detect as well as to replace the obsolete words in the existing test of articulation in Oriya. Finally, the words which the children in the pilot study were unable to identify were considered to be obsolete and were replaced by new test words. The existing test of articulation in Oriya (Panda, 1989) tests vowels in initial, medial and final positions of words. The revised articulation tests in various other Indian languages like Kannada, Malayalam, Telugu, Tamil, etc have included vowels only in the initial position which has been reported to be adequate for testing the accuracy of vowel production. So, the words from the test of articulation in Oriya (Panda, 1991) intended to test vowels in medial and final positions of words were not included in the present study. The new words with clusters were also tested and were replaced when necessary. The revised test material is called as “Odia Diagnostic Picture Articulation Test” (ODPAT).

3.3 Phase II: Administration of the test

The final test material with 115 test words intended to test the 33 phonemes of Odia language in initial, medial and final word positions, 8 vowels and 2 diphthongs in initial position and 8 medial (1 geminate and 7 non-geminate) and 7 initial non- geminate

clusters. The revised test material presented in the form of colored pictures were administered on 180 typically developing children in the age range of 2-5 years with Odia as their native language. The participants were mainly selected from various schools of Bhubaneswar. A written consent was taken from the school authorities for testing each child.

3.4 Participants: 180 typically developing children equally distributed across gender, in the age range of 2-5 years (with 6 months age interval in each age group, i.e., 6 sub-groups as 2.0-2.6 years, 2.6-3.0 years, 3.0-3.6 years, 3.6-4.0 years, 4.0-4.6 years and 4.6-5.0 years) were included in the study. The participants had Odia (Bhubaneswar dialect) as their native language; they belonged to urban set up and were devoid of any speech, language, sensory, motor or cognitive deficits.

3.5 Instrumentation: The revised test of articulation in Odia was presented in the form of colored pictures on Microsoft PowerPoint 2007 slides. The responses were recorded using a Frontech headset with a microphone and a built-in audio recorder (Sound Recorder- Sony VAIO E series laptop).

3.6 Test procedure: All the participants were seated comfortably on a chair in front of the laptop (Sony- VAIO E-Series model) and fitted with a headset consisting of a microphone attached through a flexible band. The microphone was so adjusted that the distance between the mouth of the participant and the microphone receiver was maintained at about 10 centimeters. The laptop was placed at a comfortable distance in front of the child and test stimuli were displayed in the form of full screen Microsoft PowerPoint slides.

Each child was shown one picture at a time and asked to spontaneously name the same. If the child was unable to identify the stimulus as the exact word as in the test stimuli, semantic or phonemic cues were given. Repetition tasks were carried out, especially for the younger age groups (2.0- 3.0 years), if none of the cues helped eliciting the target stimulus.

3.7 Data analysis: All the recorded responses were verbatim transcribed using IPA and analyzed for articulatory acquisition across age and gender. Appropriate statistical measures were applied to extract the mean and standard deviation, and compare the same across different age groups and gender. A criterion level of 75% and 90% were followed to proclaim a sound as acquired or mastered.

3.8 Scoring of the responses: The articulatory errors were scored as follows

- Correct response: 1
- Substitution: 0.50
- Distortion: 0.25
- Omission: 0

3.9 Statistical Analysis: Sum of the responses of each child was calculated and the raw data was subjected to statistical analysis using SPSS (Ver.18) to calculate the mean and standard deviation of articulatory scores. Significant difference between articulatory scores across age groups and gender was obtained using two-way ANOVA measures. Comparison of percentage of correct productions in terms of position in a word (I, M, F word positions), place and manner of articulation were also carried out.

CHAPTER IV

RESULTS

The aim of the present study was to revise and re-standardize the Test of Articulation in Oriya (Panda, 1991) and to update the norms for the same. Words with naturally occurring clusters in the language were included and the obsolete words in the existing Test of Articulation in Oriya, developed two decades ago were replaced based on a pilot study conducted on 18 typically developing Odia speaking children in the age range of 2-5 years. The final test material comprising of 105 picture stimuli were administered on 180 typically developing children in the age range of 2-5 years. The participants considered between 2-5 years were subdivided into 6 age groups with 6 months interval (2.0- 2.6 years, 2.6- 3.0 years, 3.0- 3.6 years, 3.6- 4.0 years, 4.0- 4.6 years, 4.6- 5.0 years).

The responses of the participants were scored in terms of frequency of occurrence of correct responses as well as different types of articulatory errors (substitution, omission, distortion and addition) using the scoring pattern described in the method section. The sum of the response scores of each participant was calculated (Total= 105), that is, if the child produced all the test stimuli correctly, the score allotted was 105. Descriptive statistics was used to obtain mean and standard deviation from the raw data scores of individual participants. Table 2 depicts the mean and standard deviation of articulatory scores for males and females in the age range of 2-5 years.

Table 2

Mean scores and Standard Deviation in different age groups

	Males	**Females**
Age Range	Mean (SD)	Mean (SD)
2-2.6 yrs	91.23 (1.93)	91.1167 (1.87)
2.6-3 yrs	97.95 (1.05)	97.9333 (1.21)
3-3.6 yrs	100.58 (1.20)	100.8167 (1.15)
3.6-4 yrs	101.63 (1.19)	99.9667 (1.00)
4-4.6 yrs	104.16 (0.88)	104.2167 (0.91)
4.6-5yrs	104.80 (0.39)	104.8333 (0.47)
Total	100.06 (4.72)	99.8139 (5.46)

The results indicate that with an increase in age, the articulatory scores increase represented by an increase in mean scores. However, the variability decreases represented by a decrease in standard deviation towards the older age groups.

Duncan's test was carried out to obtain the significant difference between articulatory scores across age groups in both males and females. The results indicate that age groups 2.0-2.6 years and 2.6-3.0 years differed significantly with all other age groups. Age groups 3.0-3.6 years and 3.6-4.0 years did not differ significantly with each other but differed significantly from all the other 4 age groups. Similarly age groups 4.0-4.6 years and 4.6-5.0 years did not differ significantly with each other but differed significantly from all the other age groups. Overall, maximum differences between the mean articulatory scores were observed in the two age groups in 2-3 years range (i.e. 2.0-

2.6 and 2.6-3.0 years). This indicates that maximum articulatory development occurs between 2-3 years of age in typically developing Odia speaking children. Increase in articulatory scores was also observed between 3.0-5.0 years (with 6 months interval in between) but the range of articulatory scores was not as large as observed between the age groups 2.0-2.6 years and 2.6-3.0 years. Table 3 depicts the presence or absence of significant difference when articulatory scores were compared across age groups using two-way ANOVA measures.

Table 3

Comparison of articulatory scores across age groups

Age (in years)	Compared to responses of age groups	Significant difference ($p<0.05$)
2.0-2.6	2.6-3.0	+
	3.0-3.6	+
	3.6-4.0	+
	4.0-4.6	+
	4.6-5.0	+
2.6-3.0	2.0-2.6	+
	3.0-3.6	+
	3.6-4.0	+
	4.0-4.6	+
	4.6-5.0	+
3.0-3.6	2.0-2.6	+
	2.6-3.0	+
	3.6-4.0	-
	4.0-4.6	+
	4.6-5.0	+
3.6-4.0	2.0-2.6	+
	2.6-3.0	+
	3.0-3.6	-
	4.0-4.6	+
	4.6-5.0	+
4.0-4.6	2.0-2.6	+
	2.6-3.0	+
	3.0-3.6	+
	3.6-4.0	+
	4.6-5.0	-
4.6-5.0	2.0-2.6	+
	2.6-3.0	+
	3.0-3.6	+
	3.6-4.0	+
	4.0-4.6	-

'+' indicates presence and '-' indicates absence of significant difference

Graph 1 depicts the mean articulatory scores between males and females across different age groups. It was observed that there was no significant difference ($p<0.05$) between males and females in any of the age groups.

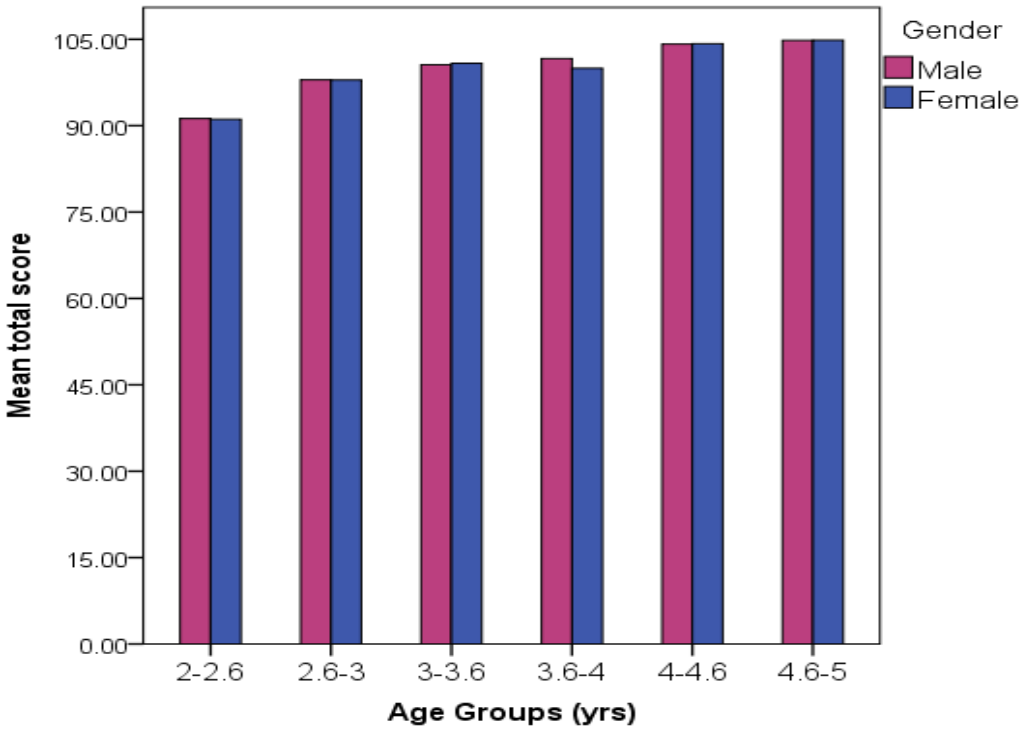

Figure 1: Mean Articulatory Scores across Age Groups.

4.1 Age of acquisition of phonemes

The criteria of 75% and 90% were followed to establish the acquisition and mastery of a phoneme respectively. Spontaneous elicitation of words with the target phoneme in initial, medial and final position was carried out and articulatory responses were scored. The percentage of children producing the correct target phoneme was calculated and the sequence of acquisition and mastery of phonemes were established.

Table 4

Age of acquisition of vowels and diphthongs in initial word position

Phoneme	**% of Correct Vowels and diphthongs (2.0-2.6 years)**
/ ɔ /	100
/a/	100
/I/	100
/i/	100
/U/	100
/u/	100
/e/	100
/o/	100
/ ɔI/	100
/ ɔU/	100

Table 4 depicts the percentage of children (in the age range of 2.0-2.6yrs) who correctly produced the vowels and diphthongs, considered in the study. As depicted in Table 4, all vowels and diphthongs were correctly produced by 100% of the children in the initial position by the age of 2.0-2.6 years itself (vowels and diphthongs were tested only in initial position). As the older groups of children produced vowels and diphthongs correctly, these are not included in the forthcoming tables.

Tables 5 to 10 depict the percentage of children correctly producing a particular target consonant across initial, medial and final word positions in the age range of 2.0-2.6 years, 2.6-3.0 years, 3.0-3.6 years, 3.6-4.0 years, 4.0-4.6 years, and 4.6-5.0 years respectively.

Table 5

Percentage of Correct Consonant Responses across Word Positions (2.0-2.6 years)

Phonemes	**Percentage**		
	Initial	Medial	Final
/k/	100	100	--
/k^{h}/	100	100	--
/g/	83.33	86.66	86.66
/g^{h}/	70	76.66	--
/ʧ/	66.66	73.33	70
/ʧ^{h}/	66.66	76.00	--
/ʤ/	66.66	73.33	--
/ʤ^{h}/	73.33	--	--
/ʈ/	73.33	70	73.33
/ ʈ^{h}/	70	73.33	--
/ɖ/	80	80	--
/ɖ^{h}/	73.33	73.33	--
/ɳ/	--	63.33	--
/ʇ/	66.66	73.33	--
/ʇ^{h}/	66.66	73.33	73.33
/ɖ/	66.66	73.33	--
/ɖ^{h}/	66.66	70.00	--
/n/	83.33	83.33	80.00
/p/	100	100	--
/p^{h}/	100	100	--
/b/	100	100	--
/b^{h}/	100	100	--
/m/	100	100	--
/j/	--	73.33	--
/r/	66.66	70.00	66.66
/ɭ/	--	70.00	--
/s/	70.00	73.33	73.33
/h/	73.33	73.33	--
/l/	70.00	76.66	73.33

Table 5 depicts the percentage of correct target consonants produced by children in the age range of 2.0-2.6 years. Seven phonemes /p/, /p^{h}/, /b/, /b^{h}/, /m/, /k/ and /k^{h}/ achieved mastery and were produced by 100% of the children in initial, medial and final word positions. Three phonemes (/g/, /ɖ/ and /n/) were achieved by more than 75% of children across all word positions. Aspirated velar plosive /g^{h}/ and aspirated affricate /ʧ^{h}/ were

produced by more than 75% of children in medial word position only. Responses of other consonants were below 75% of acquisition and were scattered across the three positions. On observation of the trend of production of phonemes, they were acquired in the order medial>initial>final.

Table 6

Percentage of Correct Consonant Responses across Word Positions (2.6-3.0 years)

Phonemes	**Percentage**		
	Initial	Medial	Final
/gʰ/	83.33	86.66	--
/ʧ/	73.33	73.33	66.66
/ʧʰ/	73.33	86.66	--
/ʤ/	70.00	73.33	--
/ʤʰ/	69.0	--	--
/ʈ/	80	86.66	86.66
/ʈʰ/	76.66	83.33	--
/ɖ/	86.66	86.66	--
/ɖʰ/	83.33	80	--
/ɳ/	--	73.33	--
/t̪/	83.33	86.66	--
/t̪ʰ/	76.66	80	80
/d̪/	80	90	--
/d̪ʰ/	76.66	83.33	--
/n/	86.66	90	86.66
/j/	--	83.33	--
/r/	80	83.33	86.66
/ɭ/	--	73.33	--
/s/	80	83.33	83.33
/h/	83.33	83.33	--
/l/	76.66	76.66	76.66

-- indicates phoneme not tested in that position

The consonants which had obtained 100% scores in the previous age group of 2.0-2.6 years (Table 5) are not included in Table 6. Three phonemes achieved mastery in this age group: dentals /n/ and /d̪/ in medial word position. The 15 phonemes acquired (>=

75%) by this age range in all the tested word positions were voiced aspirated velar plosive /g^{h}/, unaspirated and aspirated retroflexed plosives /ʈ/, /ʈ^{h}/, /ɖ/, /ɖ^{h}/, unaspirated and aspirated alveolar /t̪/, /t̪^{h}/, /d̪/ and/d̪^{h}, nasal /n/, glottal /h/, fricative /s/, glide /j/, rhotic /r/ and lateral /l/ in all word positions. So, it was observed that 27 consonants were acquired by children by the age of 3 years at least in one word position. This included 12 consonants in the age range of 2.0-2.6 years and 15 in the age range of 2.6-3.0 years. According to the place of articulation, consonant classes acquired by 3 years were bilabials and velars, followed by retroflex, dentals, alveolars and palatals.

Table 7 depicts the percentage of correct target phonemes in children in the age range of 3.0-3.6 years. The consonants which had obtained 100% scores in the previous age group of 2.6-3.0 years are not included in Table 7. Voiced unaspirated affricate /ʤ/ was observed to pass the 75% criterion of sound acquisition in this age group. Six consonants were mastered in all word positions tested. They were retroflexed plosives /ʈ/, /ʈ^{h}/ and /ɖ/, nasal /n/, glottal /h/ and glide /j/. Fricative /s/ was mastered in medial and final word positions, and voiced velar plosive /g^{h}/ mastered in medial word positions (correctly produced in >90% of the children). Overall, in this age group, seven consonants met the criteria of correct production. All other phonemes were seen to be occurring in more number of children as compared to the previous age groups but were not mastered by this age range.

Table 7

Percentage of Correct Consonant Responses across Word Positions (3.0-3.6 years)

Phonemes	**Percentage**		
	Initial	Medial	Final
/gʰ/	86.66	90	--
/ʧ/	83.33	86.66	86.66
/ʧʰ/	80	100	--
/ʤ/	76.66	80	--
/ʤʰ/	70	--	--
/ʈ/	90	90	90
/ʈʰ/	90	93.33	--
/ɖ/	93.33	96.66	--
/ɖʰ/	83.33	86.66	--
/ɳ/	--	73.33	--
/ʈ̲/	83.33	86.66	--
/ɖ̲/	86.66	93.33	--
/ɖ̲ʰ/	86.66	83.33	--
/n/	96.66	96.66	93.33
/j/	--	93.33	--
/r/	80	83.33	86.66
/ɭ/	--	76.66	--
/s/	86.66	96.66	96.66
/h/	100	100	--
/l/	80	83.33	86.66

Table 8 depicts that all consonants achieved mastery by 3.6 – 4years. The consonants which had obtained 100% scores in the previous age group of 3.0-3.6 years are not included in Table 8. Six consonants, fricative /s/, glottal /h/, nasal /n/, glide /j/ and retroflex plosives /ʈ/ and /ʈʰ/ were produced correctly by 100% of the children in all word positions. It is interesting to note that the difficult to produce fricative /s/ was produced correctly by 100% of the children in this age group. Voiced retroflex plosive /ɖ/ and unvoiced alveolar plosive /ʈ̲/ were observed in 100% of the children in initial and medial word positions only. By this age, children were observed to master sounds (>= 90%) which they had already acquired in the younger age groups. So, by 4.0 years, consonant

sound manner mastered were most of the plosives, laterals, nasals, fricatives, taps and affricates. By 3.0 years, dentals and retroflex were acquired simultaneously (almost similar % of correct productions in children across all word positions). However, closer observation of data revealed that even though both these places were acquired around the same time, retroflexed consonants were mastered earlier than dental phonemes. So, it can be said that mastery of consonants according to place of articulation progresses in the order of bilabials, velars, retroflex, dentals, alveolars and palatals (by 4 years).

Table 8

Percentage of Correct Consonant Responses across Word Positions (3.6-4.0 years)

Phonemes	**Percentage**		
	Initial	Medial	Final
/gʰ/	93.33	93.33	--
/ʧ/	90	100	90
/ʧʰ/	90	93.33	--
/ʤ/	90	93.33	--
/ʤʰ/	96.66	--	--
/ʈ/	100	100	100
/ʈʰ/	100	100	--
/ɖ/	100	100	--
/ɖʰ/	90	96.66	--
/ɳ/	--	90	--
/ʈ̪/	100	100	--
/ɖ̪/	96.66	96.66	--
/ɖ̪ʰ/	93.33	96.66	--
/n/	100	100	100
/j/	--	100	--
/r/	90	93.33	93.33
/ɭ/	--	83.33	--
/s/	100	100	100
/h/	100	100	--
/l/	90	96.66	93.33

So, it was observed that between 3.0-4.0 years, altogether 15 consonants were mastered at least in one tested word positions. 100% of the children could produce 9 consonants correctly in more than one word position tested.

Table 9 depicts the percentage of correct consonant responses in children in the age range of 4.0-4.6 years. The consonants which had obtained 100% scores in the previous age group of 3.6-4.0 years are not included in Table 9. Consonants which were mastered in this age range were /ʧ/ and /ʧʰ/ in final position, /ʤ/ and /ɖʰ/ in word initial position. So, it was observed that consonant mastery was complete by 4.0-4.6 years of age. It is clearly seen that by this age range many consonants were correctly produced by 100% of the children. Five consonants which were correctly produced by 100% of the children across all the three word positions included aspirated velar plosive /gʰ/, aspirated voiced affricate /dzʰ/, retroflexed nasal /ɳ/ and laterals /ɭ/ and /l/ in initial and medial word positions, unaspirated affricate /ʧ/ was produced by 100% of the children only in initial and medial position. Retroflexed aspirated voiced plosive /ɖʰ/ was produced by 100% of the children in medial position. So, an additional seven consonants were seen to be produced correctly by 100% of the children in the age group 4.0-4.6 years.

Table 9

Percentage of Correct Responses across Word Positions (4.0-4.6 years)

Phonemes	**Percentage**		
	Initial	Medial	Final
/g^{h}/	100	100	--
/ʧ/	100	100	96.66
/ʧ^{h}/	93.33	100	--
/dz/	90	100	--
/dz^{h}/	100	--	--
/ḍ^{h}/	96.66	100	--
/ṇ/	--	100	--
/ḷ/	--	100	--
/l/	100	100	100

Table 10

Percentage of Correct Responses across Word Positions (4.6-5.0 years)

Phonemes	**Percentage**		
	Initial	Medial	Final
/ʧ/	100	100	--
/ʧ^{h}/	100	100	--
/dz/	100	100	--
/dz^{h}/	100	--	--
/d^{h}/	100	100	100

-- Indicates phoneme not tested in that position

Table 10 depicts percentage of correct responses across word positions in children in the age range of 4.6-5.0 years. As observed, the 5 remaining phonemes obtained 100% scores in this age group. In summary, between 4.0-4.6 years, mastery of all consonants in Odia is completed and scores reach 100% accuracy in all the children as they approach 5 years.

In general, the order of mastery of sounds according to manner of articulation follows the order of plosives, nasals, fricatives, glides, taps and affricates. According to the place of articulation, the order of mastery noticed was bilabials, velars, retroflex, dentals, glottals and palatals.

4.2 Acquisition of Consonant Clusters

Seven initial clusters and eight medial clusters were tested using the developed test material on 180 children in the age range of 2-5 years. The result in terms of age of acquisition of clusters is depicted in Table 11 (percentage of correctly produced medial clusters).

Table 11

Percentage of correct production of medial clusters across age groups

Medial Clusters	2.0-2.6 years	2.6-3.0 years	3.0-3.6 years	3.6-4.0 years	4.0-4.6 years	4.6-5.0 years
/d̪r/	66.6	73.3	80.0	83.3	90.0	100.0
/rdz/	63.3	73.3	76.6	83.3	90.0	100.0
/ks/	73.3	76.6	80.0	90.0	93.3	100.0
/rs/	70.0	73.3	80.0	83.3	90.0	93.3
/ndz/	90.0	96.6	100.0	100.0	100.0	100.0
/d̪m/	70.0	73.3	76.6	83.3	90.0	100.0
/nk/	90.0	93.3	100.0	100.0	100.0	100.0
/nn/	93.3	96.6	100.0	100.0	100.0	100.0

Three medial clusters, /nn/, /ndʒ/ and /nk/ were seen to be acquired >75% of the children in the age range of 2.0-2.6 years. However, on observation of individual data in this age group, it was seen that these medial clusters were acquired by around 2.3 years of age. Four medial clusters /dr/, /ks/, /rs/ and /dm/ were acquired only by 3.0-3.6 years of age. Between 3.0-5.0 years of age, 7 out of 8 medial clusters tested were produced correctly by 100% of the children, three of which (/nn/, /nk/ and /ndʒ/) were mastered by

2.0-2.6 years of age, one of which (/ks/) was mastered by 3.6-4.0 years of age, 4 of which (/d̪r/, /rdʒ/ and /d̪m/) were mastered by 4.0-4.6 years of age. Medial cluster /rs/ passed the 90% criteria of mastery even though it was not produced by 100% of the children by 4.6-5.0 years. Table 12 depicts the percentage of correct production of initial clusters in children from 2-5 years of age.

Table 12

Acquisition of clusters in initial position across age groups

Initial Clusters	2.0-2.6 years	2.6-3.0 years	3.0-3.6 years	3.6-4.0 years	4.0-4.6 years	4.6-5.0 years
/sk/	53.3	66.6	76.6	80.0	90.0	93.0
/pl/	76.6	83.3	90.0	93.3	100.0	100.0
/kr/	66.6	70.0	70.0	80.0	90.0	100.0
/pr/	70.0	73.3	83.3	90.0	96.6	100.0
/str/	70.0	73.3	80.0	86.6	90.0	96.6
/tr/	66.6	73.3	80.0	90.0	93.3	100.0
/skr/	60.0	73.3	76.6	76.6	90.0	100.0

As depicted in Table 12, by 2.0-2.6 years, only /pl/ was acquired which was mastered by 3.0-3.6 years of age. All the 7 initial clusters tested (except /kr/) were acquired by 3.0-3.6 years of age. Two initial clusters /pr/ and /tr/ were mastered by 3.6-4.0 years of age. All initial clusters tested, were mastered (>=90%) by 4.0-4.6 years of age. However, by 4.6-5.0 years, initial clusters /sk/ and /str/ were not produced correctly by 100% of the children.

Table 13 depicts the number of medial and initial clusters acquired (75%), mastered (90%) and produced correctly in 100% of the children considered in the study. As observed from Table 13, all medial clusters are acquired by 3.0-3.6 years of age and all initial clusters are acquired by 3.6-4.0 years. In the younger age groups (2.0-3.6 years), more number of medial clusters were acquired. It is worth noticing that, till 3.6

years, only one initial cluster was acquired. Between 3.6-4.0 years, 5 more initial clusters were acquired. Hence, it can be stated that medial clusters are acquired earlier than initial clusters in Odia language.

Table 13

Acquisition of Medial and Initial clusters across age groups

Age range (years)	Criterion	No. of Medial Clusters	No. of Initial Clusters
2.0-2.6	75%	3	1
	90%	3	--
	100%	--	--
2.6-3.0	75%	1	--
	90%	--	--
	100%	--	--
3.0-3.6	75%	+4	+5
	90%	--	1
	100%	3	--
3.6-4.0	75%	--	1
	90%	+1	+2
	100%	--	--
4.0-4.6	75%	--	--
	90%	+4	+4
	100%	--	1
4.6-5.0	75%	--	--
	90%	--	--
	100%	+4	+4

+ indicates “in addition to clusters in the previous age group”; -- indicates no clus achieved d criteria

Four medial clusters were acquired during the period of 2.6-3.0 years of age compared to just one initial cluster in the same age range. By 3.0-3.6 years of age, additional 3 medial clusters had achieved 100% mastery whereas only 1 initial cluster has achieved 90% mastery in this age group. As observed in Table 13, medial clusters were

acquired earlier than initial clusters. Mostly cluster substitution types of errors were observed followed by cluster reductions and cluster simplifications (epenthesis).

The results of the present study, in terms of age of acquisition of phonemes, were compared with earlier such studies conducted in English and other Indian languages. The comparison is summarized in Tables 14 and 15. When compared with English, phonemes were seen to be mastered at an earlier age itself. It was observed that in the present study, all the phonemes were mastered by 4.0-4.6 years of age whereas in the English studies mastery is shown to occur much later.

Comparing with the Indian studies also, phonemes were seen to be acquired earlier than the previously established norms. However, they were in par with the recently revised norms. One of the interesting points in the present study is the early acquisition of a few aspirated plosives and affricates (/ʧʰ/) as early as 2.6-3.0 years of age.

Table 14: Comparison of phoneme acquisition of the present study with existing norms in English

Sp sd.	Poole (1934)	Templin (1957)	Prather et al. (1975)	Fudala (1986)		Smit (1990)	Present study (90%)
				M	F		
/m/	3.6	3	2	2	2	3	2.0-2.6
/n/	4.6	3	2	2	2	3.6	3.0-3.6
/ ŋ/	3.6	3	2	1.6	--	--	2.6-3.0
/p/	3.6	3	2	2	3	3	2.0-2.6
/f/	5.6	3	2-4	2.6	3	3.6	--
/w/	3.6	3	2-8	1.6	--	--	--
/b/	3.6	4	2-8	2	3	3	2.0-2.6
/ŋ/	4.6	3	2	--	3	--	--
/j/	4.6	3.6	2-4	3	--	4	3.0-3.6
/k/	4.6	4	2-4	2.6	3	3	2.6-3.0
/g/	4.6	4	2-4	2.6	3	3	2.6-3.0
/l/	6.6	6	3-4	5	5	--	3.0-3.6
/d/	4.6	4	2-4	2.6	2.6	3	2.6-3.0
/t/	4.6	6	2-8	3	4	4.6	3.0-3.6
/s/	7.6	4.6	3	11	11	--	3.0-3.6
/r/	7.6	4	3-4	5.6	--	--	3.6-4.0
/tʃ/	--	4.6	3-8	5.6	5.6	--	3.0-3.6
/v/	6.6	6	4	5.6	5.6	5.6	--
/Z/	7.6	7	4	11	11	--	--
/z/	6.6	7	4	--	--	7-9	--
/th/	7.6	6	4	6	6	6	--
/dz/	--	7	4	5	--	--	3.0-3.6
/ʃ/	6.6	4.6	3-8	5.6	5.6	6	--

-- indicates sound not tested.

Table 15: Comparison of phoneme acquisition of the present study and earlier studies on articulation acquisition in Indian languages

Spsd.	Usha (1986) Tamil	Padmaja (1988) Telugu	Arun Banik (1988) Bengali	Maya (1990) Malayalam	Panda (1991) Odia	Prathima (2009) Kannada	Deepa (2010) Kannada	Divya (2010) 90%	Present study (90%) (Odia)
/m/	3	2.6	2.5	3-3.6	3-3.6	3-3.6	2	2.3	2-2.6
/n/	3	2.6	2.5	3-3.6	3-3.6	3-3.6	2	2.3	3-3.6
/ ŋ/	-	-	2.5	3-3.6	-	3-3.6	4.6	2.3	-
/p/	3	2.6	2.5	3-3.6	3-3.6	3-3.6	2	2.3	2-2.6
/f/	-	2.9	-	3-3.6	-	-	-	-	-
/h/	3	2.6	3	3-3.6	3.6-4	-	>6	>3	2.6-3
/k/	3	2.6	2.7	3-3.6	3-3.6	3-3.6	2	2.6	2.6-3
/ḍ/	3	2.6	2.5	3-3.6	3-3.6	3-3.6	2	-	2.6-3
/g/	3	2.6	3	3-3.6	3-3.6	3-3.6	3.6	2.9	2.6-3
/r/		3.9	3	3.7-4	3.6-4	-	2	>3	3.6-4
/s/	3	3.3	4	3-3.6	3.6-4	3-3.6	5	>3	3-3.6
/ʃ/	6	3.6	-	5-5.6	-	3.6-4	4.6	>3	-
/ʧ/	3	2.6	3	3-3.6	5.6-6	3-3.6	4	2.3	3.6-4
/v/	3	2.6	3	3-3.6	-	3-3.6	3.6	2.6	
/l/	3	2.6	3	3-3.6	-	3-3.6	3.6	>3	3.6-4
/ʧ^{h}/	3	-	-	3-3.6	5.6-6	3-3.6	3.6	2.6	3.6-4
/ʤ^{h}/	-	-	-	6-6.6	5.6-6	3-3.6	3	-	3.6-4

- indicates phoneme not tested.

Table 15 adds in to our understanding that compared to the earlier study in Odia, present day norms are much ahead in terms of age of acquisition and mastery of speech sounds. It can also be seen that on comparison with few recent studies (Deepa, 2010, Prathima, 2009, and Vrinda, 2011), a few speech sounds are earlier in acquisition in the present study. To summarize, the findings of the present study indicate that

- Phoneme acquisition pattern in Odia follows a developmental trend. It is a continuous process which continues till the child obtains mastery and consistent correct productions.
- Maximum development in terms of acquisition of sounds was observed between 2.0-2.6 years and 2.6-3.0 years of age, after which phoneme acquisition and mastery were more gradual with lesser variability.
- Place of articulation mastery followed the order bilabials, velars, retroflex, dentals, glottals and palatals.
- Manner of articulation followed the order vowels and diphthongs followed by plosives, nasals, fricatives, glides, taps and affricates.
- Consonant cluster acquisition and mastery followed the trend of medial earlier than initial.
- Cluster acquisition emerged as early as 2.0-2.6 years and continued till 3.0-3.6 years for medial clusters and 3.6-4.0 years for initial clusters for those clusters included in the study.
- Compared to earlier articulation acquisition study in Odia (Panda, 1991), the participants of the present study were seen to be acquiring and mastering sounds much earlier, thereby strengthening the fact that present day children are seen to be acquire speech sounds much earlier when compared to earlier norms.

4.3 Age-wise cut-off articulatory scores

The calculated mean represents the cut-off articulatory score for a particular age group. If a child is able to accomplish the cut-off score +/- standard deviation, it can be said that the child falls under the normal distribution curve for articulatory scores and would represent normal articulatory development. A child who falls below the cut off score +/- standard deviation would indicate deviant articulation skills and would require additional probing in terms of intervention. On comparing his/ her mean score with the group mean, the articulatory age can be calculated.

Table 16

Age-wise cut-off scores for articulation

Age Range (years)	Expected Articulatory Scores (+/- SD)
2.0-2.6	91.17 (1.00)
2.6-3.0	97.94 (1.00)
3.0-3.6	100.70 (1.00)
3.6-4.0	100.80 (1.00)
4.0-4.6	104.19 (0.30)
4.6-5.0	104.81 (0.30)

Maximum Possible Score: 105

CHAPTER V

DISCUSSION

The results of the present study revealed the following. **First, the articulatory scores increase with an increase in age in both boys and girls**. This implies that a direct relation exists between articulatory scores and chronological age. This finding is in agreement with norms established in English by Wellman et al. (1931), Poole (1934), Templin (1957) and Smit (1990) and in Indian languages like Kannada (Tasneem Banu, 1977), Prathima, 2009, & Deepa (2010), in Tamil (Usha, 1986), in Telugu (Padmaja, 1988), Usha Rani, 2010), in Malayalam (Maya, 1990, Neenu, 2011, Vrinda, 2011, Vipina, 2011), in Hindi (Deepa Shankar, 1998), in Bengali (Arun Banik, 1988) and in Odia (Panda, 1991). This could be attributed to the maturing motor system which aids in better, finer and more precise movement of articulators for the production speech sounds as a child grows older. It is also an established factor that as a child gets older, the phonological neighborhoods of a word increase, giving a child better scope to identify, discriminate and choose among a pool of phonemes activated in the mental lexicon. Phonetic inventory shows a maximum development between 2-3 years. This could be attributed to maximum brain plasticity and spurt of neuronal growth occurring at this age. Also, this is the time when children are stimulated maximum for speech and because the family is extremely fascinated with the child's one-two word utterances and the child's experiment with novel words (compared to his repertoire), their speech utterances reinforced, due to which the child is encouraged to experiment with new phonemes, thereby boosting the child's articulatory output.

Second, certain speech sounds were acquired earlier than the others and a typical developmental trend prevailed for the same. It was observed that all vowels, diphthongs, and several singleton consonants including some of the aspirated phonemes were acquired by 2.0-2.6 years of age. Studies even in the recent past have indicated that aspirated phonemes are acquired later in the developmental stage (Prathima, 2009, Vrinda, 2011). The earlier acquisition of aspirated phonemes could be attributed to ambient language effect and a higher frequency of usage of the target words considered in the present study, e.g., /matʃʰɔ/ (meaning 'fish' which is a staple food of Odisha) and used in daily conversation. This finding is strengthed by Jesheniak and Levelt (1994) who state that high frequency words are produced more proficiently in terms of naming latencies and fewer errors. Similarly in the present study, glottal /h/ was acquired by 2.6-3.0 years and was mastered by 3.0-3.6 years. This is contrary to the reports of Deepa (2010) who reported that the mastery of /h/ is not accomplished even by 6 years of age in Kannada. This further strengthens the need to construct articulation tests in different languages as the frequency of phonemes vary across languages.

In a nutshell, consonants were seen to be acquired first in the medial position, followed by initial position and last in the final position. The first sounds to develop were vowels, diphthongs, plosives, nasals and laterals, followed by fricatives and trills/ taps. The last to be acquired were affricates (except aspirated voiceless affricate /ʧʰ/ which was acquired by 2.6 years). Speech sounds with a less complex manner of articulation are acquired first (vowels, diphthongs and plosives) as they are unmarked. Glides, nasals and laterals were seen to be acquired next. Those obstruents, which require fine precision in building an adequate intraoral breath pressure as a stream of air passing through a tiny

orifice (fricatives) and combination of both (affricates), were acquired at a later stage when the speech motor system is much matured and the child is able to manipulate his articulators to make these subtle adjustments in the place and manner features of the speech sound. However, these difficult sounds (/s/, /r/ etc.) were also acquired by 3.6 years contrary to the notion that they are acquired beyond 5 years of age.

According to the place of articulation, the order of mastery observed was bilabials, followed by velars, retroflex, dentals, alveolars, glottal and palatals. It is a general impression that dentals are mastered earlier than retroflex sounds. The difference in the conventional findings and the findings of the present study (retroflex versus dentals) could be attributed to a higher frequency of usage of words containing retroflexed phonemes in Odia. Similar findings were also reported by Divya (2010) in Malayalam language.

Comparing the present findings with phonological acquisition data in Odia language by Panda (1991), it was found that the order of acquisition of phonemes remained the same but they were acquired much earlier than the previously established norms in Odia. This could be because of increased speech and language exposure, better and sooner formal education, exposure to multiple languages at an earlier age itself, educated parents, exposure to television, better parental care and better nutrition (Divya, 2010, Deepa, 2010).

Fourth finding was with respect to consonant clusters. The present study included 15 naturally occurring clusters of the language in initial and medial word positions. It is interesting to note that three clusters were acquired as early as 2.0-2.6 years and these clusters contain nasals. Since the presence of nasals favors consonant coarticulation,

articulating such clusters become easy. Among the initial clusters, /pl/ was acquired by 76.6% of the subjects in the age range of 2.0-2.6 years. This could be because of the presence of bilabial /p/ and lateral /l/ both of which are acquired at an early age. This is in accordance with studies in English (Stoel- Gammon 1985, Watson & Skukanec, 1997) who reported the acquisition of /pl/ cluster by 2 years of age. In general, medial clusters were seen to be acquired before initial clusters in accordance with Deepa (2010), Divya (2010) and Sneha (2012). The reason for similar findings in the present study could be attributed to a greater number of medial clusters in Odia language and the inclusion of loan English words as stimuli to test initial clusters. This is further strengthened by the finding that by 3.6 years only one out of 7 initial clusters were acquired whereas a sudden spurt of acquisition of 5 additional initial clusters was observed by the next age group (3.6-4 years). The remarkable leap in the number of initial clusters could be because formal education in English begins between 3.6-4.0 years wherein children are taught rule governed English.

Almost all the other tested clusters were acquired by 3-3.6 years and the process of mastery is completed by 4-4.6 years of age. Similar findings were reported by Vipina (2011) in Malayalam who accounted medial clusters to be acquired by 90% of the children in 4.9- 5 years age range. In the present study, medial cluster /nk/ achieved 100% by 3-3.6 years of age in accordance with Neenu (2011) reported the same in Malayalam language. Also, /sk/ and /skr/ were acquired by 3-3.6 years and mastered by 4-4.6 years. Similar findings have been reported in Kannada by Deepa (2010). The later mastery of these clusters could be attributed to the mastery of the constituent phonemes towards this age range only.

It is appealing to look at the early age of acquisition of clusters. Generally, SLPs believe that clusters are acquired at a later stage in developmental phonology and do not tend to see the non-acquisition of clusters as an indicator of phonological impairment nor do they take up clusters as therapeutic targets at early stages of intervention. So, this study has added on to indicate that one geminate and fourteen non-geminate clusters are mastered by 3.6-4.0 years of age itself and absence of the same should be dealt with caution during assessment as well as intervention of children with articulatory problems. The norms of the existing test can be utilized to assess as well as plan order of selection of phoneme targets in Odia during speech intervention.

Lastly, no significant difference was found with respect to gender in accordance with Winitz (1969), Tasneem Banu (1977), Padmaja (1988) and Prathima (2009). This could be accredited to equal speaking opportunities and speech stimulation to both males as well as females in the present nuclear family scenario.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The aim of the present study was to revise the existing test of articulation in Oriya (Panda, 1991) and re-standardize the same on typically developing urban children in the age range of 2-5 years with Odia as their native language.

The study was conducted in 2 stages. Stage 1 included preparation of the test material which consisted of incorporation of words with naturally occurring clusters in initial and medial word positions in Odia language and revision of the obsolete words in the existing test of articulation in Oriya (Panda, 1991). Eight medial and seven initial clusters chosen from the selected words were adjoined to the existing test of articulation (Panda, 1991) and administered on 18 typically developing children in the age range of 2-5 years as a part of pilot study.

Stage 2 included administration of the revised test on 180 typically developing Odia speaking children in the age range of 2-5 years (with an inter-age interval of 6 months). Colored pictures of test stimuli prepared on Microsoft PowerPoint slides were presented to the individual participants and the subjects were instructed to name the pictures one after another displayed on the laptop screen. All responses were recorded using an inbuilt audio- recorder (Sound Recorder- Sony VAIO E series laptop), transcribed verbatim and scored. The individual scores were subjected to statistical analysis to obtain mean articulation score and Standard Deviation for each age group separately.

75% and 90% criteria were followed to establish the acquisition and mastery of a phoneme respectively. The order of acquisition of phonemes was delineated by description of the percentage of children who could correctly produce a phoneme in a particular word position. The order of acquisition was compared across all age groups and three word positions (Initial, Medial and Final).

The results of the present study suggested that the articulatory scores increased with age, the phoneme acquisition followed a developmental trend. Vowels, diphthongs, bilabial plosives, nasals, palatal plosives and velar plosives (except /g/) were acquired by 2.0-2.6 years of age itself, dentals plosives and fricatives were the next, followed by affricates (except /ʤʰ/) which were acquired by 3.0-3.6 years of age.

In general, the order of consonant mastery according to place of articulation followed the order of bilabials, velars, retroflex, dentals, alveolars, glottal and palatals. The order of consonant mastery according to manner of articulation followed the order of plosives, nasals, retroflex, glides, fricatives, taps and affricates.

The results of the present study were compared with existing norms of articulation acquisition in English as well as many Indian languages. In general, it was observed that present day children acquired speech sounds at an earlier age when compared to earlier existing norms and maximum articulatory development occurred between 2-3 years of age.

On comparing the articulatory scores across age groups for significant difference, it was observed that the youngest two age groups (2.0-2.6 and 2.6-3.0) were significantly different with the older age groups. The findings also indicated that maximum change in articulatory scores were between 2.0-3.0 years.

With respect to the acquisition of consonant clusters, it was observed that 3 clusters were acquired by 2.0-2.6 years of age itself. The medial clusters were acquired before initial clusters. And clusters with bilabials, laterals and nasals were earlier in acquisition when compared to clusters with fricatives and trills/taps. By 4.6-5.0 years, 13/15 tested clusters had acquired by 100% of the children.

Hence, the revised test of articulation in Odia included consonant clusters, deleted the word medial and final vowels, and obsolete words from the existing test of articulation (Panda, 1991). The present test of articulation called as Odia Diagnostic Picture Articulation Test (ODPAT) intends to examine the phonetic inventory of Odia speaking children using picture elicitation task, and can be used to ascertain the articulation age of the child tested by comparing with the mean articulation scores which are provided for each age group separately.

Limitations of the study

- It does not include nasalized vowels of the language.
- It does not test /ʤʰ/, /ɳ/ in all word positions due to unavailability of unambiguous picturable and easy words with this phoneme.
- It includes just 15 clusters, out of which 7 are initial clusters and 8 are medial clusters.
- It tested only children belonging to urban set-up and speaking the Kataki dialect of Odia language (spoken in Bhubaneswar region).

Future directions for research

- Nasalized vowels could also be tested and included to the revised test.
- More number of clusters could be included in the study.
- The present test developed can be computerized for scoring and analysis.
- The test could be validated with disordered population also.

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APPENDIX- I

Odia Diagnostic Picture Articulation Test (ODPAT)

Scoring sheet

Phoneme	Word Position	Target Word	IPA	Response	SODA	Score
/ɔ/	I	ଅଣ୍ଡା	/ɔnɖa/			
/a:/	I	ଆଖି	/ak^{h}i/			
/i/	I	ଇନ୍ଦ୍ରଧନୁ	/inɽr ɔɖ^{h}ɔnu/			
/i:/	I	ଈସ	/i:sɔ/			
/u/	I	ଉଈ	/ui/			
/u:/	I	ଊଖଳ	/u:k^{h} ɔl̩ɔ/			
/e/	I	ଏକ	/e:kɔ/			
/ɔi/	I	ଐରାବତ	/ɔirabɔt̪ɔ/			
/o/	I	ଓଟ	/oṭɔ/			
/ɔu/	I	ଔସଧ	/ɔusɔɖ^{h}ɔ/			
/k/	I	କାଉ	/kau/			
/k/	M	କୁକୁର	/kukurɔ/			
/k^{h}/	I	ଖଟ	/k^{h}ɔṭɔ/			
/k^{h}/	M	ଆଖି	/ak^{h}i/			
/g/	I	ଗଛ	/gɔʧ^{h}ɔ/			
/g/	M	ଏଗାର	/egarɔ/			
/g/	F	ବ୍ୟାଗ୍	/bjag/			
/g^{h}/	I	ଘୋଡା	/g^{h}oɖa/			
/g^{h}/	M	ବାଘ	/bag^{h}ɔ/			
/ʧ/	I	ଚପଲ୍	/ʧɔpɔl/			
ʧ/	M	ଆଚାର	/aʧarɔ/			
/ʧ/	F	ଚାମୁଚ୍	/ʧamuʧ/			
/ʧ^{h}/	I	ଛତା	/ʧ^{h}ɔt̪a/			
/ʧ^{h}/	M	ମାଛ	/maʧ^{h}ɔ/			

/ʤ/	I	ଜୋତା	/ʤoʈa/			
/ʤ/	M	ପ୍ରଜାପତି	/prɔʤapɔʈi/			
/ʤʰ/	I	ଝରକା	/ʤʰɔrɔka/			
/ʈ/	I	ଟମାଟ	/tɔmatɔ/			
/ʈ/	M	ଝିଟିପିଟି	/ʤʰiʈipiʈi/			
/ʈ/	F	ପ୍ଲେଟ୍	/pleʈ/			
/ʈʰ/	I	ଠିପି	/ʈʰipi/			
/ʈʰ/	M	ଆଣ୍ଠୁ	/anʈʰu /			
/ɖ/	I	ଡମ୍ବରୁ	/ɖɔmbɔru/			
/ɖ/	M	ଘୋଡା	/gʰoɖa/			
/ɖʰ/	I	ଢାକୁଣୀ	/ɖʰankuɳi/			
/ɖʰ/	M	ଦାଢ଼ୀ	/ɖaɖʰi/			
/ɳ/	M	ଝରଣା	/ʤʰɔrɔɳa/			
/ʈ̪/	I	ତରକାରୀ	/ʈ̪ɔrɔkari/			
/ʈ̪/	M	ପତକା	/pɔʈ̪ɔka/			
/ʈ̪ʰ/	I	ଥାଳି	/ʈ̪ʰaḷi/			
/ʈ̪ʰ/	M	ପୃଥିବି	/pruʈ̪ʰibi/			
/ʈ̪ʰ/	F	ଜଗନ୍ନାଥ୍	/ʤɔgɔnnaʈ̪ʰ/			
/ɖ̪/	I	ଦାନ୍ତ	/ɖ̪anʈ̪ɔ/			
/ɖ̪/	M	କଦଳୀ	/kɔɖ̪ɔḷi/			
/ɖ̪ʰ/	I	ଧନୁ	/ɖ̪ʰɔnu/			
/ɖ̪ʰ/	M	ଇନ୍ଦ୍ରଧନୁ	/inɖ̪rɔɖ̪ʰɔnu/			
/n/	I	ନଡିଆ	/nɔɖia/			
/n/	M	କାନ	/kanɔ/			
/n/	F	ପେନ୍	/pen/			
/p/	I	ପାଦ	/paɖ̪ɔ/			
/p/	M	ସାପ	/sapɔ/			
/pʰ/	I	ଫୁଲ	/pʰulɔ/			

/p^{h}/	M	ଟେଲିଫୋନ୍	/telip^{h}on/			
/p^{h}/	F	ବରଫ୍	/bɔrɔp^{h}/			
/b/	I	ବିଲେଇ	/bilei/			
/b/	M	ଟେବୁଲ୍	/tebul/			
/b^{h}/	I	ଭାଲୁ	/b^{h}alu/			
/b^{h}/	M	ଜିଭ	/ʤib^{h}ɔ/			
/m/	I	ମନ୍ଦିର	/mɔnɖirɔ/			
/m/	M	ଟମାଟ	/ʈɔmaʈɔ/			
/j/	M	ବ୍ୟାୟମ	/bjajamɔ/			
/r/	I	ରଥ	/rɔʈ^{h}ɔ/			
/r/	M	ବରଫ୍	/bɔrɔp^{h}/			
/r/	F	କାର୍	/ka:r/			
/s/	I	ସାପ	/sapɔ/			
/s/	M	ଚସମା	/ʧɔsɔma/			
/s/	F	ଗ୍ୟାସ୍	/gjas/			
/h/	I	ହରିଣ	/hɔriɳɔ/			
/h/	M	ବହି	/bɔhi/			
/l/	I	ଲଙ୍କା	/lɔnka/			
/l/	M	ବିଲେଇ	/bilei/			
/l/	F	ଚପଲ୍	/ʧɔpɔl/			
/sk/	I	ସ୍କରଟ୍	/skɔrʈ/			
/pl/	I	ପ୍ଲେଟ୍	/ple:ʈ/			
/kr/	I	କ୍ରିକେଟ୍	/kriketʈ/			
/pr/	I	ପ୍ରଜାପତି	/prɔʤapɔʈi/			
/ʈr/	I	ଟ୍ରକ୍	/ʈrɔk/			
/sʈr/	I	ସ୍ତ୍ର	/sʈrɔ/			
/nɖr/	M	ଇନ୍ଦ୍ରଧନୁ	/inɖrɔɖhɔnu/			
/rʤ/	M	ସୁର୍ଯ୍ୟ	/surʤjɔ/			

/ks/	**M**	ରିକ୍ସା	**/riksa/**			
/rs/	**M**	ବର୍ଷା	**/bɔrsa/**			
/ndʒ/	**M**	ଲାଞ୍ଜ	**/landʒɔ/**			
/ɖm/	**M**	ପଦ୍ମ	**/pɔɖmɔ/**			
/nn/	**M**	ଜଗନ୍ନାଥ୍	**/dʒɔgɔnnaʈh/**			
/nk/	**M**	ଲଙ୍କା	**/lɔnka/**			

Scoring

- Correct Response: 1
- Substitution: 0.5
- Distortion: 0.25
- Omission: 0

APPENDIX- II

Age-wise Cut-Off Articulatory Scores for ODPAT

Age Range (years)	Expected Articulatory Scores (+/- SD)
2.0-2.6	91.17 (1.00)
2.6-3.0	97.94 (1.00)
3.0-3.6	100.70 (1.00)
3.6-4.0	100.80 (1.00)
4.0-4.6	104.19 (0.30)
4.6-5.0	104.81 (0.30)

Maximum Score: 105

Sample Stimuli Pictures (ODPAT)

/ak^{h}i/ - To Test /a/ in Initial Position

/ɔnḍa/ - To Test /ɔ/ in Initial Position

/prɔʤapɔʈi/ - To Test Initial Cluster /pr/

/bilei/ - To Test /l/ in Medial Position

The present test material ODPAT is provided in a CD format along with the hard copies of the dissertation.