PROTOCOL FOR APPRAISAL OF VERBAL PRAXIS IN TYPICALLY DEVELOPING CHILDREN (2.6-4.0 YEARS)

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CERTIFICATE

This is to certify that this Dissertation " **Protocol for appraisal of verbal praxis in typically developing children (2.6-4.0 years)"** is a bonafide work in part fulfillment for degree of masters of (Speech Language Pathology) of the student (Registration No.06SLP015). 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

I declare that, this Dissertation entitled **"Protocol for appraisal of verbal praxis in typically developing children (2.6-4.0 years)"** is the result of my own study and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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INTRODUCTION

Speech is a motor skill. Speech production is the process of converting one's thoughts and ideas into meaningful speech. It is governed by many factors, of which motor control of speech forms an important aspect. Motor control of speech is often learned by children through the imitation of acoustic patterns provided by an "adult model" of the language. Maturity and clarity of speech in a child reflects on good speech motor control. A developmental trend in speech motor control is supported by the concept of "speech motor age" proposed by some investigators (Miller, Rosin, & Netsell, 1979; Morris, 1980). Speech motor age defines the early expressive speech of children as a sequentially acquired motor event consequent to neuronal maturation. Various studies indicate that speech motor control continues till the age of eight years, and the refinement period extends from eight to twelve or fourteen years of age in typically developing children (Kent, 1976). By this age, various processes of speech such as articulation, fluency, voice, & prosody assume adult like speech motor control, which in turn is reflected as good speech motor control or normal "speech praxis".

'Praxis' is a Greek word, which is used to describe the learned ability to plan, and carryout sequences of coordinated movements in order to achieve an objective, which could be a speech or a non-speech act. Praxis control is very important for speech production in terms of generation of articulatory postures and seriation of speech gestures. In children with developmental apraxia of speech (DAS), the deficits in verbal

praxis are primarily due to disruption of two processes. Firstly, an impaired ability to produce postures required for speech as a result of degraded internalized schemata for the three dimensional space in which the posture is to be performed (McNeilage, 1970). Secondly, an impaired ability to seriate muscle contractions to achieve accurate continuous action patterns as required for speech, which is an element of praxis. Inability to sequence or seriate muscle contractions leads to inaccurate control of skilled speech action sequences. Kent and Rosenbek (1983), attribute the disruption of speech in apraxia as due to disintegration of temporal schemata that aid in control of movement sequences, and spatial targets defined by a space coordination system of vocal tract. Because of these deficits/ disruptions, children with developmental apraxia of speech exhibit various speech sound errors like metathetic, perseverative and anticipatory errors (Smartt, LaLance, Gray & Hibbet, 1976) that may be related to the sequencing of sound elements and to reductions in the complexity of word shapes. A particular difficulty in the sequencing of phoneme elements is also present.

Very few tests / scales are available to assess developmental speech motor skills in terms of verbal praxis behaviors. There are some standard tests proposed for assessment of verbal praxis deficits in developmental apraxia of speech (Blakeley 1980; Hayden and Square 1999; Kaufman 1995; Thoonen, Maassen, Wit, Gabreels, & Schreuder 1996). There are however not many scales available to assess the developmental trend in praxis control in typically developing children. The scales developed to assess developmental apraxia of speech usually contain only those skills as test items, which are sensitive to diagnose the disorder of apraxia. These tests/ scales are not designed based on any known

data on praxis development in typically developing children. There is a need to develop a scale for assessment of verbal praxis in typically developing children and to know the patterns of speech praxis control during the course of normal development. Such a scale will help to differentiate typically developing children and children at risk for verbal praxis breakdown as in developmental apraxia of speech in the due course of development. It would further help in early diagnosis of verbal praxis errors in children and in planning for an appropriate intervention program for these children.

Need for the study:

There are no scales developed for understanding the pattern of verbal praxis development in typically developing children (2.6-4.0 years), which are standardized in Indian languages. There are very few scales which are developed for the diagnosis of developmental apraxia of speech in children lesser than six years of age. A need arises to understand the normal praxis development in order to diagnose developmental apraxia of speech in children below 6 years of age as the criteria for diagnosing dyspraxia in children older than six years cannot be applied to children lesser than six years (Thoonen, 1996,1997). For the differential diagnosis of developmental apraxia of speech versus typically developing children at this age i.e. (2.6-4.0 years), clearly defined norms for each of the verbal praxis behaviours in the form of a scale is required which are very few in number.

Aim of the study:

1. To administer a protocol developed for assessment of verbal praxis in Kannada language on typically developing children aged 2.6-4.0 years.
2. To establish norms for the various tasks in the protocol based on the performance of children included in the study, which can be used to assess children at risk for verbal praxis breakdown.

Method:

The tool called 'Assessment of oral motor, oral praxis and verbal praxis skills' was compiled and developed by Rupela (2008) & Banumathy (2008). The domains for assessing verbal praxis skills and a subsection from the oral motor assessment section, i.e., Function of the oral mechanism for speech were selected for this study from Rupela (2008) & Banumathy (2008). A section of relational speech timing in word context was included additionally to the original tool. The sections in the protocol were administered on ninety Kannada speaking typically developing children with thirty children each from the age group of 2.6-3.0, 3.0-3.6, 3.6-4.0 years. The children were selected from various primary schools/ creche in Mysore city. The children were screened for language function, oro-motor and oros-ensory skills. Any child exhibiting language delay / deviance, oro-motor, oro-sensory & orostructural deficits were excluded from testing.

The protocol included the following sections:

- Function of the oral mechanism for speech
- Isolated speech movements
- Sequential speech movements
- Word level praxis assessment- (i) Meaningful words, (ii) Non-meaningful words.
- Relational speech timing in word context
- Diadochokinetic assessment
- Sentence level assessment
- Conversational assessment

The protocol was administered to all the children in a comfortable surrounding, free of distractions. The responses were elicited by asking the child to imitate the words after hearing them. The children were given a maximum of two trials and the responses of the children were recorded using the Sony digital mini disc recorder. Video recordings were done for ten percent of the data for reliability measures. The recorded responses were transcribed and scored accordingly. The raw data was subjected to statistical analysis. Standardization of the protocol was done. A criterion of 60 percent was taken, i.e., if 60 percent of the children in the given age group perform the task correctly, then that task was considered valid for that age group. Based on the performance of children of all the three age groups, a standardized protocol is proposed. Performance of the children, on this revised scale was measured using, mean, SD and percentile scores. Inter and intrajudge reliability was done and alpha co-efficient was found out.

Implications:

- The scale will help in estimating the level of performance on verbal praxis in a given child and thus aid in early diagnosis of Kannada speaking children at risk for verbal praxis breakdown.
- It will also serve as a useful clinical tool in therapy for children with verbal praxis breakdown.

Limitations:

- Due to time constraints, the current study established standard scores for children in the age group of 2.6-4.0 years. Future studies are required to use the scale on children of older age groups and thus facilitate standardization of the protocol on larger age groups.
- Cyclic or circular error of standardization may occur. Hence, the study has to be replicated by using a population of children who had not taken part in the present study.

REVIEW OF LITERATURE

'Praxis' is the generation of volitional movements for the performance of a particular action, especially the ability to select, plan, organize and initiate a motor act. (Ayres 1985). 'Apraxia' is defined as a disorder in carrying out or learning complex movements that cannot be accounted for by elementary disturbances in strength, coordination, sensation, comprehension or attention (Strub & Black, 1981). The most distinguishing characteristic of apraxia of speech is that it is a problem of speech motor planning and programming, with no weakness, paralysis or poor co-ordination of the speech mechanism (Bowen, 1998).

Developmental apraxia of speech (DAS) is a form of apraxia, which occurs in children and is present from birth. The incidence is reported to be more in males than females. This disorder is also called 'developmental verbal apraxia', 'developmental verbal dyspraxia', 'articulatory apraxia', and 'childhood apraxia of speech' (CAS). Most latest of the label is 'Childhood apraxia of speech'. DAS is different from what is known as a developmental delay of speech, in which a child follows the "typical" pattern of speech development but does so more slowly than normal counterparts. The cause or causes of DAS are not yet well established. Some scientists believe that DAS is a disorder linked to a child's overall language development. Others believe that it is a neurological disorder which affects the brain's ability to send proper signals to move the muscles involved in speech. However, brain imaging and other studies have not found

enough evidence of specific brain lesions or differences in brain structure in children with DAS. It is also reported that children with DAS often have family members with a history of communication disorders or learning disabilities. This observation and recent research findings suggest that genetic factors may play a role as well in the disorder (Battey, 2007).

The major characteristics of children with DAS, given by Rosenbek & Wertz (1972) include, errors in sound class and manner of production, addition errors, prolongation errors, repetition errors, voicing and dipthong errors, difficulties in sequencing phonemes, metathetic errors, inconsistency and / variability of errors, poor intelligibility, groping / silent posturing of articulators and prosodic disturbances. The characteristic speech of children with developmental apraxia of speech includes differences in the rhythm and timing prosody or 'melody' of speech and inconsistent speech sound errors. According to Velleman and Davis, (2000), the phonetic / phonological characteristics in infants and toddlers with apraxia of speech include:

- Systematic gaps in consonant or vowel repertoire. Little variety either of consonants or vowels
- Marginal babble, without "true" consonants. Lack of consonant, vowel babble. Few idiosyncratic word shapes with consistent meaning.
- Incomplete syllables or presence of isolated consonants and vowels. Consonants and vowels in the repertoire are not combined freely.
- Lack of variation in vowels.
- Limited or stereotyped intonation patterns.

- Overall vocal output may be very limited. There could be a regression in the vocabulary (words used by the child earlier is lost).
- Cannot combine different syllables.
- Groping / lack of flexibility.

Velleman & Davis (2000) also listed out the phonetic / phonological characteristics of older children. They include:

- Limited consonant and vowel phonetic inventory.
- Predominant use of simple syllable shapes.
- Frequent omission errors.
- High incidence of vowel errors.
- Altered supra-segmental characteristics.
- Variability / lack of consistent patterns of output.
- Increased errors on longer sequences.
- Groping / lack of willingness to imitate.

The visible symptoms of CAS as cited by Velleman & Davis (2000) include:

- Little or no babbling in infancy and presence of few consonants only.
- Understanding of language is much better than production of language.
- Slow, effortful, or halting speech and sometimes associated with struggle.
- Speech is very difficult to understand.
- Slow progress in therapy.

Apraxia of speech could be present in young children. Since, verbal expression is limited as a developmental feature, presence of apraxia of speech can only be suspected in young children. Such children are labeled as having suspected childhood apraxia of speech (sCAS). Shriberg, Kwiatkowski, & Rasmussen (1990), suggested that errors in stress production could be a significant diagnostic marker for sCAS. Earlier, Shriberg (1997), listed two diagnostic features as characteristic of children with suspected Childhood apraxia of speech. These included: (a) differences in the errors of children with developmental speech delay and (b) errors resemble that of adults with acquired apraxia of speech.

According to Bowen (1998), the key features that alert a speech-language pathologist to the possible presence of CAS in a young child include:

1. No words, or presence of very few words, or presence of 100 to 200 words only in their vocabulary. They may attempt to make not more than a handful of 2-word combinations.

2. Presence of effortful speech, exhibiting trial and error attempts to say words, accompanied by great frustration.

3. Use of self-learnt signs and gestures to augment communication, which may include a lot of ingenious body language, facial expression, mime and gestures to communicate. Some may also use a repertoire of sound-effects (car noises) to augment signs and gestures, to good effect.

4. Speech of such children may be characterized by:

- Unclear words, though there could be some exceptions such as a very clear and useful 'no'. Examples: The word 'ball' may be pronounced as 'or' and 'knee' as 'dee'.
- Increased frequency of vowel errors. For instance, 'milk' might be pronounced as 'mih', 'muh' or 'men'.
- Inconsistent errors on the same word. A target word is often pronounced in several different ways (e.g., 'me' pronounced as 'ee', 'dee', 'bee' 'nee', or 'mee'). This is called as token-to-token variability.
- Inconsistent omission of sounds in words. For example, a child may use /p/ twice in the word 'Poppi', but pronounce both 'happy' and 'puppy' as 'huh-ee'.
- Poor imitation of speech sounds and sound effects (e.g., car noises: brm-brm etc).
- Unusual intonation, pause and stress patterns in the speech.
- Improper use of nasal resonance.

5. Good comprehension of language at a more advanced level than the limited speech output. This is sometimes called the Receptive-Expressive gap.

6. Poor abilities to copy mouth movements (i.e., non-speech movements) and general reluctance to imitate speech movements and words.

Davis, Jakielski & Marquardt (1998), reported the following speech characteristics in children with suspected apraxia of speech (sAOS):

- Limited phonemic inventory
- Omission errors

- Vowel errors
- Inconsistent articulation errors
- Altered suprasegmental characteristics such as disordered prosody, voice quality and fluency.
- Increased errors on longer units of speech output.
- Difficulty initiating words and phrases.
- Predominant use of simple syllable shapes.
- Impaired volitional oral movements.
- Reduced expressive versus receptive language skills and
- Reduced diadochokinetic rate.

In another study by Marquardt, Sussman, Snow and Jacks (2002) three out of six children with sCAS showed poorer perception and / or representation of syllable structure than their typically developing peers. In a longitudinal study of children with CAS, Davis, Jacks & Marquardt (2005) found persistence of vowel inaccuracies in CAS children inspite of a relatively complete vowel inventory. Peter & Gammon (2005) studied timing errors in children with sCAS using sentence & nonword imitation tasks and found that children with sCAS produced longer vowel durations than their typically developing peers.

The speech disorder described as Developmental verbal dyspraxia has proved to be one of the most controversial of the developmental speech disorders. The developmental apraxia of speech or Childhood apraxia of speech is a disorder with vague characteristics of speech which makes it impossible to distinguish from other childhood

speech disorders (Guyette & Diedrich, 1981). Characterizing apraxia of speech in children have frequently led to description of a variety of characteristics of a group of children in an attempt to delineate the cluster of features, that would permit clinicians to distinguish developmental apraxia of speech from other communication disorders. Stackhouse (1992) attributed the difficulty in differential diagnosis of DAS from other speech sound disorders to three major factors. They include,

- Lack of detailed description of the speech errors found in children with DAS.
- Methodological problems within individual studies; specifically with respect to subject selection criteria.
- Lack of a developmental perspective; which is the most serious barrier.

There is lack of knowledge about the development of praxis and its influence on child's developing linguistic system. Stackhouse (1992) proposed a list of speech characteristics in children with DAS, which may not be present in children of all age groups. The defining characteristics of the disorder depend on the child's developmental level. This suggests the unfolding and changing nature of the condition as new demands are made on the child and Stackhouse (1992) thus concluded that there is no single diagnostic marker for DAS. Hall, Jordan & Robin (1993) argued that DAS is a diagnosis based on speech characteristics that are seldom uniquely descriptive of the disorder and there are no non-speech diagnostic criteria to characterize DAS or differentiate DAS from other speech disorders. Shriberg & Campbell (2003) supported these results and suggested that the symptoms change over time in DAS.

The major problem in diagnosing young children with childhood apraxia of speech is that there is no single universally accepted diagnostic marker for this disorder. Also, there is lack of appropriate diagnostic guidelines for childhood apraxia of speech. Shriberg & Campbell (2003) suggest that the major source of over diagnosis of CAS is the inconsistent and conflicting behavioural features proposed as the diagnostic signs of CAS. The diagnostic criteria used to identify developmental apraxia of speech (DAS) have been the center of controversy for decades. In an experiment by Forrest (2003), the criteria used by 75 speech language pathologists to establish a diagnosis of DAS indicated that there were fifty different characteristics used by these speech language pathologists. Amongst them six characteristics accounted for 51.5% of the diagnosis, and these included:

- Inconsistent productions.
- General oral- motor difficulties.
- Groping.
- Inability to imitate sounds.
- Increasing difficulty with increased utterance length.
- Poor sequencing of sounds.

Study by Forrest (2003) suggested that many diagnostic markers were used by speech language pathologists to diagnose developmental/ childhood apraxia of speech and there were some controversies in the criteria used.

The major solution to these difficulties in diagnosis and differential diagnosis of CAS / sCAS is to develop appropriate scales or tests for assessing the development of verbal praxis. Some studies have addressed the development of oral praxis in young toddlers and children. In an experiment by Kools & Tweedie (1975), the performances of 87 normal male children, between the ages one to six years, were assessed on the four measures of praxis i.e. oral praxis command, oral praxis demonstration, limb praxis command, and limb praxis demonstration. Results showed an orderly emergence of praxis control in all measures beginning by about age one and reaching nearly perfect performance by age six. The ability to follow demonstration emerged earlier than ability to follow spoken commands. Praxis correlated somewhat with articulation and language skills at age 2 but the magnitude of the correlations decreased with increasing age intervals. Normative data were also provided for clinical researchers interested in studying "apraxic" children.

A few standard tests are proposed for the assessment of verbal praxis deficits in developmental apraxia of speech. But they are very few in number especially for the toddlers and young children. Blakeley (1980) developed a screening test for developmental apraxia of speech. This test was specifically constructed to aid in the differential diagnosis of developmental apraxia of speech. It consists of eight subtests that investigate:

- The discrepancy between expressive and receptive language ability.
- Production of vowels and dipthongs in words.
- Oral motor movements.

- Production of three syllable sequences.
- Imitation of multisyllabic motorically complex words.
- Production of words presented three at a time.
- Transpositions in the imitation of words.
- Prosody in connected speech.

Guyette & Diedrich, (1981) pointed to the theoretical and methodological limitations of this test & reported that it was less sensitive in identifying children with developmental apraxia of speech.

Hayden and Square (1999), proposed the " Verbal Motor Production Assessment for Children (VMPAC)" scale for children aged 3 to 12 years. The VMPAC includes a step-by-step evaluation of the child's motor speech system. Profiles for normal children are established for the "95", "50" and "5" percentile points. This test was designed to identify children who have motor problems that negatively affect normal speech motor control, focal oromotor control, sequencing, connected speech and language control, and speech characteristics with the test items arranged from basic to complex skills. VMPAC evaluates the overall speech motor development and helps in the diagnosis of the developmental apraxia of speech.

The Kaufman speech praxis test (KSPT) developed by Nancy Kaufman (1995), identifies the level of breakdown in a child's speech so that treatment goals can be selected and progress recorded. Test items are organized from simple to complex motor-

speech movements, using meaningful words whenever possible. The test is easy to administer and score, and it helps to measure a child's imitative responses to the clinician, locates where the child's speech system is breaking down, and points to a systematic course of treatment. The test includes an imitative, stimulus / response format that can be administered easily without pictorial stimulation. Norm-referenced and standardized items are made available that provide a raw score, a standard score, and a percentile ranking for each section of the test. A diagnostic rating scale assists in delineating severity levels on a continuum and also normative information related to the "normal" speaking population of children and the "disordered" population. Results of the KSPT are useful beyond establishing an initial diagnosis. Gains in motor-speech proficiency can be measured and quantified in several ways. Individual sections of the test can be used to establish treatment goals and measure progress.

Thoonen, Maassen, Wit, Gabreels, & Schreuder, (1996) developed a protocol for assessing the maximum performance abilities of children. They used maximum phonation duration (MPD), maximum fricative duration (MFD), maximum repetition rate for single syllables (MRRmono), maximum repetition rate for tri-syllabic sequences (MRRtri) as measures to assist in the differential diagnosis of speech dyspraxia and dysarthria in pediatric clients. The prolongation tasks such as prolongation of [a] and the word [mama] to yield a maximum phonation duration (MPD), prolongation of [f], [s], & [z] to yield a maximum fricative duration (MFD) & repetitions of [pa], [ta], [ka] , [pataka] did not appear to be potential indicators of dysarthria or dyspraxia in this age group. Repetition rates were much more stable within and across children whereas

prolongation tasks were highly variable within and across children. They concluded that MRRmono can be effectively used for children in the age range of 4-6 years but usage of MPD led to misdiagnosis.

Blackley (2001) developed another screening test for DAS in children aged 4.0-12.11 years. A pre screening task (comparison of receptive and expressive language abilities) has to be completed before administering this test. If the client passes the prescreening, then three subtests are administered, including prosody, verbal sequencing and articulation. This was standardized on children with DAS and children with normal speech development. This screening instrument points to the need for additional and more specific speech and neurological evaluation.

There are no scales available to assess the developmental trend in praxis control in typically developing children. The scales developed to assess developmental apraxia of speech usually contain only those skills as test items, which are sensitive to diagnose the disorder of apraxia. These tests / scales are not designed based on any known data on praxis development in typically developing children. Thoonen, Massen & Gabreels (1997) made an attempt to propose a standardized procedure for the differential diagnosis of DAS. Firstly, a standardized assessment procedure for the elicitation and analysis of real word and nonsense word imitation was used and validated as an adequate procedure to measure relevant speech symptoms of DAS. Secondly, a combined score of three parameters (error counts of substitutions, omissions and cluster reductions) was proposed which turned out to be an adequate measure of severity of DAS. Thirdly, a comparison of

error rates in real words and nonsense words revealed an important speech characteristic of DAS, which might contribute to differential diagnosis. Methodologically, the results of this study emphasize the importance of a standardized procedure and the analysis of a comprehensive set of speech characteristics that allows for the assessment of a speech profile.

A longitudinal study was conducted by Davis, Jakielski, & Marquardt (1998) at the University of Texas. The purpose of the study was to follow up children diagnosed as having DAS. Of the twenty-two children referred with a diagnosis of DAS or sCAS, the DAS diagnosis was confirmed in only four children at the University of Texas. Camphell (2003) reported that second opinion assessment conducted at the children's hospital of Pittsburgh confirmed a prior diagnosis of childhood apraxia of speech in only 17% of cases, suggesting a significant over diagnosis of childhood apraxia of speech among children with severe and persistent speech disorder. These studies suggest that for a definite diagnosis of developmental apraxia of speech and other speech sound disorders, a validated scale/ test is required.

There is a need to develop a scale for assessment of verbal praxis in typically developing children in order to know the patterns of speech praxis control during the course of normal development. Such a scale will help to differentiate between typically developing children and children at risk for verbal praxis breakdown as in developmental apraxia of speech in the due course of development. It would further help in early diagnosis of verbal praxis errors in children and also help in planning for an appropriate intervention program for these children. There are no such scales or tests, which are

developed, in the Indian languages. Hence there is a need for the development of a standardized scale/ test for assessing the development of praxis in typically developing children. This study proposes to investigate the development of verbal praxis skills in typically developing children with Kannada as native language in the ages 2.6-4.0 years and propose norms for assessment of verbal praxis in this age group.

METHOD

The study aimed to develop a protocol for the appraisal of verbal praxis in typically developing Kannada speaking children (2.6 - 4.0 years). The protocol can be used as an assessment scale for identifying Kannada speaking children who are at risk for praxis breakdown. The protocol consists of various sections for comprehensive assessment of the verbal praxis breakdown in Kannada speaking typically developing children in the age range of 2.6-4.0 years.

Aim of the study:

1. To administer a protocol developed for assessment of verbal praxis in Kannada language on typically developing children aged 2.6 - 4.0 years.
2. To establish norms for the various tasks in the protocol based on the performance of children included in the study, which can be used to assess children at risk for verbal praxis breakdown.

Subjects:

A total of ninety children were included in the study. There were thirty children in each of the age groups 2.6 - 3.0, 3.0 - 3.6, & 3.6 - 4.0 years. The details are provided in table 1.

Table 1: Distribution of subjects across age and sex

Age groups	No. of subjects	
	Males	Females
2.6-3.0	16	14
3.0-3.6	16	14
3.6-4.0	12	18
Total	44	46
	90	

All the subjects were typically developing children having their first language as Kannada and second language as English. They were selected randomly from English medium creche, preschools and primary schools in Mysore city. The language abilities were screened to verify delay / deviance if any using the "Assessment Checklist For Speech and Language Skills" (Geetha, 2007) developed in Kannada. Only those children whose language age was on par to their chronological age were included. Children were also screened for oro-motor and sensory weakness and oro-structural abnormalities by using a screening questionnaire, and also by asking them to perform certain simple oro-motor tasks. The items in the questionnaire (as shown in Appendix B) were adapted from the "Oro-motor section" of the Screening Test for Developmental Apraxia of Speech (Blackley, 1980). Oro-structural abnormalities were screened based on oral mechanism examination. Any child exhibiting language delay / deviance, oro-motor, oro-sensory & oro-structural problems were not included in the study.

Test protocol and administration of the protocol:

No standardized assessment tool is available in Kannada to assess oral motor, oral praxis and verbal praxis skills. A tool called "Assessment of oral motor, oral praxis and verbal praxis skills' was compiled and developed by Rupela (2008) & Banumathy (2008) for assessment of individuals with Down's syndrome & Suspected Apraxia of speech in Kannada language. The items, in this tool were specifically designed to meet the needs of Kannada speaking individuals typically developing in the age range of 4 to 7 years. This assessment tool is meant for observation of oral motor, oral praxis & verbal praxis skills. In this study however, only the verbal praxis assessment section and a subsection from the oromotor assessment section, i.e. Function of the oral mechanism for speech is included. The purpose of this study was to administer these sections of the test on typically developing Kannada speaking children in the age range of 2.6 - 4.0 years (3 groups with 6 month interval) and establish norms. This will help in understanding verbal praxis deficits in children with various developmental disabilities who are at risk for verbal praxis failures.

The sections included from the protocol of Rupela (2008) & Banumathy (2008) are as follows:

I. Function of the oral mechanism for speech.

II. Verbal praxis assessment:

   A. Isolated speech movements

   B. Sequential speech movements

C. Word level praxis assessment

(i) Meaningful words, (ii) Non-meaningful words

D. Diadochokinetic assessment

E. Sentence level praxis assessment

F. Conversational assessment

The stimuli i.e. the words and sentences selected under verbal praxis assessment section by Rupela (2008) & Banumathy (2008) were based on the degree of difficulty ranging from easy to difficult, the distance of placement between the adjacent sounds in the words. The stimuli words were subjected to pilot study for validation and they were also verified by a linguist.

This study, an additional task of "Test for relational speech timing in words" was included along with the other tasks of verbal praxis tool of Rupela (2008) & Banumathy (2008). In this study, an additional task of "Test for relational speech timing in words" was included along with the other tasks of verbal praxis tool of Rupela (2008) & Banumathy (2008) because, relational speech tasks reflects on the timing inaccuracies and inconsistencies in the speech of individuals with apraxia of speech (Forrest, 2003; Strand & McNeil, 1996; Rogers, 1997).

The details about the assessment protocol used in the present study is given in Table 2.

Table 2: The assessment protocol used in the present study

Section No.	*Tests*
I	Test for function of oral mechanism for speech
II. A	Test for isolated speech movements
II. B	Test for sequential speech movements
II. C	Test for word level praxis assessment in (i) meaningful words, (ii) nonmeaningful words
II. D	* Test for relational speech timing in word context- monosyllables, bisyllables
II. E	Diadochokinetic assessment
II. F	Test for verbal praxis in sentences
II. G	Test for verbal praxis in conversation

Note :[* Extra task included in the study.]

The protocol used in this study is presented in Appendix A and the details of the sections included in the protocol are as follows:

Test I: Function of the oral mechanism of speech.

Velleman (2002) emphasizes the need for assessing the function of oral mechanism for speech in terms of oral-nasal distinction, air build up for stops, fricatives, and range of movement of articulators in persons with Childhood Apraxia of Speech. This section was included in order to assess for adequacy of oral mechanism as required for verbal praxis behaviors. The section included 6 tasks. The subjects were instructed to

imitate the activities following the investigator. Scores of 0 -1 was offered based on the adequacy / inadequacy of the performance. A score of '0' represents inadequate performance and a score of 'I' represents adequate performance.

Test II. A: Isolated speech movements

Stimuli including vowels, continuant consonants and CV syllables with consonants that occur in initial position in Kannada were included. There were a total of twenty-four stimuli in this test. The selection of these stimuli was based on the predominant use of jaw, lip and tongue structures for the utterance of these sounds. The subjects were instructed to imitate the sound after the investigator and a repetition of two were provided if the child was unable to do it or perform the task inappropriately. The performance of the subjects was assessed using a 4-point rating scale. The rate of movement during the production of the task was not considered. Each item was scored based on accuracy of movement and whether repetitions were required to perform the task. Scores of '0' to '3' were given as follows:

3 - Movement / action is accurate

2 - Movement / action is accurate with one repetition

1 - Movement / action is inappropriate with more than one repetition

0 - Child is unable to perform even with repetitions.

Test II. B: Sequential speech movements:

This section was incorporated to increase the complexity of the task for assessment of verbal praxis deficits. It was adapted from the 'Multiple oromotor-phoneme (speech) movements' section of VMPAC (Hayden & Square, 1999). Stimuli selected in this section gave scope for double and triple speech movements. This section incorporated utterance of vowels and continuant consonant /m/. The participants were instructed to imitate the speech movement as produced by the investigator. Initially the sound was produced once, and if the child was able to imitate the stimuli, it was repeated three times in a sequence and the child was asked to imitate the sequence. The ability of the child to produce the sequence was analyzed and scored.

Two types of scores namely; 'Motor control score' and 'Sequential motor score' were used to calculate the appropriateness of movements and maintenance of sequence respectively. Scoring was done as follows based on the responses given by the participants:

Motor control score (MCS):

'2'- All movements are precise in every parameter

'1'- One or all movements are partially imprecise in one or more parameters

'0'- One or all movements are severely imprecise in one of more parameters or child substitutes one phoneme for another or child does not say all phonemes

Sequence maintenance score (SMS):

'2'- Repeats all phonemes in the sequence correctly.

'1'- Repeats 2 out of 3 sequences correctly or repeats the phonemes 5 or 6 times

'0'- Repeats one out of 3 sequences correctly or repeats the phoneme sequence more than 6 times.

If the child did not respond to the task due to inability to do so and not due to noncompliance or inattentiveness, then the item was marked as NR (no response) and a score of '0' was given.

Test II. C: Word level praxis assessment

In children with childhood apraxia of speech (CAS), the deficits in verbal praxis are primarily due to disruption of two processes. Firstly, an impaired ability to produce postures required for speech as a result of degraded internalized schemata for the three dimensional space in which the posture is to be performed (Mc Neilage, 1970). Secondly, an impaired ability to seriate muscle contractions to achieve accurate continuous action patterns as required for speech, which is an element of praxis. Inability to sequence or seriate muscle contractions leads to inaccurate control of skilled speech action sequences. Two types of stimuli were incorporated in this section: (i) Meaningful words & (ii) Non-meaningful words.

(i) Meaningful words:

180 commonly occurring Kannada words differing in syllable length and presence of clusters were compiled from a pictorial glossary in Kannada (Kumari & Mallikarjun, 1985) by Rupela (2008) & Banumathy (2008). These words were short-listed by two speech language pathologists to sixty commonly occurring words. These words were then

rated for their degree of familiarity by five, 4-5 year old typically developing children on a 3-point rating scale that was devised as follows:

'0'-1 don't know this word

' 1'-1 have heard it, but don't know what it means

'2'-1 know this word well.

Thirty most familiar words i.e. the ones that were rated '2' were selected from this list including five words each from disyllabic, tri-syllabic and multisyllabic structure with and without clusters. In order to include words with more complex structure, another list of 100 words with two and three clusters was prepared from a Kannada dictionary. These words were short-listed to thirty words by a speech language pathologist and then ten words by another speech-language pathologist. The list was finalized after consulting a linguist regarding the dialectal appropriateness of the words amongst the Bangalore-Mysore Kannada speaking persons. All words were arranged in a hierarchy of increasing length and presence of clusters as follows:

- Disyllabic words without clusters
- Disyllabic words with clusters
- Tri-syllabic words without clusters
- Tri-syllabic words with clusters
- Multisyllabic words without clusters
- Multisyllabic words with clusters
- Disyllabic words with two clusters-one in the initial and one in the medial position

- Tri-syllabic words with two clusters-one in the initial and one in the medial position.

Totally, forty words were selected in the protocol proposed by Rupela (2008) & Banumathy (2008). The same was adopted in this study. The investigator uttered the words one by one and the subjects were asked to imitate them. The responses of the subjects were analyzed in two ways.

(a) Number of words correct:

All words were transcribed using the Broad transcription of International Phonetic Alphabet (IPA) and total numbers of words produced correctly were tabulated.

(b) Syllable sequence score: This was calculated to assess whether the sequence of syllables within the words was maintained. The number of syllables that were misplaced or exchanged in terms of sequence were noted. A score of '0' to '2' were given as follows:

Sequence maintenance score-disyllabic words:

2 - Repeats both syllables in the correct order

1 - Repeats both syllables in reverse order or adds an extra syllable or repeats a syllable, consonant cluster reduction / deletion, consonant harmony, vowel harmony.

0 - Repeats only one syllable or does not repeat any syllable in the correct order.

If the child does not respond, it is scored as 'no response (NR)' with score 0.

Sequence maintenance score - trisyllabic and multisyllabic words:

2- Repeats all syllables in the correct sequence

1- Repeats all syllables except one in the correct sequence or any one syllable in reverse order or addition of a syllable, consonant cluster reduction / deletion, consonant harmony, vowel harmony.

0- Repeats one syllable correctly or does not repeat any syllable in the correct order

If the child does not respond, it is scored as 'no response (NR)' with score 0. The scores were not reduced for consonant / vowel substitution unless where consonant / vowel harmony occured as repetition of syllables and deletion or reduction of syllables occured as a result of consonant cluster reduction or deletion.

(ii) Non-meaningful words: The non-meaningful words were included based on the frequency of occurrence of sounds and sound combinations in Kannada language. Totally 4 sets of words were included. Each set consisted of 5 words each and hence the total number of words was 20. Very few studies have used non-meaningful words to assess praxis failures. Thoonen, Maassen & Gabreels (1997) used real words & nonsense words to assess children with DAS and normal controls and found that both subject groups performed worse on nonsense words than on real words. The target words in this section were uttered by the investigator and they were imitated by the subjects. The responses of the subjects were transcribed using broad transcription of International Phonetic Alphabet (IPA). The responses were scored as follows:

(a) Number of words correct:

The total numbers of words produced correctly were tabulated.

(b) Syllable sequence score: This was calculated to analyze whether the sequence of syllables was maintained. The number of syllables that were misplaced or exchanged in sequence within each target word was analyzed.

Task II D: Relational speech timing in word context:

A list of meaningful words (4 monosyllables & 4 bi-syllables) was selected. Relational speech timing task used in this study consists of 8 base words with three levels of increasing utterance lengths due to suffixes added to the base word. Totally 24 stimuli items are present. The first stimuli (RST-I) in each set of words is the Base Word (BW) condition. The second set of stimuli (RST-II) is the Base Word + Suffix I (BW+SI) condition, and the third stimuli (RST-III) is the Base Word + Suffix II (BW+SII) condition. All of the base words and their suffix conditions were meaningful words. The stimuli words selected were checked for item validity by two speech language pathologists.

Investigations have reported increased errors with increased utterance length (timing errors) as one of the early diagnostic signs of praxis failures and one which can account for the diagnosis of CAS (Forrest, 2003). Hence relational speech timing tasks is considered as a sensitive measure to tap the praxis failures. Strand and Mc Neil (1996) and Rogers (1997) reported that the relational speech timing measures are most likely to reveal unique characteristic of speakers with apraxia of speech. They found that in the

production of words, word-strings and sentences, apraxic subjects exhibited significantly longer vowel and between-word segment durations in sentence & word contexts. Collins, Rosenbek & Wertz (1983) used three sets of words, which progressively increased in length and found that the word and vowel duration in apraxic speakers were significantly longer than those for normal speakers. Hence, this test was added, due to its increased sensitivity to identify praxis breakdown in children with suspected apraxia of speech (sCAS). The target words were uttered by the investigator and they were imitated by the subjects. The responses of the subjects were transcribed using broad transcription method of International Phonetic Alphabet (IPA). The responses were scored as follows:

(a) Number of words correct:

Number of words correct for each set was tabulated.

(b) Syllable sequence score: This was calculated to analyze for the ability to maintain syllable sequence by the subjects. The number of syllables that were substituted or exchanged in terms of sequence were noted per utterance.

The three subsections in word level praxis assessment (meaningful words, non-meaningful words and, relational speech timing task), phonological processes were analyzed and they were categorized as space errors, timing errors, whole word errors, & others. Refer Appendix-C for the phonological processes observed in children.

Task II E: Diadochokinetic assessment

The measure of DDK is considered sensitive in CAS & is included in most assessment protocols developed for persons with CAS. The subjects were instructed to

repeat syllables /pə/, /tə/, /kə/, (SMR-Sequential Motion Rates) and /pə/, /tə/, /kə/, independently (Alternative Motion Rates-AMR) as fast as they could. If they did not understand the instructions, they were given clues by tapping a finger for every syllable and progressively moving it upwards. The analysis of the responses of the subjects was made in terms of rate, accuracy and consistency of the production. A maximum of two attempts were given to produce a minimum of ten iterations per trial to each child. The scoring / analysis were carried out in the following ways:

a) Attempts:

A maximum of two attempts were given to each child, and the best attempt with atleast ten iterations was considered for calculation of DDK rate.

b) Scoring for Accuracy:

Accuracy of utterance is considered an important measure for the analysis of DDK in typically developing children (Williams, & Stackhouse, 2000). Responses of all the subjects were rated for accuracy with respect to articulation. If the first four repetitions were accurately produced, a score of 1 was given and 0 if the repetitions were inaccurate.

c) Scoring for consistency:

Consistency in the repetition of pə- tə- kə from token to token or token-to-token variability in the SMR task is considered important to evaluate praxis breakdown. Inconsistent errors characterize the speech of persons with CAS (Robin, 1992; Davis et al., 1998; Forrest & Morrisette, 1999; Nijland et al., 2002; Forrest, 2003; Nijland et.al.,

2003). In order to evaluate consistency of productions in the DDK tasks, the following scoring procedure was used:

'3'- Consistent repetitions; no change from one repetition to the next

'2'- Three of the four repetitions are consistently repeated.

' 1'- Two of the four repetitions are consistently repeated.

'0'- All repetitions are different from one another.

d) DDK rate:

Continuously uttered and clearly enunciated segments of iterations were marked using 'wavesurfer'software, an open source tool for sound visualization and manipulation (Sjolander, & Beskow, 2005). DDK rate was calculated using the following formula.

$$\text{DDK rate} = \frac{\text{Total number of iterations}}{\text{Duration of trial}} \text{ (Iterations/second or it/sec)}$$

Task II. F: Sentence level praxis assessment

A list of thirty sentences with increasing syllable length was prepared and a linguist was consulted to look into the dialectal appropriateness and adequate vernacular forms of these sentences. The sentences were then subjected to a familiarity rating by five, 4-5 year old typically developing children using a 3-point rating scale that was devised as follows:

'0'-1 don't understand this sentence at all

' 1'-1 understand this sentence partially

'2'-1 understand this sentence well

Ten 'most familiar' sentences which were scored as '2' were selected and arranged hierarchically based on the syllable length. Syllable length of the shortest sentence was three syllables and the longest sentence was twelve syllables. The word length of the shortest sentence was two words and the longest sentence was six words. The subjects were instructed to repeat each sentence after the investigator and each response was transcribed using the broad IPA system of transcription. The analysis was carried out in two ways:

(a) Number of sentences correct:

The total number of sentences produced correctly was tabulated.

(b) Sequence maintenance scores for sentences:

This score was adapted from the 'Oromotor production in word sequences and sentences' section of VMPAC (Hayden & Square, 1999). Slight modifications were made when compared to VMPAC. The VMPAC does not use greater than four word sentences. The word length in this test varied from two to six words. The responses of the subjects were scored on the basis of number of words in the sentences, i.e. sentences were considered as belonging to two groups, (i) lesser than three words & (ii) greater than three words. A three point rating scale was used for scoring the responses in lesser and greater than 3 words as follows:

2- All the words are in the exact order or position / child uses a consistent phoneme substitution

1- Sentences with ≤ 3 words - At least 1 word is in order

Sentences with > 3 words - At least 3 of the key words are in order

0- Sentences with ≤ 3 words - 0 words in order

Sentences with > 3 words -2, 1 or no key words are in order.

If the child did not respond due to inability to do so and not due to noncompliance or inattentiveness, then the item was marked as NR (no response) and a score of '0' was given.

Task II. G: Conversational analysis/ analysis of spontaneous speech:

Several researchers have hypothesized that the underlying deficit in CAS is in the syllabic framework (Davis et.al., 1998; Marquardt et al., 2002; Maassen, 2002; Nijland et al., 2003), or sequencing of syllable (Thoonen, Maassen, Wit, Gabreels, & Schreuder, 1996). Davis et al. (1998) proposed 8 key characteristics of CAS, including frequent omissions, increased errors on longer units, and predominant use of simple syllable shapes. Lewis et.al (2004) found that children with CAS who were followed from preschool into school age differed from children with speech disorders at school age with respect to sequencing errors in conversational speech than the speech-delayed children. Thoonen et al. (1996) also noted that multisyllabic word tasks were critical for differentiating CAS from dysarthria.

A spontaneous speech sample of at least a hundred utterances was collected from each child by indulging in general conversation about home, routine, and school. The recorded sample of atleast a hundred utterances of each child was transcribed using the broad system of IPA transcription. The child was engaged in conversation for approximately three minutes. A conversation sample of one minute of each child was considered and approximately 15- 20 words appearing in the middle of the sample was taken for analysis. The conversation sample was analysed using percentage consonant correct (PCC) and percentage vowel correct (PVC) measures.

Before the analysis of PCC, the following data were excluded from the sample:

- Unintelligible and partially intelligible utterances
- Vowels
- Consonants which were repeated for the third time or more on repetition of the same word, if the pronunciation did not change. But if the pronunciation changed all the consonants were included for scoring.

The following were considered when the sample was analyzed for consonant errors.

- Dialectal changes, casual speech pronunciations and allophonic variations were not scored as incorrect.
- Consonant deletions were scored as incorrect
- Consonant substitutions were scored as incorrect
- Partial voicing were scored as incorrect
- Distortions were scored as incorrect
- Additions of consonants were scored as incorrect.

Before the analysis of PVC, the following data were excluded from the sample:

- Unintelligible and partially intelligible utterances
- Consonants
- Vowels which were repeated for the third time or more on the same word, if the pronunciation did not change, but if pronunciation changed, all the vowels were included for scoring.

The errors in the remaining data was identified using the following criteria:

- Dialectal changes, casual speech pronunciations and allophonic variations were not scored as incorrect.
- Vowel deletions were scored as incorrect.
- Vowel substitutions were scored as incorrect.
- Distortions were scored as incorrect.
- Additions of vowels were scored as incorrect.

(i) PCC scoring:

The total number of consonant errors was tallied from the transcribed samples and the percentage of consonants correct (PCC) were calculated using the formula as follows:

$$PCC = \frac{\text{Total number of correct consonants}}{\text{Total number of consonants attempted}} \times 100$$

(ii) PVC scoring:

The total number of vowel errors was tallied from the transcribed samples and the percentage of vowels correct (PVC) were calculated using the formula as follows:

$$PVC = \frac{\text{Total number of correct vowels}}{\text{Total number of vowels attempted}} \times 100$$

Administration of the protocol:

The demographic information such as name, age with date of birth, education and school, was obtained from each child and the tasks in the protocol was administrated to each child in a comfortable, non distractible surroundings. All children were tested individually in relatively quiet and familiar surroundings. The stimuli were spoken out by the tester with correct articulation and with correct rate giving adequate time for the child to respond. The responses were elicited by asking the child to imitate the words after hearing them. A minimum of two repetitions were given per item. The better of the two repetitions was considered for analysis. The conversation sample was elicited by asking general questions about the child's name, friends, family, house, school etc. Reinforcements were given whenever required. The child's responses were recorded online using the Sony mini disc recorder with microphone kept approximately 10 cm from the child's mouth. Each participant was also provided with intermittent breaks after every 20 minutes or much earlier whenever required based on the temperament of the child. Total recording time ranged from 20 minutes to 30 minutes per child depending on the co-operation of the child.

Reliability:

Reliability measures were done in order to check for the reliability of the tests, and the rating scores. Since, the protocol involved the use of rating scales, the scoring system was subjected to variability. Two types of reliability measures (inter-judge & intra-judge reliability) were carried out.

Inter - judge reliability: A judge matched in gender, education, and work experience with the principal investigator was identified for the task. The judge was briefed about the scoring pattern of the various tasks. Video recordings of the testing by the principal investigator were done on ten percent of the data (i.e. nine children), for reliability measures. Video recordings were done using Canon ZR 90 Digital video camcorder and were converted into DVDS for permanent storage. The video camera was placed on a table in front of the child and the investigator and the child were seated side by side. Video recording was started whilst administration of the test battery where positive feedback and appropriate cues were given in order to elicit the speech. These recorded videos were viewed by the judge on a 20 inches wide computer monitor. The responses of nine children randomly selected from different age groups and across sex were analyzed by the judge based on the video samples. The scores of these subjects as graded by the judge and the principal investigator was compared and the reliability co- efficient alpha was calculated.

Intra-judge reliability: Ten percent of the subjects (i.e. nine children), was again analyzed by the principal investigator after a gap of six weeks. The scores obtained by the subjects during the first and the second analysis was compared and the reliability co-efficient alpha was calculated for the same.

Statistical Analysis:

SPSS (version 10) was used (Garrett & Woodsworth, 1979). The data obtained from the subjects was subjected to the following statistical procedures.

1. Standardization of the protocol was done. The criteria for choosing a skill as appropriate for that age group was 60%, i.e. if 60% of the children in that age group were able to perform correctly & accurately on the skill, the skill was considered to be appropriate for that age group of children. A revised protocol was proposed based on the performances of the children. The means and SD were obtained from the raw score for all the tests in the protocol.
2. Reliability co-efficient alpha was found for inter and intra -judge reliability.

RESULTS AND DISCUSSION

Aims of the study

1. To administer a protocol developed for assessment of verbal praxis in Kannada language on typically developing children aged 2.6 - 4.0 years (2.6-3.0; 3.0-3.6; 3.6-4.0).
2. To establish norms for the various tasks in the protocol based on the performance of typically developing children on various tasks included in the protocol.

The protocol was administered on 30 children in each of the three age groups (total 90). The sections in the protocol included assessment of: (1) Function for the oral mechanism for speech, (2) Isolated speech movements, (3) Sequential speech movements, (4) Word level praxis assessment (meaningful words & non-meaningful words), (5) Relational speech timing (word context), (6) Diadochokinetic assessment, (7) Sentence level assessment, (8) Conversational analysis (PCC, PVC). The responses of the children for the tasks were recorded. A performance criterion of 60% was used to consider a task as applicable for a particular age group. That is, if 60% of the children in a given age group performed the task of a section accurately, then that task was considered valid for that age group. The raw scores were subjected to statistical analysis & means, SD, & percentage scores were calculated only for those items, passed by 60% of children in a age group. The graphs used the percentage data for better understanding

of the performance of children across the three age groups. A range of performance of + 3 SD from the mean is considered as normal.

The results are presented and discussed separately under the following heads:

I. Function of the oral mechanism for speech.

II. Verbal praxis assessment tool:

A. Isolated speech movements

B. Sequential speech movements

C. Word level praxis assessment

(i) Meaningful words, (ii) Nonmeaningful words

D. Relational speech timing in word context

E. Diadochokinetic assessment

F. Sentence level praxis assessment

G. Conversational assessment

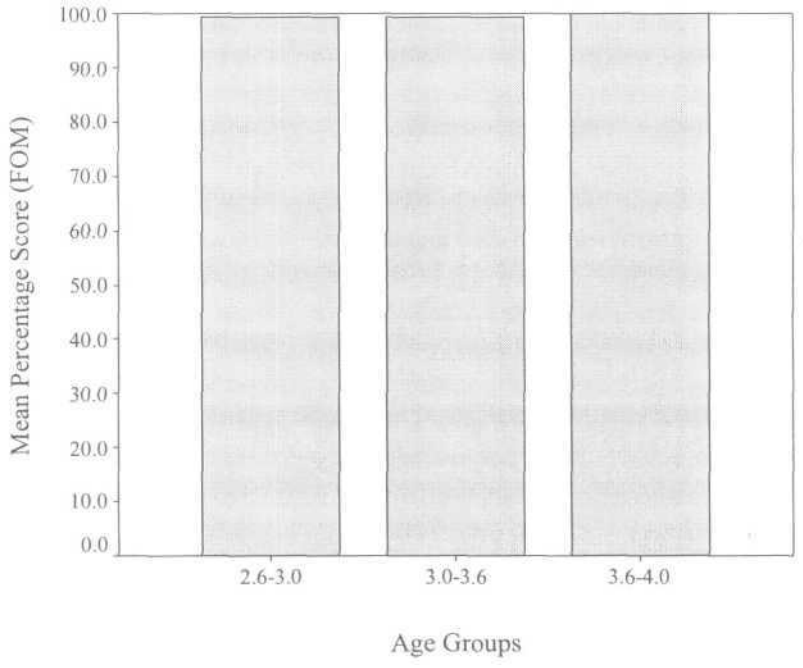
I. Function of the oral mechanism for speech

This section used tasks, which assessed the function of the oral mechanism for speech (FOM) in terms of oral-nasal distinction, air build up for stops, and fricatives, and range of movement of articulators. There were six tasks included in this section. Table 3 illustrates the mean and standard deviation of the children across all the three age groups. Graph 1 illustrates the performance of children across the three age groups on function of the oral mechanism for speech.

Table 3: Mean and SD for function of the oral mechanism of speech

S.No	*Age Groups*	*Maximum score*	*Mean scores of the group*	*SD*
1.	2.6-3.0	6	5.96	00.18
2.	3.0-3.6	6	5.96	00.18
3.	3.6-4.0	6	6.0	00.00

Graph]: Mean percentage scores of three age groups on Function of the oral mechanism for speech (FOM.)



From Table 3, it can be seen that most of the children across the three age groups could perform accurately on all the six tasks meaning that the tasks can be used in all the children above 2.6 years of age for testing the function of the oral mechanism for speech. Also from the table, it is evident that, the SD value for the highest age group of children (i.e. 3.6-4.0 years) is 0 suggesting the complete maturation of this function in these children.

Hayden, Wetherby, Cleary & Prizant (2004) assessed the motor control of hand, oral, and vocal mechanisms necessary for the accurate production of gestures and speech emerging between 8 and 24 months of age in typically developing children and found that the development of voicing, jaw, facial, labial and lingual control showed a significant change at 15-17 months. They also correlated this change with the development of first words and the beginning of two word phrases. The study suggested that the motor control for speech function shows a significant maturity as early as 15-17 months in young infants. The results of this study supports the findings of Hayden et.al (2004) as children as young as 2.6 years performed well on all the six tasks of the section used for testing the function of the oral mechanism for speech.

Robbins & Klee (1987), developed a protocol for assessing the structural and functional integrity of the vocal tract in children and found that functional skills assessed in the protocol was most sensitive to developmental change up to age 3.6 years with an asymptote in performance thereafter. The results of the present study seem to suggest that the function of oral mechanism for speech is well established by the age of 2.6 years as no developmental trend was observed thereafter. Hence, it refutes Robbins & Klee's (1987) observation with respect to the suggested age range of 3.6 years.

The mean scores were converted into percentage scores (mean percentage scores). Graph 1 illustrates that all the three age groups of children perform similarly on the function of the oral mechanism for speech.

II. Verbal Praxis Assessment:

A. Isolated speech movements (ISM):

A total of twenty-four tasks divided on the basis of predominant use of jaw, lip and tongue movements were included in this section. Table 4 illustrates the mean and standard deviation of the children across the three age groups.

Table 4: Mean & SD for isolated speech movements.

S.No	*Age Groups*	*Maximum score*	*Mean scores of the group*	*SD*
1.	2.6-3.0	69	66.93	3.21
2.	3.0-3.6	72	69.13	3.44
3.	3.6-4.0	72	71.36	1.21

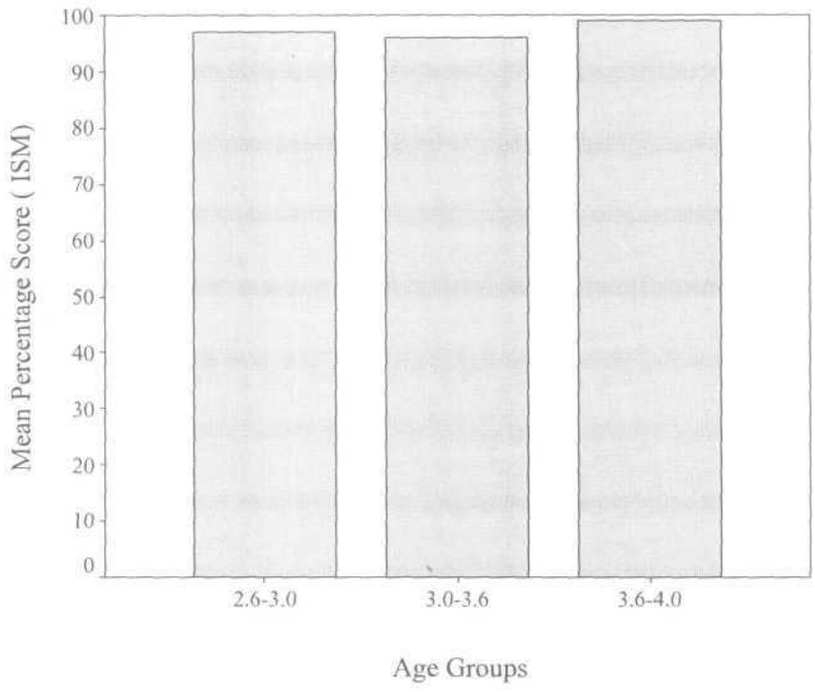
From Table 4, it can be seen that, the number of tasks applicable for children of the youngest age group (2.6 - 3.0) is lesser than that for the children of the older age group (3.0 - 3.6 & 3.6 - 4.0). This is evident from the increase in the maximum scores from the youngest age group (2.6 - 3.0) years to the oldest age groups (3.6 - 4.0). The mean scores also increase with the children of the youngest age group, (2.6 - 3.0) years having the least scores and children of the oldest age group (3.6-4.0 years) having the highest scores. The SD values decreased with increase in age, suggesting reduced variability due to maturation in children of the oldest age group (3.6 - 4.0) than the children of the younger age group (2.6 - 3.0).

Children in the age group of 2.6 - 3.0 years could not perform one task (task no. 24 - /'shh…7) out of the twenty four tasks in this section. That is, 60 % of the children in this age group could not perform this task, whereas 60% of children in the age groups 3.0 - 3.6 years and 3.6-4.0 years could perform all the twenty-four items in this section. Hence the number of tasks applicable for children of 2.6 - 3.0 years was twenty-three with a score of sixty-nine. The item number twenty-four was considered to be developed only after 3.0 years and not between 2.6-3.0 years.

Banu (1977) studied the articulatory acquisition in Kannada speaking typically developing children from 3.0 - 6.6 years of age. Findings of this study revealed that all the vowels and the diphthong /ai/ in Kannada language is acquired by 3.0-3.6 years of age. The consonants, /m-/, /-m -/, /n-/, /-*n-/*, /p-/, /-p/, /t-/, /-*t-/*, /k-/, /-k-/, /b-/, /-*b-/*, /d-/, /-d/-, /g-/, /-*g-/*, /l-/, /-l-/,/s-/, /-s-/, /-l/, /j-/, */-j-/*, */d-/*, */-d-/*, */y-/*, */-y-/* were found to be achieved by 3.0-3.6 years of age. The diphthong /au/ and the consonants /t-/, /-*t-/*, */c-/*, /-*c-/*, */v-/*, */-y-/* were acquired by 3.7 - 4.0 years of age. The results of the present study suggest that, the vowels and diphthongs are acquired as early as 2.6 years of age. All the consonants involving the lip movement and the tongue movements except the sound /'shh… '/ is achieved in children as early as 2.6 years of age.

The articulatory control seemed to be achieved much earlier than that suggested by Banu (1977). The differences could be attributed to the fact that Banu's study used lesser number of attempts to children to articulate the sounds correctly compared to the number of attempts given in the present study

Graph 2: Mean percentage scores of three age groups on Isolated speech movements



The mean scores were converted into percentages (mean percentage scores) and the performance of three groups are shown in graph 2. The findings suggest that children of the oldest age group (i.e. 3.6 - 4.0 years) performed better than children of the younger age groups.

II.B. Sequential speech movements:

A total of seven tasks were included in this section.

The responses of the children were scored for two features:

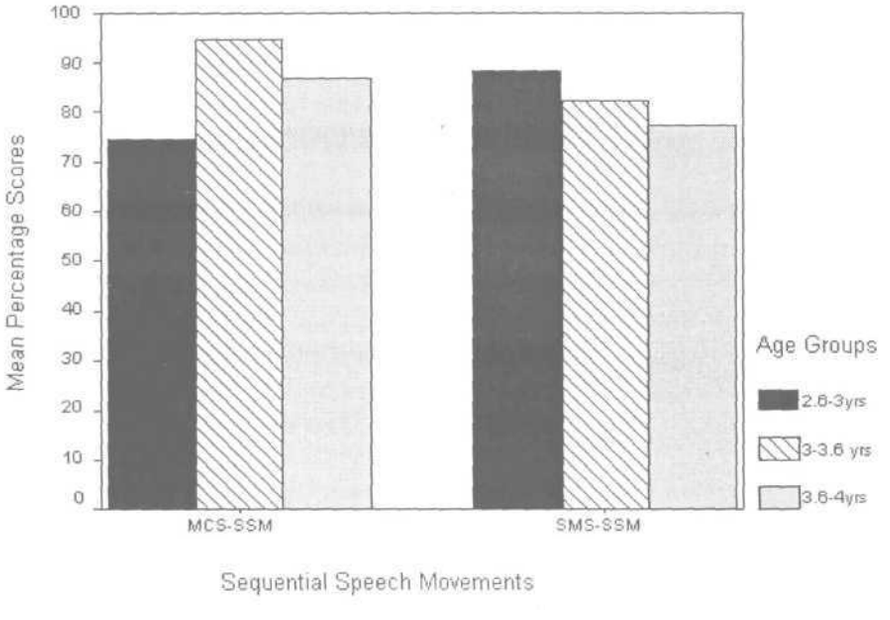
1. Motor control score
2. Sequence maintenance score

Table 5 & Graph 3 illustrates the mean and SD of the performance of children on motor control and sequence maintenance scores (Sequential speech movements) across the three age groups.

Table 5: Mean & Standard deviation for Sequential speech movements

S.No	*Age Groups*	*Motor Control Score (MCS)*			*Sequence Maintenance Score (SMS)*		
		Maximum scores	*Mean scores of the group*	*SD*	*Maximum scores*	*Mean*	*SD*
1.	2.6-3.0	8	5.96	1.82	*2*	1.76	.62
2.	3.0-3.6	10	9.46	1.30	8	6.56	2.16
3.	3.6-4.0	14	12.13	2.09	12	9.30	2.70

Graph 3: Mean percentage scores of three age groups on sequential speech movements



(a) Motor control score (MCS - SSM): For this scoring, the investigator produced sequences of consonants and vowels and the child was instructed to imitate them after the investigator. Only four of seven items were passed by 60 % of the children in the age group of 2.6 - 3.0 years, whereas five out of the seven items and all the seven items were passed by 60 % of the children from the 3.0 -3.6 and 3.6 - 4.0 age groups respectively. The children in the age group of 2.6 - 3.0 years could reach 60 % criteria in all tasks except for task 5 (o-m-i), task 6 (a-m-u), task 3 (m-u). These stimuli involved a bilabial nasal sound /m/ placed in between two vowels requiring a co-ordination between the nasal and oral port along with the opening and closing of lips. It is probable that such complicated co-ordination is not achieved before three years. The children in the age group of 3.0-3.6 years could reach the 60 % criteria on all tasks except task 5 (o-m-i) & task 6 (a-m-u). This can be attributed to the same reason as that stated for children of 2.6 - 3.0 years. This is also evident from table 5 which shows that scores are the least in youngest age group (2.6 -3.0) and highest in oldest age group (3.6 - 4.0). task like Task 5 and 6 (o- m- i) & (a-m-u) may be presumed to be sensitive in tapping praxis failures because of the complexity involved in producing them.

It is also evident that, the maximum scores & the mean scores attained increased from the youngest age groups, to the oldest age group. This may be because the number of tasks applicable for children of the younger age group is lesser than that of the older age groups. The SD values are lower for children in the youngest age group compared to the oldest age group. This can be attributed to the fact that, although the number of tasks passed by children of the youngest age groups was less, they were simple and hence

almost all of the children could perform them. On the other hand, the number & complexity of the tasks increased for the older age groups. Although 60 % percent of the children could perform a majority of the tasks selected, not all of them could perform accurately suggesting that the process of maturation is incomplete in the oldest age group.

Graph 3 illustrates the mean percentage scores of children on motor control score and sequence maintenance score across the three age groups. The graph which shows variability in the performance of children of the three age groups on motor control score and a clear developmental pattern has not emerged.

(b) Sequence maintenance score (SMS - SSM):

The sequence maintenance score depicted the ability of the children to produce the target utterance three times sequentially. Only one of the seven tasks (a-u) was passed by 60% of the children in the age group of 2.6 - 3.0 years, and they failed to maintain the sequence of /o-i/, /m-u/, /i-u-a/, /a-m-u/, /u-i-a & /o-m-i/. Four of the seven tasks were passed by 60 % of the children of the age groups 3.0-3.6 years & they failed to perform the sequential tasks for /o-m-i/, /a-m-u/ and /u-i-a/. Six of the seven tasks were passed by 60 % of the children from the 3.6 - 4.0 age group, who failed to perform the task /o-m-i/.

From Table 5, it is evident that, the maximum scores increased from younger to older age group on the tasks applicable for younger age group was lesser than that of the older age group. Also, the mean & SD scores increased from younger to older age

groups. This can be attributed to the fact that, the younger age group could perform only few tasks which were simple. The numbers of tasks & their complexity increased for children of the older age groups. Although, 60 % of the children in the older age groups could perform the task, not all of them passed and hence the variability also increased as depicted by the SD values. The finding suggests that sequence maintenance scores reflect the maturity of the praxis control, more so compared to the motor control scores. The SMS scores reflected immaturity in praxis control even in the oldest group of this study.

Graph 3 illustrates the mean percent scores of all the children on motor control score and sequence maintenance score across the three age groups. The mean SMS scores showed a gradual decrease with age. This is not indicative of a developmental trend, but is attributable to the difference in the total number of tasks passed by the groups. The younger groups could perform only one out of seven tasks and hence the percent scores were higher in this group compared to the older groups, which passed more number tasks.

From Table 5 & Graph 3, it is also evident that the overall scores for sequence maintenance (SMS) was much poorer than the scores for motor control (MCS). This implies that sequence maintenance is a comparatively difficult task than the motor control and the maturation for sequence maintenance takes a longer time compared to motor control. Hence, it can be expected that in a typical child, the motor control score can be higher than the sequence maintenance score and still it need not necessarily point to praxis breakdown, since the maturation for sequence maintenance is later than that for the

motor control. This suggests that the sequence maintenance is more sensitive in reflecting praxis control compared to motor control because of the inherent complexity involved in sequence maintenance task.

I. C. *Word level praxis assessment*

(i) Meaningful words:

The investigator uttered a list of forty words one by one and the participants were asked to imitate them. The difficulty of the words progressively increased from task one to the next.

The responses of the children were scored in two ways.

(a) Number of words correct

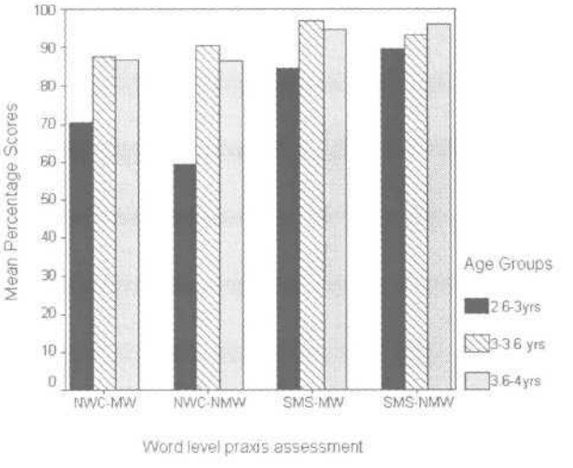
(b) Syllable maintenance score

Table 6 illustrates the mean & SD of the scores of children across the three age groups on the praxis assessment for meaningful words. The mean scores were converted into percentage & the name is shown in Graph 4.

Table 6: Mean & Standard deviation for Word level praxis assessment - (i) meaningful words.

S.No	*Age Groups*	*No. of words correct (NWC)*			*Sequence Maintenance Score (SMS)*		
		Maximum scores	*Mean*	*SD*	*Maximum scores*	*Mean*	*SD*
1.	2.6-3.0	21	14.80	4.42	60	50.63	7.10
2.	3.0-3.6	27	23.73	4.36	62	60.10	4.40
3.	3.6-4.0	33	28.60	4.43	74	70.20	4.52

Graph 4: Mean percentage scores of children across the three age groups on word level praxis assessment - Meaningful words (MW), Nonmeaningful words (MW).



(a) Number of words correct (NWC - MW): Out of the forty tasks, twenty-one tasks were passed by 60 % of the children in the age group of 2.6 - 3.0 years. Generally, words with clusters were found to be more difficult in this group. 60% of the children couldn't pass in most of the tasks under the following sub sections,

- Disyllabic words with clusters. (DWC)
- Tri-syllabic words with clusters. (TWC)
- Multisyllabic words with clusters. (MWC)

The following tasks were specifically found to be difficult in more than 60 % of children in this age group.

- Disyllabic words with two clusters-one in the initial and one in the medial position (D2C).
- Tri-syllabic words with two clusters-one in the initial and one in the medial position (T2C)

The high error rates in clusters could be due to the difficulty involved in producing clusters. Other than this, many errors were also found in multisyllabic words without clusters (MNC). Since multisyllabic words are complex and there is a increase in utterance length, children in this age group would have found it difficult to produce these utterances correctly. Investigators have observed increasing difficulty with increased utterance length (timing errors) as one of the early diagnostic signs in children with speech praxis failures such as CAS (Forrest, 2003). Out of the forty tasks, only twenty seven tasks were passed by 60 % of the children of 3.0 -3.6 age group. The error rates were high in the sub sections of D2C, T2C similar to that of children of 2.6 - 3.0 age group. Out of the forty tasks, only thirty-three tasks were passed by 60 % of the children in 3.6 -4.0 age group. The error rates were high in the sub sections of D2C and T2C.

From table 6, it is also evident that there is an increase in the maximum scores with the increase in age. This is because the number of tasks applicable for children of

the younger age group was lesser than that of children of the older age group. The mean scores is also seen to increase with increase in age suggesting a developmental trend. It is also evident, that the SD values are variable and this can be attributed to the increase in the complexity of the tasks that were applicable to children of the older age group. It can be noted from the table that the SD's in the oldest age group (3.6 - 4.0) were highest, implying that many of the tasks applicable for these children were still in the developmental stage and were not completely acquired even by 3.6 - 4.0 years. Generally the error rates in clusters are more in children of all the three age groups. This finding draws support from a study by Banu (1977) who studied the articulatory development in Kannada speaking children and suggested that blends and clusters are acquired completely only at 6 years of age in these children. Graph 4, also shows that the mean percentage scores for number of words correct of children on meaningful words is highly variable as also depicted in table 6.

(b) Syllable maintenance score (SMS - MW): This score depends on the ability to sequence the syllables in a given word. Out of the forty tasks, only thirty tasks were passed by 60 % of the children in the age group of 2.6 - 3.0 years. Overall, the children in this age group found more difficulty with words involving clusters compared to words without clusters. Most of the words under the following sub sections were not passed by 60% of the children.

- Disyllabic words with two clusters-one in the initial and one in the medial position (D2C).

- Trisyllabic words with two clusters-one in the initial and one in the medial position (T2C).

Out of the forty words, only thirty-one words were passed by 60 % of the children in the age group of 3.0 -3.6 years. Similar to the children of 2.6 - 3.0 age group, children in this group also had more error in sub sections of D2C, T2C. Out of the forty words, almost thirty-seven tasks were passed by 60 % of the children in the age group of 3.6 - 4.0 years. Only three tasks belonging to the subsection of T2C were not passed by 60 % of the children in this age group. The high error rates in clusters can be supported by the findings of the study done by Banu (1977).

From table 6, it can be seen that, the number of tasks performed successfully increased from younger age group to the older age groups, as is evident from the increasing number of maximum scores. The mean scores increased from the younger age group of children to the older age group and the SD's were highly variable, with the SD's being highest for the youngest age group (2.6 -3.0 years). This implies that the development of the selected tasks is progressive from younger to older age groups.

The mean percentage for syllable maintenance scores of the three groups are shown in Graph 4. The findings here support observations that performance of children in terms of sequence maintenance in meaningful words is highly variable as shown in table 6. Generally, the error rates were lesser in syllable sequencing in all the groups. This is because even if the word is not produced correctly, children could still maintain the sequence of the syllables correctly and get a score of "2". For example, for the target

word, /ʧəppəlɪ/ the child could say [təppəlɪ] and still get a syllable sequence score of "2", while the child would have lost a score of " 1 " for incorrect production of the word.

(ii) Non-meaningful words (NMW):

There were totally 20 non- meaningful words in four sets (5 words in each set) and the responses of the children were scored in two ways.

(a) Number of words correct (NWC)

(b) Syllable maintenance score (SMS)

Table 7 illustrates the mean and SD scores of children on nonmeaningful words across the three age groups. Graph 4 illustrates the performance of children on non meaningful words (Word level praxis assessment).

Table 7: Mean & Standard deviation for Word level praxis assessment- (ii) non-meaningful words.

S.No	*Age Groups*	*No. of words correct (NWC)*			*Sequence Maintainance Score (SMS)*		
		Maximum scores	*Mean*	*SD*	*Maximum scores*	*Mean*	*SD*
1.	*2.6-3.0*	13	7.70	2.43	30	30.10	2.88
2.	*3.0-3.6*	14	12.63	1.86	36	32.36	2.82
3.	*3.6-4.0*	17	14.70	1.96	36	34.20	1.49

a) Number of words correct (NWC - NMW): Out of the twenty words / tasks, only thirteen words / tasks were passed by 60 % of the children in the age group of 2.6 -3.0. Most of the words / tasks in the following subsections were not passed by 60 % of the children of this age group.

- Set B (I)
- Set B (II)

Out of the twenty words / tasks, only fourteen words / tasks were passed by 60 % of the children in the age group of 3.0 - 3.6 years. One word from the Set B (I) and five words from Set B (II) were not passed by 60 % of the children of this age group. Out of the twenty words / tasks, only seventeen words / tasks were passed by 60 % of the children in this age group. Three words from Set B (II) were not passed by 60 % of the children in this age group.

From table 7, it is seen that the maximum scores increased from children of the youngest to the oldest age group. This implies that the number of tasks / words applicable for children increased as the age increased. It is also observed that the mean scores also increased as the age increased, with higher SD's in youngest age group (2.6 - 3.0 years), and variable thereafter. A clear developmental trend is not seen. Yet, the lower SD values in the older age group compared to the younger age group (2.6 - 3.0 years) suggest that the development is more mature for children of the older age group than for younger age group.

These findings are well supported by the mean percentage scores shown in Graph 4, which shows that the performance of children in terms of number words correct in nonmeaningful words is highly variable with children of 3.0 - 3.6 years of age performing better than children of 2.6 -3.0 years & 3.6 —4.0 years.

(b) Syllable maintenance score (SMS - NMW):

Out of the twenty words, only fifteen words were passed by 60 % of children in the age group of 2.6 - 3.0 years. The words of the following subsections were not passed by 60 % of the children in this age group.

- Set B (I)
- Set B (II)

Out of twenty words, eighteen tasks were passed by 60 % of the children in the age groups of 3.0 - 3.6 years & 3.6 -4.0 years. Two tasks in Set B (II) which included the most complex tasks were not passed by 60 % of the children in this age group.

From table 7, it is understood that there is increase in the maximum score from the younger age group (2.6 -3.0 years) to the older age groups (3.0- 3.6, 3.6- 4.0). This implies that the number of tasks passed by children of the older group were more than that for the children of the younger age group. The mean scores also improved with the age. From the SD scores, which is least for the children of the oldest age group, it is evident that, there is a developmental trend with the children of the older age group (3.6 - 4.0 years) performing better than the children of the younger age groups. The findings are further supported by the mean percentage scores shown in graph 4, which clearly

demonstrates a developmental trend across the three age groups. From the results (table 7 & graph 4) it is understood that the performance on sequence maintenance is better than the performance on number of words correct. This is because the incorrect production of a word doesn't always accompany incorrect / inappropriate sequence maintenance.

//. *D. Relational speech timing task:*

There are totally eight sets of words. Each set, has three words (stimuli 1, stimuli 2, stimuli 3) in which there is a progressive increase in the length of the base word. All of the words are meaningful words. The responses are scored in two ways:

(a) Number of words correct (NWC)

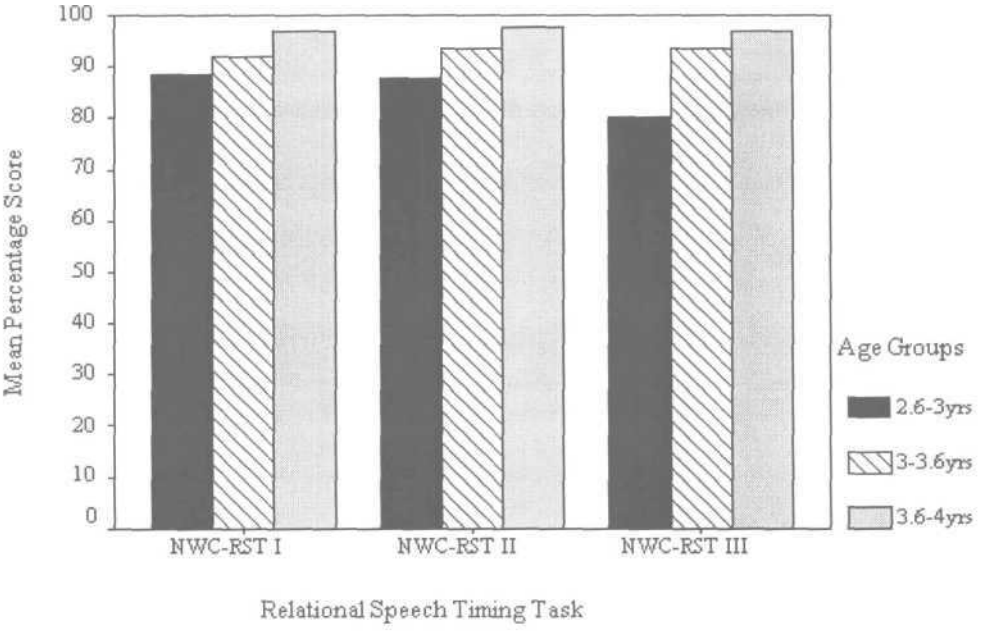
(b) Syllable maintenance score (SMS)

Table 8 (a), 8 (b) illustrates the performance of children across the three age groups on relational speech timing in word context. The mean percentage scores are shown in Graph 5 (a), 5 (b).

Table 8 (a): Mean and Standard deviation of the number of words correct (NCW) scores obtained in Relational speech timing tasks.

S.No	*Age group*	*NWC -RSTI*			*NWC-RST II*			*NWC-RST III*		
		Max	*Mean*	*S.D*	*Max*	*Mean*	*S.D*	*Max*	*Mean*	*S.D*
1	2.6-3.0	8	7.06	1.33	7	6.13	1.52	5	4.00	1.14
2	3.0-3.6	8	7.36	1.03	7	6.53	0.73	5	4.66	0.60
3	3.6-4.0	8	7.76	0.43	8	7.80	0.61	7	6.76	0.67

Graph 5 (a): Mean percentage scores of the three age groups on Relational speech timing asks on number of words correct (NWC)



(a) Number of words correct:

Out of twenty-four words, twenty words were passed by 60 % of the children in 2.6 - 3.0 & 3.0 - 3.6 age groups. The children in this age group had difficulty in words in the stimuli 3 condition (RST - III). This was because the stimuli 3 words had the greatest utterance length and children found it difficult to articulate multisyllabic words. Out of the twenty-four words, twenty-three words were passed by children of 3.6 - 4.0 age group.

From table 8 (a), it can be seen that the maximum scores increased with age, due to the increased number of tasks applicable for the children of the older age group, than that of the children of the younger age group. The maximum scores decreased across the three stimuli conditions (RST- I, RST- II, RST- III) as there was progressive difficulty in production of the tasks from RST-I to RST - III. It is evident from the table 8 (a) that, the SD scores were least for the children of the older age group suggesting improvement in performance of children of the older age group. The mean scores shows that there is a developmental trend in the performance of children across the three age groups.

The findings are supplemented by graph 5 (a), which clearly indicates a developmental trend across the three stimuli conditions and across the three age groups and it also shows that, the performance of the children is better in RST - I condition compared to RST - III condition across the three age groups.

(b) Syllable maintenance score (SMS):

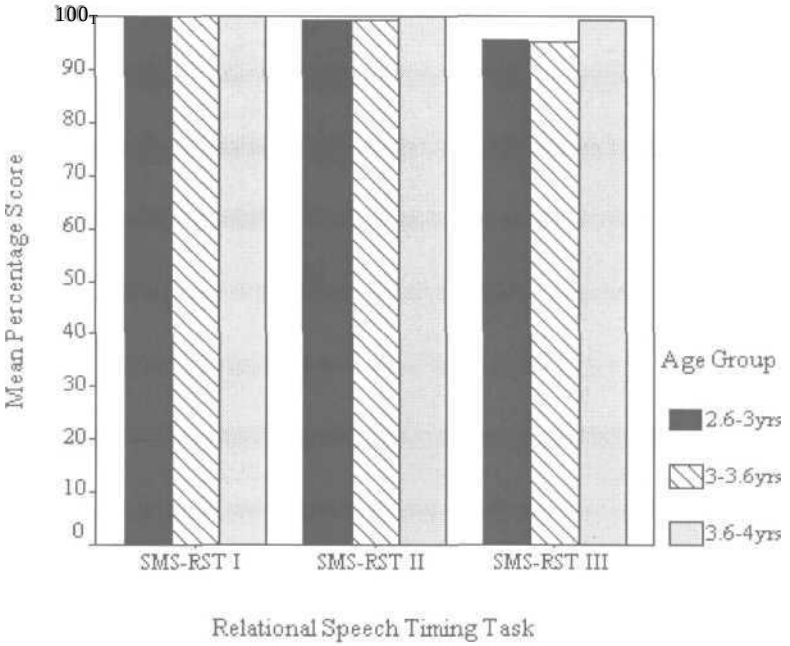
All the twenty-four words were passed by 60% of the children of the 2.6 - 3.0, 3.0 - 3.6 & 3.6 - 4.0 years age groups.

Table 8 (b) illustrates Mean and Standard deviation of the sequence maintenance scores (SMS) obtained in Relational speech timing tasks. The mean percentage scores are shown in Graph 5 (b).

Table 8 (b): Mean and Standard deviation of the sequence maintenance scores (SMS) obtained in Relational speech timing tasks.

S. No	*Age groups*	*SMS - RST-I*			*SMS'RST-II*			*SMS-RST-III*		
		Maximum scores	*Mean*	*SD*	*Maximum scores*	*Mean*	*SD*	*Maximum scores*	*Mean*	*SD*
1.	2.6-3.0	16	16.00	0.00	16	16.00	0.00	16	15.30	1.05
2.	3.0-3.6	16	16.00	0.00	16	16.00	0.00	16	15.15	1.20
3.	3.6-4.0	16	16.00	0.00	16	16.00	0.00	16	15.48	0.91

Graph 5 (b): Mean percentage scores of three age groups on relational speech timing tasks on sequence maintenance score (SMS)



From the table 8 (b), it is seen that, on SMS- RST- I, SMS- RST -II tasks are completely matured in children of all the three age groups. This can be noted from the SD scores, which are zero, indicating complete maturation of these tasks in 2.6 - 3.0, 3.0 - 3.6 & 3.6 - 4.0 age groups. The third set of words, i.e, SMS-RST-III consisted of words of greater utterance length and children belonging to the age groups of 2.6 - 3.0 & 3.0 - 3.6 years performed poorer than the children of the oldest age group. The SD scores which are least for the children of 3.6 - 4.0 age groups suggests a superior performance of children in this age group compared to the children of the younger age group. The findings are clearly depicted on graph 5 (b).

E. Diadachokinetic assessment:

The responses of children in the three groups were analyzed for the following:

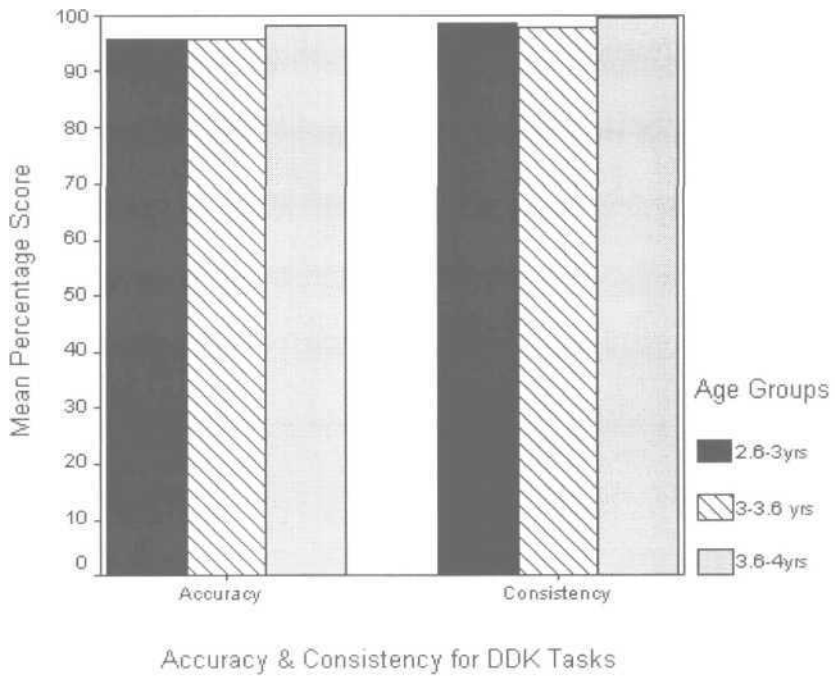
(a) Accuracy, (b) consistency & (c) DDK rate.

Table 9 & graph 6 illustrates the mean & SD for accuracy and consistency on DDK assessment tasks.

Table 9: Accuracy & consistency in the performance of DDK tasks for children across the three age groups

S.No	*Age Group*	*Accuracy*			*Consistency*		
		Maximum scores	*Mean*	SD	*Maximum scores*	*Mean*	*SD*
1.	2.6-3.0	4.00	3.83	0.46	12.03	11.83	0.53
2.	3.0-3.6	3.97	3.83	0.37	12.02	11.77	0.67
3.	3.6-4.0	4.02	3.93	0.25	12.03	11.97	0.18

Graph 6: Mean percentage scores of three age groups on accuracy and consistency in DDK tasks.



(a) Analysis / scoring for accuracy:

The total scores for accuracy were approximately four, for all the groups, as seen in Table 9. There is no developmental trend seen in this measure of DDK. However the decreasing SD with increasing age shows that the accuracy measure in DDK tasks is more mature in children of the older age group, compared to children of the younger age group. Graph 6 shows a slight developmental trend, although not so significant.

b) Analysis / scoring for consistency:

The total scores for consistency was approximately 12 for all the groups, and it was based on a 0 - 3 rating scale, wherever a maximum score of 3 was offered for consistent production on DDK. From the mean scores & the maximum scores in the table, it is understood almost all the children across the age groups performed similarly on the consistency measure of the DDK tasks. The SD also suggests variability in the performance. However, the least SD observed in children of the oldest age group (3.6-4.0 years) suggests that the consistency measure in DDK tasks is more mature in children of the older age group, compared to children of the younger age group, as is also evident in the trend observed in Graph 6. Yaruss & Kenneth (2002) also studied the accuracy of the DDK productions and found no significant correlations between children's chronological age and the average number of articulation errors (Accuracy was rated based the presence/absence of articulatory errors). The findings of the present study support the findings of Yaruss et.al (2002) since a clear developmental trend did not emerge in the measures of accuracy on DDK tasks in the present study.

F. Sentence level assessment:

Totally ten sentences were used and the analysis/scoring was done in two ways,

(a) Number of sentences correct (NSC)

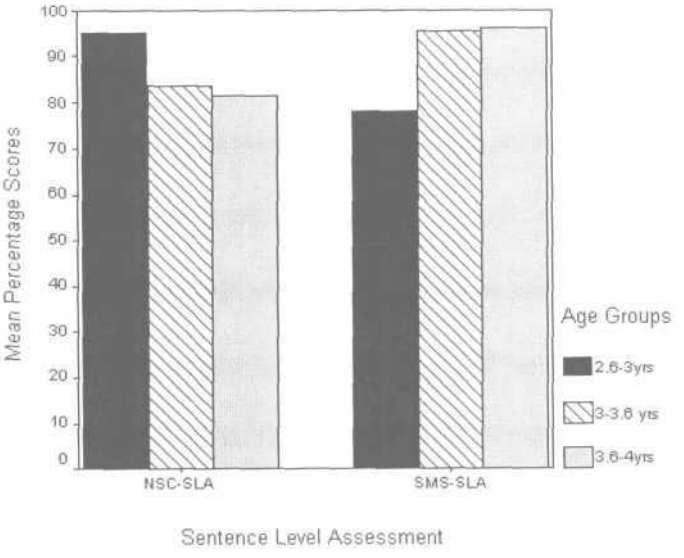
(b) Sequence maintenance score (SMS)

Table 11 illustrates the performance of children on sentence level assessment across the three age groups. Graph 8 shows the mean percentage scores of children on sentence level assessment across the three age groups.

Table 11: Mean & SD of the scores obtained by children across the three age groups in sentence level assessment

S.No	*Age Groups*	*No. of sentences correct (NSC)*			*Sequence Maintenance Score (SMS)*		
		Maximum scores	*Mean*	*SD*	*Maximum scores*	*Mean*	*SD*
1.	*2.6-3.0*	2	1.90	0.40	12	9.36	2.60
2.	*3.0-3.6*	5	4.16	1.14	14	13.36	1.47
3.	*3.6-4.0*	9	7.33	1.74	18	17.26	0.82

Graph 8: Mean percentage scores of three age groups on sentence level assessment.



(a) Number of sentences correct (NSC):

Out of the ten tasks, two, five, nine tasks were passed by 60 % of the children in the age groups of 2.6 - 3.0, 3.0 - 3.6, 3.6 - 4.0 respectively. The task 10 in this section included a sentence with six words and this was not achieved by children of any age group.

From the table, it is seen that, the maximum scores increases as the age increases. This implies that, the number of items passed by children of the older age groups is more than that of the younger age group and hence there is an increase in the mean scores also as age increased. The SD is seen to increase with increase in age. The reason for this can be that, children of the older age groups attempted more sentences but because of the complexity involved in producing them correctly, relatively lesser number of children

were able to produce them correctly. Hence the SD is highest for children of the oldest age group and least for children of the youngest age group. The trend is also supported in the representation made Graph 8.

(b) Sequence maintenance score for sentences (SMS - SLA):

Out of ten tasks, six, seven and nine tasks were passed by 60% of the children in the age groups of 2.6 - 3.0, 3.0 - 3.6, 3.6 - 4.0 respectively. The children had more difficulty on tasks with greater word and syllable length. From table 11, it is seen that, there is an increase in the maximum scores as age increased with an increase in the mean scores also being evident. The decreasing SD as age increased shows that the tasks are more mature in children of the oldest age groups compared to children of the younger age groups. The clear developmental trend here suggests the sequence maintenance could be a sensitive measure for identifying praxis failures. It has been noted earlier that increasing difficulty with increased utterance length (timing errors) could be one of the early diagnostic signs in children with speech praxis failures such as CAS (Forrest, 2003). Generally the scores are better for sequence maintenance than for the number of sentences correct. This is because the praxis control required for correct production / articulation of the sentence is more complex than maintaining the sequence of words in a sentence. Also, the scoring for sequence maintenance in sentences does not penalize scores for consistent phonemic errors. Graph 8 depicts the developmental trend across the three age groups.

(V) Conversational assessment:

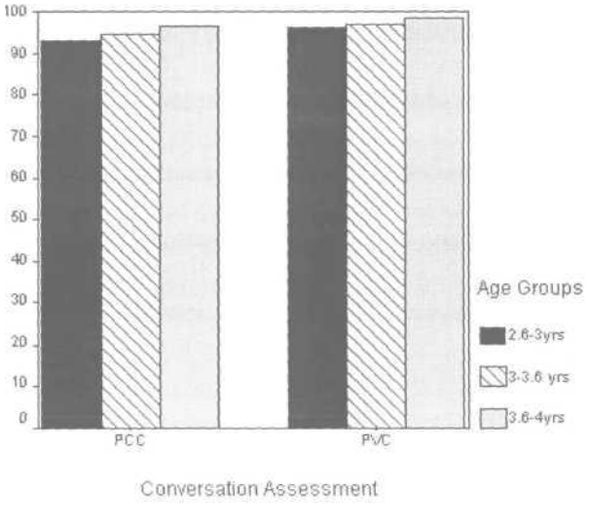
The conversational analysis consisted of the calculation of Percentage Consonant Correct (PCC) & Percentage Vowel Correct (PVC).

Table 12 illustrates the mean, & SD of PCC and PVC measures across children of the three age groups. The percentage mean scores are as shown in Graph 9.

Table 12: Mean & SD of Percentage consonant correct (PCC) & Percentage vowel correct (PVC) obtained by children across the three age groups in conversational assessment

S.No	*Age Groups*	*PCC*			*PVC*		
		Maximum scores	*Mean*	*SD*	*Maximum scores*	*Mean*	*SD*
1.	*2.6-3.0*	97.23	93.17	10.8	98.71	96.14	6.8
2.	*3.0-3.6*	96.55	94.80	4.6	98.67	97.14	4.1
3.	*3.6-4.0*	97.79	96.70	2.9	99.05	98.27	2.1

Graph 9: Mean percentage scores of three age groups on conversational assessment (PCC & PVC)



From the table and graph, it can be seen that there is a developmental trend in the PCC as well as PVC measures across the children of the three age groups. The SD also suggests that, the older age groups of children are performing better than the children of the younger age group, as the variability reduced across the three age groups.

Dood, Holm, Hua & Crosbie (2003) studied the phonological development of British English speaking children and proposed the measures of PCC & PVC in children in the age group of 3.0-6.11 and found that the measures of PCC & PVC increased progressively for children in the higher age group. The results of the present study support the findings of Dood et al. (2003) as a clear developmental trend was evident in the PCC and PVC measures.

Phonological processes:

There were also many phonological processes seen in the speech of children who participated in the study. This was observed in the sections of word level praxis assessment (meaningful and non-meaningful words and relational speech timing tasks). They can be classified into space errors, timing errors and whole word errors. The predominant processes that occurred in children of this age group were:

1. Cluster reduction
2. Fronting
3. Degemmination of geminate clusters.
4. Gemmination

5. Deaffrication
6. Affrication
7. Backing of dental stops
8. Stopping
9. Epenthesis
10. Depalatalization.
11. Reduplication
12. Consonant harmony
13. Consonant deletions
14. Post vocalic devoicing
15. Prevocalic voicing
16. Substitution of geminate clusters for non geminate clusters.
17. Syllable deletion

Some of the vowel deviations found were,

1. Vowel decentralization
2. Vowel centralization
3. Monophthongization or diphthong reduction
4. Vowel prolongation
5. Vowel raising
6. Vowel lowering
7. Vowel harmony

The operational definitions of phonological processes observed in the participants of the study are presented in Appendix - C. In addition, to the above processes, some unusual processes were also seen in these children, which included:

1. Substitution of /v/ for /*xl*.
2. Substitution of /*v*/ for /*x*/.
3. Substitution of /*t*/ for /r/

The inference that can be drawn from this observation is that children in these age groups are still not able to produce, /r/ accurately, and hence substitutes this sound with all other earlier acquired sounds.

Intra & inter-judge reliability

Since, the scoring system involved is based on rating scales, the scoring can be subjected to great variations when used by different people at different points in time. So 10% of the data i.e., for 9 children (3 children from each age group), was video recorded and their responses were recorded by another judge to establish inter-judge reliability & by the investigator after a period of four weeks from the initial assessment to establish intra-judge reliability. Intra and inter judge reliability was found out by Alpha (reliability co-efficient). The measure yielded 91 % for intra judge & 94 % for inter-judge reliability suggesting a high reliability for the scoring of response.

Summary

A revised protocol based on the performance of children across the three age groups is presented in Appendix D. Also Graphical representation of mean for the different tasks is presented in Appendix E. This graph will help in interpreting the scores / results obtained after assessing a given child with suspected apraxia of speech.

There were totally eight sections in the protocol. The performance of children on some of the sections showed developmental trend whereas others did not. The following tasks showed a developmental trend, function of the oral mechanism for speech, isolated speech movements, the sequence maintenance score of non meaningful words (Word level praxis assessment), all the measures (NWC & SMS) in the section of relational speech timing in word context, DDK rate in /pə tə kə/ task, sequence maintenance scores of sentence level assessment, PVC and PCC measures of conversational assessment.

The present study provides a protocol for assessing the development of verbal praxis in children with suspected apraxia of speech (sCAS) by using a wide range of tasks required for tapping verbal praxis deficits. The study provides normative data and hence allows the investigator to in estimating the level of performance on verbal praxis in a given child and thus aid in early diagnosis of Kannada speaking children at risk for verbal praxis breakdown. It will also serve as a useful clinical tool in therapy for children with verbal praxis breakdown.

SUMMARY AND CONCLUSIONS

The study focused on the development of praxis in Kannada speaking typically developing children (2.6-4.0) years. The study used a protocol developed by Rupela and Banumathy (2008) for assessing the praxis control across several tasks and provides normative data for assessing children at risk for sCAS.

Studies in this direction are highly important because, it is important to identify children with sCAS at an early age for prompt intervention and good prognosis. Literature has suggested that, of all other speech disorders, Developmental Apraxia of Speech (DAS) is proved to be one of the most controversial of the developmental speech disorders. The major problem in diagnosing young children with childhood apraxia of speech is that there is no single universally accepted diagnostic marker for this disorder. Also, there is lack of appropriate diagnostic guidelines for childhood apraxia of speech. Hence, it is important to develop accurate diagnostic guidelines, which can be done only by studying the normal development of praxis in young children. For quantifying the development of praxis, normative data is required. Based on these observations, the current study aimed at the following:

- To administer a protocol developed for assessment of verbal praxis in Kannada language on typically developing children aged 2.6-4.0 years.
- To establish norms for the various tasks in the protocol based on the performance of children included in the study, which can be used to assess children at risk for verbal praxis breakdown.

A total of ninety Kannada speaking typically developing children with thirty children from each from the age groups of 2.6-3.0; 3.0-3.6; 3.6-4.0 years respectively participated in the study. The children were screened for language abilities, oromotor & sensory weakness and oro-structural abnormalities. Any child exhibiting language delay / deviance, oro-motor, oro-sensory and oro-structural problems were not included in the study.

The protocol consisted of the following tasks.

- Function of the oral mechanism for speech
- Isolated speech movements
- Sequential speech movements
- Word level praxis assessment- (i) Meaningful words, (ii) Non- meaningful words
- Relational speech timing in word context
- Diadochokinetic assessment
- Sentence level assessment
- Conversational assessment

In addition, the protocol allows the examiner to classify the phonological processes into space errors, timing errors and whole word errors. These children were screened for language development, oro-motor function and oro-structural anomalies. The protocol was administered to all the children and their responses were recorded using a digital mini-disc recorder. The responses of the children were transcribed and scored accordingly using rating scales. The protocol was standardized based on the performance of the children. A criterion of 60% was taken, i.e. if 60% of the typically developing children in that age group could perform the task correctly, then that task was considered to be valid for children in that age group. Hence, based on the performance of all the children, a standardized protocol is proposed. Statistical analysis was done using the SPSS (version 10,) statistical package. The mean scores, and standard deviations were found out. Since, the protocol involved rating scales, reliability measures were also carried out. For ten percent of the children, intra and inter-judge reliability was found out and the results showed high reliability.

Important findings from the study are as follows:

There were totally eight sections in the protocol. The performance of children on some of the sections showed developmental trend whereas others did not. The tasks which showed developmental trend were, isolated speech movements, the sequence maintenance score of non meaningful words (Word level praxis assessment), all the measures (NWC & SMS) in the section of relational speech timing in word context, DDK rate in /pə tə kə/ task, sequence maintenance scores of sentence level assessment, PVC

and PCC measures of conversational assessment. The protocol provides normative data for the investigator and hence helps in early identification and intervention of children at risk for praxis failures. Appendix D is proposed for the three age groups of 2.6 - 3.0, 3.0 - 3.6, and 3.6 - 4.0 years. The scores obtained by a given child with suspected features of verbal apraxia can be compared with the means of the groups on which norms are established in this study. A child at risk will be scored below the mean bar and a child who crosses the mean bar is not considered at risk for verbal praxis failures.

Future directions:

1. The protocol can be standardized on children of older age groups (above 4 years of age).
2. Such protocols can be developed in other Indian languages for aiding early identification and intervention of children with suspected apraxia of speech (sCAS).

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APPENDIX-A

ASSESSMENT TOOL FOR VERBAL PRAXIS SKILLS

[Adopted from Rupela (2008) & Banumathy (2008)]

Name:

Date:

Age/Gender:

Education:

School:

Language age:

Other relevant information:

I. FUNCTION OF THE ORAL MECHANISM FOR SPEECH:

Instructions: The child is instructed to imitate the following activities after the investigator.

Stimuli:

1. The intra-oral air build-up for stops is Adequate/Inadequate
2. Air build up and precision of fricatives is Adequate/Inadequate
3. Oral-nasal distinction is Adequate/Inadequate

The following activities have to be observed without asking the child to imitate or do these activities

4. When the child spreads his lips, the range of movement of lips is Adequate / Inadequate
5. When the child opens and closes his/her mouth, range of movement of jaw is Adequate / Inadequate
6. When the child moves the tongue from side to side, the range of movement is Adequate / Inadequate

Scoring: Scores of 0-1 is offered based on the adequacy / inadequacy of the performance.. A score of '0' is given for inadequate performance and a score of '1' would be given for adequate performance.

II. **VERBAL PRAXIS TOOL**

A. ISOLATED SPEECH MOVEMENTS:

Instructions: The child is instructed to imitate the following vowels, consonants and syllables after the investigator.

Stimuli:

Action	***Accuracy***	***Repitition***	***Score***
Jaw movement			
1. Open your mouth and say 'ahh'			
2. Close your mouth and say 'm…'			
3. Say /jə/			
4. Say /əi/			
5. Say /əu/			
Lip movement			
6. Say /pə/,			
7. Say /o/			
8. Say /u/			
9. Say /i/			
10. Say /e/			
Tongue movement			
11. Say /tə/,			
12. Say /də/,			
13. Say'n…'			
14. Say 'l...'			
15. Say 's…'			
16. Say /kə/,			
17. Say, /gə/			
18. Say /Tə/,			
19. Say /ɖə/			
20. Say /ə/			
21. Say /lə/			
22. Say /ʧə/			
23. Say /rə/			
24. Say'shh...'			

Scoring: Scores of 0 to 3 is offered based on the accuracy of speech movements and depending on whether repetitions or cues are given to the child. It may be noted that additional cues given if the child is not paying attention &/ or not compliant should be disregarded in scoring.

3 - Movement / action is accurate
2 - Movement / action is accurate with one repetition
1 - Movement / action is inappropriate with more than one repetition
0 - Child is unable to perform even with repetitions.

B. SEQUENTIAL SPEECH MOVEMENTS:

Instructions: The child is instructed to imitate the following sequences of vowels and consonants .If the child is able to do this, then the child is instructed to imitate each sequence three times each followed by the investigator. A maximum of two attempts can be given to the child for the correct production.

Stimuli:

Action	*Response*	*No. of trials/times repeated*	*MCS*	*SMS*
1. a-u				
2. o-i				
3. m-u				
4. i-u-a				
5. o-m-i				
6. a-m-u				
7. u-i-a				

Scoring:

Motor control score (MCS): Scores of 0-2 is offered based on the appropriateness of movements. The number of times /trials the actions was repeated can be noted down.

Motor control score (MCS)

2 - All movements are precise.
1 - One of the movement is imprecise.
0 - All movements are imprecise or child substitutes one phoneme for another or child does not say all phonemes.

Sequence maintenance score (SMS): Scores of 0-2 is offered based on the appropriate maintenance for the sequence (i.e. the correct order in which, the sequences of vowels, consonants are repeated). The number of times / trials the actions was repeated can be noted down.

Sequence maintenance score (SMS)

2 - Repeats all phonemes correctly.
1 - Repeats 2 out of 3 sequences correctly or repeats the phonemes 5 or 6 times.
0 - Repeats one out of 3 sequences correctly or repeats the phoneme sequence more than 6 times.

C. WORD LEVEL PRAXIS ASSESSMENT:

(i) MEANINGFUL WORDS:

Instructions: The child is instructed to repeat the following words after the investigator. A maximum of two attempts can be given to the child for the correct production. The responses have to be transcribed and scored accordingly.

Target	*Response*	*Phonological Errors*			*Dysfluencies*	*Weak precision*	*Score (NWC)*	*Sequence Score (SMS)*
		SE	*TE*	*WWE*				
DNC								
təlɛ								
sirɛ								
mənɛ								
sebu								
najɪ								
DWC								
bɛkkʊ								
pɛnnʊ								
ʧʰətrɪ								
təʈʈɛ								
surja								
TNC								
bagɪlʊ								
hʊɖʊgɪ								
kɪʈəkɪ								
ʧəməʧa								
kudəlʊ								
TWC								
rəŋgolɪ								
da[ɪmbɛ								
pʊstəkə								
ʧəppəlɪ								
iru[[ɪ								

Target	*Response*	*Phonological Errors*			*Dysfluencies*	*Weak precision*	*Score (NWC)*	*Sequence Score (SMS)*
		SE	TE	WWE				
MNC								
ərəmənɛ								
əɖɪgemənɛ								
batʃəɳɪgɛ								
gəɖɪjara								
gaɭɪpəʈə								
MWC								
kənnəɖəka								
baɭɛhəɳɳʊ								
devəst^{h}ana								
alu:gəɖɖɛ								
tɛŋgɪnəkaji								
D2C								
krɪʂɳa								
drɪçjə								
prəçnɛ								
swəʧʧ^{h}ə								
drakʂi								
T2C								
vjəvəst^{h}ɛ								
prart^{h}əne								
brəhmərʂi								
svərgəst^{h}ə								
prəkʂʊbdatɛ								

The target words increase in syllabic complexity from:

DNC - Di-syllable No cluster (with out cluster)
DWC - Dis-syllabic with cluster
TNC - Tri-syllabic No Cluster
TWC - Tri-syllabic with cluster
MNC - Multisyllabic No Cluster
MWC - Multisyllabic with cluster
D2C - Disyllabic with two clusters
T2C - Trisyllabic with two clusters

The following types of errors are noted after transcribing the responses.

Space errors: Fronting, backing and vowel deviations including vowel prolongation, vowel centralization, monophthongization, diphthongization.
Timing errors: voicing errors, affrication, deaffrication, nasalization, denasalization, gemination and consonant cluster reduction.
Whole word errors: sequencing errors like reduplication, consonant harmony, migration, metathesis, epenthesis, initial consonant deletion, final consonant deletion, initial, medial and final syllable deletions (mention the number of syllables deleted).
Dysfluencies: repetitive production of speech sounds, hesitations, pauses, secondaries.

Scoring:

Scores of 0-1 is offered based on the correct production of the words. (Number of correct words- NWC)

Sequence maintenance score (SMS): Scoring of 0-2 is offered based on the appropriate maintenance of the sequence of syllables.

Sequence maintenance score for disyllabic words:
2 - Repeats both syllables in the correct order.
1 - Repeats both syllables in reverse order or adds an extra syllable or repeats a syllable, if consonant cluster reduction / deletion, consonant harmony, vowel harmony is present.
0 - Repeats only one syllable or does not repeat any syllable.

If the child does not respond, mark as No Response (NR) and score 0

Sequence maintenance score for trisyllabic and multisyllabic words
1 - Repeats all syllables in the correct sequence
1 - Repeats all syllables except one in the correct sequence or any one syllable in reverse order or addition of a syllable, consonant cluster reduction / deletion, consonant harmony, vowel harmony.
0 - Repeats one syllable correctly or does not repeat any syllable in the correct order

If the child does not respond, mark as No Response (NR) and score 0. The scores were not reduced for
consonant / vowel substitution unless where consonant/vowel harmony occured as repetition of syllables and deletion or reduction of syllables occured as a result of consonant cluster reduction or deletion.

(ii) NONMEANINGFUL WORDS:

Instructions: The child is instructed to repeat the following words after the investigator. A maximum of two attempts can be given to the child for the correct production. The responses have to be transcribed and scored accordingly.
Stimuli:

Target	*Response*	*Phonological Errors*			*Dysflu-encies*	*weak precision*	*Score (NWC)*	*Syllable sequence (SMS)*
Set A (I)		SE	TE	WWE				
pəkʊ								
nɪtɛ								
gɪba								
dɪbʊ								
lʊʧɛ								
Set A (II)								
pɪʧəbɪ								
nələta								
tɪpʊʤʊ								
dəmətə								
dəʤolʊ								
Set B (I)								
rəɪsa								
çɛʧo								
gɪmbʊ								
trəjjo								
pləŋgo								
Set B (II)								
kɛtrəjo								
səʊʤɪ								
rəŋgəʧʊ								
çɔkkəmbɛ								
strəgoʤʊ								

The following types of errors are noted after transcribing the responses.

Space errors: Fronting, backing and vowel deviations including vowel prolongation, vowel centralization, monophthongization, diphthongization.
Timing errors: voicing errors, affrication, deaffrication, nasalization, denasalization, gemination and consonant cluster reduction.
Whole word errors: sequencing errors like reduplication, consonant harmony, migration, metathesis, epenthesis, initial consonant deletion, final consonant deletion, initial, medial and final syllable deletions (mention the number of syllables deleted).
Dysfluencies: repetitive production of speech sounds, hesitations, pauses, secondaries.

Scoring:

Scores of 0-1 is offered based on the correct production of the words. (Number of words correct- NWC).

Sequence maintenance score (SMS): Scoring of 0-2 is offered based on the appropriate maintenance of the sequence of syllables.

Sequence maintenance score for disyllabic words:
2 - Repeats both syllables in the correct order.
1 - Repeats both syllables in reverse order or adds an extra syllable or repeats a syllable, if consonant cluster reduction / deletion, consonant harmony, vowel harmony is present.
0 - Repeats only one syllable or does not repeat any syllable.

If the child does not respond, mark as No Response (NR) and score 0

Sequence maintenance score for trisyllabic and multisyllabic words
2 - Repeats all syllables in the correct sequence
1 - Repeats all syllables except one in the correct sequence or any one syllable in reverse order or addition of a syllable, consonant cluster reduction / deletion, consonant harmony, vowel harmony.
0 - Repeats one syllable correctly or does not repeat any syllable in the correct order

If the child does not respond, mark as No Response (NR) and score 0. The scores were not reduced for consonant / vowel substitution unless where consonant/vowel harmony occured as repetition of syllables and deletion or reduction of syllables occured as a result of consonant cluster reduction or deletion.

III. DIADOCHOKINETIC ASSESSMENT:

Instructions:

The child is instructed to repeat /pə – pə – pə/, /ʈə – ʈə - ʈə/, /kə - kə - kə/, /pə -ʈə -kə/ as fast as possible. The task is demonstrated by the investigator and the child is asked to imitate the same. The duration of the trial has to be noted down.

Stimuli:

S.No.	*Stimulus*	*No. of iterations*	*Duration of trial (in sec)*	*DDK (it/sec)*	*Attempts*	*Accuracy*	*Consistency*
1.	/pə – pə – pə/						
2.	/ʈə – ʈə - ʈə/						
3.	/kə – kə– kə/						
4.	/pə -ʈə -kə/						

A minimum often iterations within two attempts is required for the diadochokinetic assessment .If a child is able to perform this, then the sample is considered for the following analysis.

- *Attempts:*
  The number of attempts, the child took to produce a minimum often iterations can be noted down. It is a qualitative measure. No scoring is done for this.

- *Accuracy:*
  Responses of all the subjects were rated for accuracy with respect to articulation.

  Scoring: Score of 1 is offered for the accurate production of the sequences, and 0 for inaccurate production of the sequences.

- *Consistency:*
  The first four iterations were selected from the sample and these iterations were considered for scoring.

  Scoring:
  Scores of 0-3 are offered based on the consistency of production of the first three iterations.

- *Consistency scores:*
  3 - Consistent repetition, no change from 1 repetition to next.
  2 - Three of the four repetitions are consistently repeated.
  1 - Two of four repetitions are consistently repeated.
  0 - All repetitions are different from one another.

- *DDK rate:*
  A minimum of ten iterations are considered for calculating diadochokinetic rate (DDK rate).

  DDK rate = $\frac{\text{Total number of iterations}}{\text{Duration of trial}}$ (Iterations/second or it/sec)

IV. SENTENCE LEVEL ASSESSMENT:

Instructions: The child is instructed to repeat the following sentences after the investigator. A maximum of two attempts can be given to the child for the correct production.

Stimuli:

Stimuli	*Response*	*Score (NSC)*	*Sequence maintenance (SMS)*
1.ɪllɪ ba			
2.ədu mərə			
3.nan bərɪjəlla			
4.nənge ʤvəra ɪdɛ			
5.a karʊ hogta ɪdɛ			
6.skuləlli ʧənnag odbekʊ			
7.məisurəllɪ ərməne ɪdɛ			
8.gaʃɪpəʧə məgu kəijəllɪdɛ			
9.nəməɳɳə kafi kʊɖɪta ɪddarɛ			
10.nɛnnɛ əmma nənge məɪsur pak maɖkɔʧru			

Scoring:
A score of 0-1 is offered for the correct production of the sentences. Score of 0 is offered for the incorrect production of the sentence and score of 1 for the correct production of the sentence. (Number of sentences correct- NSC)

Sequence maintenance score (SMS):
Scores of 0-2 are offered based on the maintenance of correct sequencing of words in sentences.

2 - All the words are in the exact order or position/ child uses a consistent phoneme substitution
1 - Sentences with < 3 words- At least 1 word is in order
Sentences with > 3 words-At least 3 of the key words are in order
0 -Sentences with < 3 words- 0 words in order
Sentences with > 3 words-2, 1 or no key words are in order

If the child does not respond, mark as No Response (NR) and score 0.

V. CONVERSATIONAL ASSESSMENT:

Instructions:
The conversational speech sample of around 100 words is recorded by asking the child general questions about his name, friends, family, house, school etc. The following errors are calculated:

1. Consonant Errors:

For calculating Percentage consonant correct (PCC) the following data is excluded from the analysis:

- Unintelligible and partially intelligible utterances
- Vowels
- Consonants which are repeated for the third time or more on repetition of the same word, if the pronunciation did not change. But if the pronunciation changed all the consonants are included for scoring.

The following were considered when the sample was analyzed for consonant errors.

- Dialectal changes, casual speech pronunciations and allophonic variations were not scored as incorrect.
- Consonant deletions are scored as incorrect
- Consonant substitutions are scored as incorrect
- Partial voicing are scored as incorrect
- Distortions are scored as incorrect
- Additions of consonants are scored as incorrect.

Calculate the 'Percentage of Consonants Correct' (PCC) using the formula:

$$PCC = \frac{\text{Total number of correct consonants}}{\text{Total number of consonants attempted}} \times 100$$

2. Vowel errors:

For calculating Percentage vowel correct (PVC) the following data is excluded from the analysis.

- Unintelligible and partially intelligible utterances
- Consonants
- Vowels which are repeated for the third time or more on the same word, if the pronunciation did not change, but if pronunciation changed, all the vowels are included for scoring.

The errors in the remaining data is identified using the following criteria:

- Dialectal changes, casual speech pronunciations and allophonic variations are not scored as incorrect.
- Vowel deletions are scored as incorrect.
- Vowel substitutions are scored as incorrect.
- Distortions are scored as incorrect.
- Additions of vowels are scored as incorrect.

The total number of vowel errors is tallied from the transcribed samples and the percentage of vowels correct (PVC) will be calculated as follows:

$$PVC = \frac{\text{Total number of correct vowels}}{\text{Total number of vowels attempted}} \times 100$$

Transcribed sample:

Appendix- B

Questionnaire for screening oro-motor deficits

Model for given for each activity.

1. Stick your tongue out
2. Put your tongue on one corner of your mouth
3. Put your tongue on the other corner of your mouth.
4. Put your tongue on the upper lip
5. Put your tongue on the lower lip
6. Put your tongue behind your upper teeth.
7. Round your lips
8. Protrude your lips and then retract it.
9. Protrude and retract the lips in three complete sequences of lip- protrusion and retraction.

Procedure for screening oral sensory deficits:

Oral sensory deficits were screened informally, by touching various parts of the child's mouth. Here, the child was asked to close his/her eyes and say, which part of the mouth the examiner is touching.

APPENDIX- C

Operational definitions of phonological processes

	Phonological processes	Definitions
I	Space errors	
1.	Fronting of retro flex stops	Replacement of retroflex stops /ʈ/ , /ɖ/, by their dental (/t/,/d/) counterparts was considered as defined as fronting of retroflex stops.
2.	Fronting of /ɳ/ and /ɭ/	It was considered as the replacement of retroflex nasal continuant / ɳ / and lateral /ɭ/ to their alveolar (/n/, /l/) counterparts.
3.	Fronting of velars:	This includes the replacement of velars /k/,/g/ to a more anterior position, generally an alveolar stop. In the present study, replacement of velars with retroflex and dental stops was also considered.
4.	Backing of dental stops	Backing of dental stops: It occurred when dental stops /t/ and /d/ were replaced by their palatal (retroflex) or velar counterparts.
5.	Vowel centralization	Any vowel when changed into the central vowel /ə/ was considered as vowel centralization.
6.	Vowel raising	It was considered when a low vowel was raised to a higher position (Pollack, & Keiser, 1990).
7.	Vowel lowering	This process occurred when a high vowel was produced as a lower vowel (Pollack, & Keiser, 1990).
8.	Vowel decentralization	This process was operationally defined as the subsituition of the schwa vowel with a vowel involving both a change of height and/or space (front/back).
9.	Monophthongization or diphthong reduction	It was noticed when a diphthong was changed into a vowel.

10	Depalatalization of palatal fricative /ʂ/	This occurred when an alveolar fricative was subsituited for a palatal fricative.
II	Timing errors	
11	Stopping	Stopping is considered as the subsituition of stops for fricatives and affricates.
12.	Deaffrication of affricates (to fricatives)	This sometimes refers to the replacement of an affricate with a stop or fricative, but in the present analysis, only subsituition of fricatives for affricates was considered; the former subsituition was considered as stopping.
13.	Affrication of fricatives	This occurred when fricatives were incompletely stopped (Velleman, 1998), ie., when a fricative was replaced with an affricate sound. In the words selected for imitation, the palatal fricative /ʂ / was present in clusters only.
14.	Degemmination	This occurred when a geminate cluster loses its geminate quality and was replaced by its singleton counterpart. This phonological process was also noted by Rama Devie (2006) as a type of cluster reduction.
15.	Gemmination	This process occurred when more "stress" was placed on the singleton consonant so that it acquires a 'geminate' quality. It was considered by Rama Devi (2006) as an atypical phonological process. This process was often associated with syllable deletions in the medial position and vowel shortening.
16.	Postvocalic devoicing	It occurred when a voiced obstruent that was followed by a voiced became voiceless (Pena-Brooks, & Hegde, 2000).
17.	Prevocalic voicing	When a voiceless sound preceeding a vowel became voiced (Pena-Brooks, & Hegde, 2000), it was considered as prevocalic devoicing. It is said to affect mostly stops and in the present analysis, only stops were considered.

III.	Whole word errors:	
18.	Consonant cluster reduction	This was considered as the subsituition of some or all members of a cluster. It included either deletion of a member of the target cluster (Stoel-Gammon, & Dunn, 1985).
19.	Consonant deletion	Omissions of singleton consonants in all positions of the word except the final position were considered in this study since final consonants are not observed with a high frequency in colloquial Kannada (Hiremath, 1980). Traditionally initial consonant deletions and final consonant deletions have been reported in literature. Consonant deletions in the medial position were also observed in children who participated in the study. Rama Devi (2006) also observed this phonological process in hearing impaired children in the age range of 5 to 9 years.
20.	Epenthesis in clusters only	Traditionally epenthesis has been defined as the insertion of an unstressed vowel, usually schwa /a/, typically inserted between two contiguous consonants that make up the original cluster.
21.	Consonant Harmony	This occurred when two non-adjacent consonants within a word become alike or more alike (Velleman, 1998). Assimilation processes are also divided into nasal, labial, velar assimilation and include voicing changes (Bernthal & Bankson, 1993). This analysis did not include voicing changes and considered all assimilation processes together as consonant harmony. Only total consonant harmony was observed in the children who participated in the study. It may be noted that nasal, velar and labial assimilation were taken as examples of consonant harmony.
22.	Vowel Harmony	This occurred when two vowels that are not adjacent to each other in a word become alike or more alike (Velleman, 1998).
23.	Reduplication	Repetition of a syllable of a target word that resulted in the creation of a multisyllabic word

		form (Penna-brooks & Hegde, 2000) was noted as reduplication. Only total reduplication was considered; repetitions of consonants only were considered consonant harmony and repetitions of vowels only were categorized as vowel harmony.
IV.	Others:	
24.	Substitution of geminate clusters for non-gemminate clusters	This occurred when a non-gemminate cluster was replaced by a geminated cluster that comprised one (lengthened) member of the non-geminate cluster or of a sound that was not a member of the original cluster (Rama Devie, 2006).
25.	Syllable deletion	Omission of syllables in any position of the word i.e. initial, medial or final positions was operationally defined as syllable deletion. Omission of only vowels was also considered syllable deletion since vowels serve as syllabic nuclei in Kannada (Rajapurohit, 1975).
V.	Unusual processes:	
26.	Subsituition of /l/ for /r/.	
27.	Subsituition of /v/ for /r/.	
28.	Subsituition of /t/ for /r/	

APPENDIX-D

PROTOCOL FOR APPRAISAL OF VERBAL PRAXIS IN TYPICALLY DEVELOPING CHILDREN (2.6 - 4.0 YEARS)

Name:

Date:

Age/Gender:

Education:

School:

Language age:

Other relevant information:

I. FUNCTION OF THE ORAL MECHANISM FOR SPEECH:

Instructions: The child is instructed to imitate the following activities after the investigator.

Stimuli:

1. The intra-oral air build-up for stops is Adequate / Inadequate
2. Air build up and precision of fricatives is Adequate / Inadequate
3. Oral-nasal distinction is Adequate / Inadequate

The following activities have to be observed without asking the child to imitate or do these activities

4. When the child spreads his lips, the range of movement of lips is Adequate/Inadequate
5. When the child opens and closes his/her mouth, range of movement of jaw is Adequate/Inadequate
6. When the child moves the tongue from side to side, the range of movement is Adequate/Inadequate

Scoring: Scores of 0 - 1 is offered based on the adequacy / inadequacy of the performance. A score of '0' is given for inadequate performance and a score of '1' is given for adequate performance.

II. VERBAL PRAXIS TOOL

A. ISOLATED SPEECH MOVEMENTS:

Instructions: The child is instructed to imitate the following vowels, consonants and syllables after the investigator.

Stimuli:

Action	*Accuracy*	*Repitition*	*Score*
Jaw movement			
1. Open your mouth and say 'ahh'			
2. Close your mouth and say 'm…'			
3. Say /jə/			
4. Say /əi/			
5. Say /əu/			
Lip movement			
6. Say /pə/,			
7. Say /o/			
8. Say /u/			
9. Say /i/			
10. Say /e/			
Tongue movement			
11. Say /tə/,			
12. Say /də/,			
13. Say 'n…'			
14. Say 'l...'			
15. Say 's…'			
16. Say /kə/,			
17. Say /gə/			
18. Say /Tə/,			
19. Say /ɖə/			
20. Say /ə/			
21. Say /lə/			
22. Say /ʧə/			
23. Say /rə/			
24. Say 'shh…' *			

Note:

* - Not applicable for children of 2.6 - 3.0

$ - Not applicable for children of 3.0 -3.6 years

• - Not applicable for children of any age group (2.6 - 3.0, 3.0 — 3.6, 3.6 — 4.0 years).

Scoring: Scores of 0 to 3 is offered based on the accuracy of speech movements and depending on whether repetitions or cues are given to the child. It may be noted that additional cues given if the child is not paying attention & /or not compliant should be disregarded in scoring.

3 - Movement / action is accurate
2 - Movement / action is accurate with one repetition
1 - Movement / action is inappropriate with more than one repetition
0 - Child is unable to perform even with repetitions.

B. SEQUENTIAL SPEECH MOVEMENTS:

Instructions: The child is instructed to imitate the following sequences of vowels and consonants .If the child is able to do this, then the child is instructed to imitate each sequence three times each followed by the investigator. A maximum of two attempts can be given to the child for the correct production.

Stimuli:

Action	*Response*	*No. of trials/times repeated*	*MCS*	*SMS*
1. a-u				
2. o-i				*
3. m-u			*	*
4. i-u-a				*
5. o-m-i			* $	* $ ♦
6. a-m-u			* $	* $
7. u-i-a				* $

Note:

* - Not applicable for children of 2.6 - 3.0

$ - Not applicable for children of 3.0 -3.6 years

• - Not applicable for children of any age group (2.6 — 3.0, 3.0 — 3.6, 3.6 - 4.0 years).

Scoring:

Motor control score (MCS): Scores of 0-2 is offered based on the appropriateness of movements. The number of times / trials the actions was repeated can be noted down.

Motor control score (MCS)

2 - All movements are precise.

1 - One of the movement is imprecise.

0 - All movements are imprecise or child substitutes one phoneme for another or child does not say all phonemes.

Sequence maintenance score (SMS): Scores of 0-2 is offered based on the appropriate maintenance for the sequence (i.e. the correct order in which, the sequences of vowels, consonants are repeated). The number of times / trials the actions was repeated can be noted down.

Sequence maintenance score (SMS)

2 - Repeats all phonemes correctly.

1 - Repeats 2 out of 3 sequences correctly or repeats the phonemes 5 or 6 times.

0 - Repeats one out of 3 sequences correctly or repeats the phoneme sequence more than 6 times.

C. WORD LEVEL PRAXIS ASSESSMENT:

(i) MEANINGFUL WORDS:

Instructions: The child is instructed to repeat the following words after the investigator. A maximum of two attempts can be given to the child for the correct production. The responses have to be transcribed and scored accordingly.

Target	*Response*	*Phonological Errors*			*Dysfluencies*	*Weak precision*	*Score (NWC)*	*Sequence Score (SMS)*
		SE	*TE*	*WWE*				
DNC								
təlɛ								
sirɛ								
mənɛ								
sebu								
najɪ								
DWC								
bɛkkʊ								
pɛnnʊ								
ʧʰətrɪ							* $	*
təʈʈɛ							*	
surja							*	
TNC								
bagɪlʊ								
hʊɖʊgɪ							* $	
kɪʈəkɪ								
ʧəməʧa								
kudəlʊ								
TWC								
rəɲgolɪ								
daɭɪmbɛ								
pʊstəkə							*	
ʧəppəlɪ								
iruɭɭɪ							* $	

Target	*Response*	*Phonological Errors*			*Dysfluencies*	*Weak precision*	*Score (NWC)*	*Sequence Score (SMS)*
		SE	TE	WWE				
MNC								
ərəmənɛ								
ədɻɪgemənɛ								
batʃəɳɪgɛ								
gədɻɪjara							*	
gaɭɪpəʈə							*	
MWC								
kənnəɖəka								
baɭɛhəɳɳʊ								
devəst^{h}ana							*	*
alu:gəɖɖɛ								
tɛŋgɪnəkaji								
D2C								
krɪʂɳa							* $ ◆	* $
drɪçjə							*	* $
prəçnɛ							* $ ◆	* $
swəʧʧ^{h}ə							* $	
drakʂi							* $ ◆	* $
T2C								
vjəvəst^{h}ɛ							* $◆	* $ ◆
prart^{h}əne							* $	* $
brəhmərʂi							* $ ◆	
svərgəst^{h}ə							* $◆	* $
prəkʂʊbdatɛ							* $ ◆	* $ ◆

Note:

* - Not applicable for children of 2.6 - 3.0

$ - Not applicable for children of 3.0 -3.6 years

• - Not applicable for children of any age group (2.6 - 3.0, 3.0 - 3.6, 3.6 - 4.0 years).

The target words increase in syllabic complexity from:

DNC - Di-syllable **No** cluster (with out cluster)
DWC - Dis-syllabic with cluster
TNC - Tri-syllabic No Cluster
TWC - Tri-syllabic with cluster
MNC - Multisyllabic No Cluster
MWC - Multisyllabic with cluster
D2C - Disyllabic with two clusters
T2C - Trisyllabic with two clusters

The following types of errors are noted after transcribing the responses.

Space errors: Fronting, backing and vowel deviations including vowel prolongation, vowel centralization, monophthongization, diphthongization.
Timing errors: voicing errors, affrication, deaffrication, nasalization, denasalization, gemination and consonant cluster reduction.
Whole word errors: sequencing errors like reduplication, consonant harmony, migration, metathesis, epenthesis, initial consonant deletion, final consonant deletion, initial, medial and final syllable deletions (mention the number of syllables deleted).

Dysfluencies: repetitive production of speech sounds, hesitations, pauses, secondaries.

Scoring (NWC- No. of words correct):

Scores of 0-1 is offered based on the correct production of the words.
Sequence maintenance score (SMS): Scoring of 0-2 is offered based on the appropriate maintenance of the sequence of syllables.

Sequence maintenance score for disyllabic words:
2 - Repeats both syllables in the correct order.
1 - Repeats both syllables in reverse order or adds an extra syllable or repeats a syllable, if consonant cluster reduction / deletion, consonant harmony, vowel harmony is present.
0 - Repeats only one syllable or does not repeat any syllable.

If the child does not respond, mark as No Response (NR) and score 0

Sequence maintenance score for trisyllabic and multisyllabic words
2 - Repeats all syllables in the correct sequence
1 - Repeats all syllables except one in the correct sequence or any one syllable in reverse order or addition of a syllable, consonant cluster reduction / deletion, consonant harmony, vowel harmony.
0 - Repeats one syllable correctly or does not repeat any syllable in the correct order

If the child does not respond, mark as No Response (NR) and score 0. The scores were not reduced for consonant / vowel substitution unless where consonant/vowel harmony occured as repetition of syllables and deletion or reduction of syllables occured as a result of consonant cluster reduction or deletion.

(ii) NONMEANINGFUL WORDS:

Instructions: The child is instructed to repeat the following words after the investigator. A maximum of two attempts can be given to the child for the correct production. The responses have to be transcribed and scored accordingly.

Stimuli:

Target	*Response*	*Phonological Errors*			*Dysflu-encies*	*weak precision*	*Score (NWC)*	*Syllable sequence (SMS)*
Set A (I)		SE	TE	WWE				
pəkʊ								
nɪtɛ								
gɪba								
dɪbʊ								
lʊʈɛ								
Set A (II)								
pɪʈəbɪ								
nələta								
tɪpʊɖʊ								
dəmətə								
dəɖolʊ								
Set B (I)								
rəɪsa								
çɛʧo							* $ ♦	*
gɪmbʊ								
trəjjo							* $	* $
pləŋgo							*	*
Set B (II)								
kɛtrəjo							* $	* $♦
səʊʤɪ							* $ ♦	
rəŋgəʧʊ								
çɔkkəmbɛ							* $	
strəgoʤʊ							* $ ♦	* $ ♦

Note:

* - Not applicable for children of 2.6 - 3.0

$ - Not applicable for children of 3.0 -3.6 years

• - Not applicable for children of any age group (2.6 - 3.0, 3.0 - 3.6, 3.6 - 4.0 years).

The following types of errors are noted after transcribing the responses.

Space errors: Fronting, backing and vowel deviations including vowel prolongation, vowel centralization, monophthongization, diphthongization.
Timing errors: voicing errors, affrication, deaffrication, nasalization, denasalization, gemination and consonant cluster reduction.
Whole word errors: sequencing errors like reduplication, consonant harmony, migration, metathesis, epenthesis, initial consonant deletion, final consonant deletion, initial, medial and final syllable deletions (mention the number of syllables deleted).
Dysfluencies: repetitive production of speech sounds, hesitations, pauses, secondaries.

Scoring (NWC) :

Scores of 0-1 is offered based on the correct production of the words
Sequence maintenance score (SMS): Scoring of 0-2 is offered based on the appropriate maintenance of the sequence of syllables.

Sequence maintenance score for disyllabic words:
2 - Repeats both syllables in the correct order.
1 - Repeats both syllables in reverse order or adds an extra syllable or repeats a syllable, if consonant cluster reduction / deletion, consonant harmony, vowel harmony is present.
0 - Repeats only one syllable or does not repeat any syllable.

If the child does not respond, mark as No Response (NR) and score 0

Sequence maintenance score for trisyllabic and multisyllabic words
2 - Repeats all syllables in the correct sequence
1 - Repeats all syllables except one in the correct sequence or any one syllable in reverse order or addition of a syllable, consonant cluster reduction / deletion, consonant harmony, vowel harmony.
0 - Repeats one syllable correctly or does not repeat any syllable in the correct order

If the child does not respond, mark as No Response (NR) and score 0. The scores were not reduced for consonant / vowel substitution unless where consonant/vowel harmony occured as repetition of syllables and deletion or reduction of syllables occured as a result of consonant cluster reduction or deletion.

D. RELATIONAL SPEECH TIMING IN WORD CONTEXT:

Instructions: The child is instructed to repeat the following words after the investigator. A maximum of two attempts can be given to the child for the correct production. The responses have to be transcribed and scored accordingly.

Stimuli:

Set number	*Type of Base word (BW)*	*Stimuli 1 Base word (RST-I)*			*Stimuli 2 Base word + Suffix 1 (RST-II)*			*Stimuli 3 Base word+suffix 1+ suffix 2 (RST-III)*		
			Score			*Score*			*Score*	
			NWC	*SMS*		*NCW*	*SMS*			*SMS*
1	***Monosyllable***	/ba:/			/ba:gi/			/ba:gilu/		
2	***Monosyllable***	/ta:/			/ta:/			/ta:ta/		
3	***Monosyllable***	/ba:/			/ba:la/			/ba:laka/		
4	***Monosyllable***	/bhu/			/bhu:mi/			/bhu:mika/		
5	***Bisyllable***	/kara/			/karaga/	* $		/karaga⌊a/	*$	
6	***Bisyllable***	/gaaja/			/gaajaka/			/gaajakaru/	*$	
7	***Bisyllable***	/dziva/			/dzi:vana/			/dzi:vanadi/		
8	***Bisyllable***	/sara/			/sara⌊a			/sara⌊ate/	* $ ♦	

Note:

* - Not applicable for children of 2.6 - 3.0

$ - Not applicable for children of 3.0 -3.6 years

• -Not applicable for children of any age group (2.6 -3.0, 3.0 - 3.6, 3.6-4.0 years).

Scoring (NCW):
A score of 0-1 is offered based on the correct production of the words.

Sequence maintenance score (SMS): Scoring of 0-2 is offered based on the appropriate maintenance of the sequence of syllables.

Sequence maintenance score for disyllabic words:
2 - Repeats both syllables in the correct order.
1 - Repeats both syllables in reverse order or adds an extra syllable or repeats a syllable, if consonant cluster reduction / deletion, consonant harmony, vowel harmony is present.
0 - Repeats only one syllable or does not repeat any syllable.

If the child does not respond, mark as No response (NR) and score 0

Sequence maintenance score for trisyllabic and multisyllabic words

2 - Repeats all syllables in the correct sequence

1 - Repeats all syllables except one in the correct sequence or any one syllable in reverse order or addition of a syllable, consonant cluster reduction / deletion, consonant harmony, vowel harmony.

0 - Repeats one syllable correctly or does not repeat any syllable in the correct order

III. DIADOCHOKINETIC ASSESSMENT:

Instructions:

The child is instructed to repeat /pə – pə – pə/, /ʈə – ʈə - ʈə/, /kə - kə - kə/, /pə -ʈə -kə/ as fast as possible. The task is demonstrated by the investigator and the child is asked to imitate the same. The duration of the trial has to be noted down.

Stimuli:

S.No.	*Stimulus*	*No. of iterations*	*Duration of trial (in sec)*	*DDK (it/sec)*	*Attempts*	*Accuracy*	*Consistency*
1.	/pə – pə – pə/						
2.	/ʈə – ʈə - ʈə/						
3.	/kə – kə– kə/						
4.	/pə -ʈə -kə/						

A minimum often iterations within two attempts is required for the diadochokinetic assessment .If a child is able to perform this, then the sample is considered for the following analysis.

- *Attempts:*
  The number of attempts, the child took to produce a minimum often iterations can be noted down. It is a qualitative measure. No scoring is done for this.

- *Accuracy:*
  Responses of all the subjects were rated for accuracy with respect to articulation.

  Scoring: Scores of 1 is offered for the accurate production of the sequences & 0 for inaccurate production of the sequence.

- *Consistency:*
  The first four iterations are selected from the sample and these iterations were considered for scoring.

  Scoring:

Scores of 0-3 are offered based on the consistency of production of the first three iterations.

- ***Consistency scores:***
  3 - Consistent repetition, no change from 1 repetition to next.
  2 - Three of the four repetitions are consistently repeated.
  1 - Two of four repetitions are consistently repeated.
  0 - All repetitions are different from one another.

- ***DDK rate:***
  A minimum of ten iterations are considered for calculating diadochokinetic rate (DDK rate).

  $$\text{DDK rate} = \frac{\text{Total number of iterations}}{\text{Duration of trial}} \quad \text{(Iterations/second or it/sec)}$$

IV. SENTENCE LEVEL ASSESSMENT:

Instructions: The child is instructed to repeat the following sentences after the investigator. A maximum of two attempts can be given to the child for the correct production.

Stimuli:

Stimuli	*Response*	*Score*	*Sequence maintenance (SMS)*
1.ɪllɪ ba			
2.ədu mərə			
3.nan bərɪjəlla		*	
4.nənge ʤvəra ɪdɛ		*	
5.a karʊ hogta ɪdɛ		*	*
6.skuləlli ʧənnag odbekʊ		* $	
7.məisurəllɪ ərməne ɪdɛ		* $	
8.gaɭɪpəʈə məgu kəijəllɪdɛ		* $	* $
9.nəməɳɳə kafi kʊɖɪta ɪddarɛ		* $	* $
10.nɛnnɛ əmma nənge məɪsur pak maɖkɔʈru		* $ ♦	* $ ♦

Note:

* - Not applicable for children of 2.6 - 3.0

$ - Not applicable for children of 3.0 -3.6 years

• - Not applicable for children of any age group (2.6 - 3.0, 3.0 - 3.6, 3.6 - 4.0 years).

Scoring (NSC- No. of sentences correct):
A score of 0-1 is offered for the correct production of the sentences. A score of 1 is offered for the correct production of the sentence and score of 0 for is offered for incorrect production of the sentence.

Sequence maintenance score (SMS):
Scores of 0-2 are offered based on the maintenance of correct sequencing of words in sentences.

2 - All the words are in the exact order or position/ child uses a consistent phoneme substitution
1 - Sentences with < 3 words- At least 1 word is in order
Sentences with > 3 words-At least 3 of the key words are in order
0 -Sentences with < 3 words- 0 words in order
Sentences with > 3 words -2, 1 or no key words are in order

If the child does not respond, mark as No Response (NR) and score 0

V. CONVERSATIONAL ASSESSMENT:

Instructions:

The conversational speech sample of around 100 words is recorded by asking the child general questions about his name, friends, family, house, school etc. The following errors are calculated".

1. Consonant Errors:

For calculating Percentage consonant correct (PCC) the following data is excluded from the analysis:

- Unintelligible and partially intelligible utterances
- Vowels
- Consonants which are repeated for the third time or more on repetition of the same word, if the pronunciation did not change. But if the pronunciation changed all the consonants are included for scoring.

The following were considered when the sample was analyzed for consonant errors.

- Dialectal changes, casual speech pronunciations and allophonic variations were not scored as incorrect.
- Consonant deletions are scored as incorrect
- Consonant substitutions are scored as incorrect
- Partial voicing are scored as incorrect
- Distortions are scored as incorrect
- Additions of consonants are scored as incorrect.

Calculate the 'Percentage of Consonants Correct' (PCC) using the formula:

$$PCC = \frac{\text{Total number of correct consonants}}{\text{Total number of consonants attempted}} \times 100$$

2. Vowel errors:

For calculating Percentage vowel correct (PVC) the following data is excluded from the analysis.

- Unintelligible and partially intelligible utterances
- Consonants
- Vowels which are repeated for the third time or more on the same word, if the pronunciation did not change, but if pronunciation changed, all the vowels are included for scoring.

The errors in the remaining data is identified using the following criteria:

- Dialectal changes, casual speech pronunciations and allophonic variations are not scored as incorrect.
- Vowel deletions are scored as incorrect.
- Vowel substitutions are scored as incorrect.
- Distortions are scored as incorrect.
- Additions of vowels are scored as incorrect.

The total number of vowel errors is tallied from the transcribed samples and the percentage of vowels correct (PVC) will be calculated as follows:

$$PVC = \frac{\text{Total number of correct vowels}}{\text{Total number of vowels attempted}} \times 100$$

Transcribed sample:

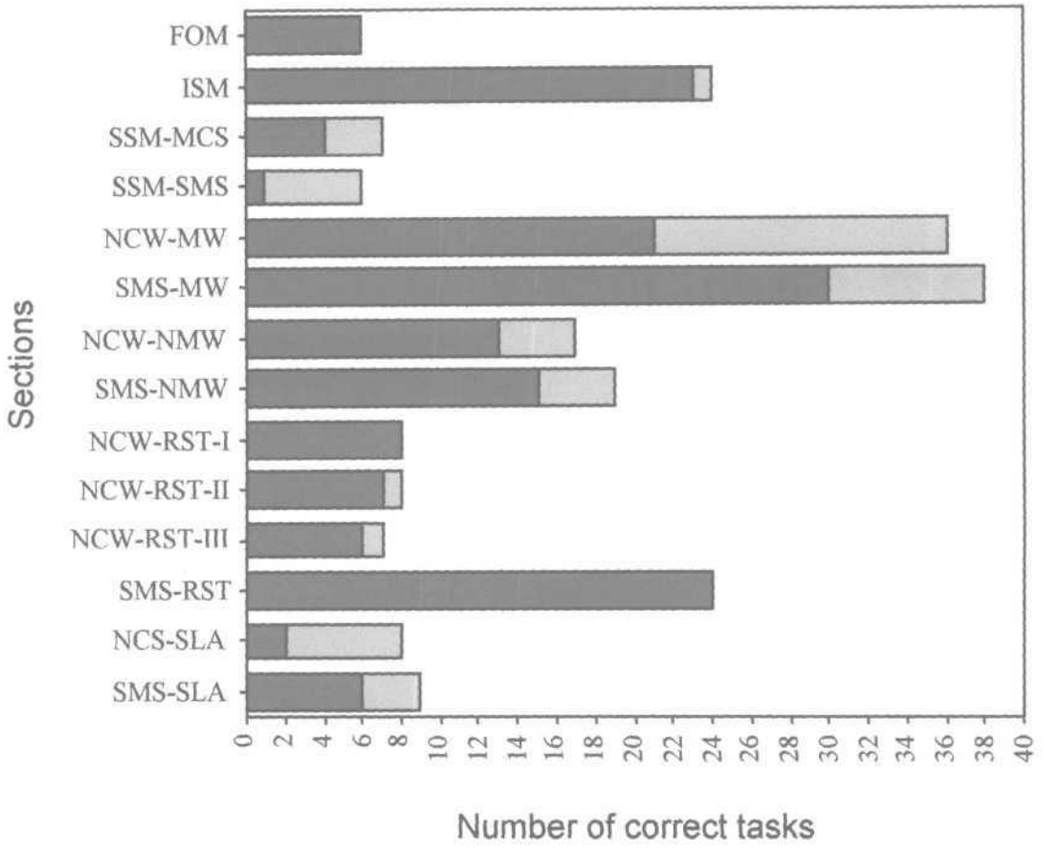
APPENDIX -E

The three graphs provided below helps the investigator in interpreting the results of the protocol. The graphs are given separately for children of the three age groups (2.6 - 3.0, 3.0 - 3.6, 3.6 - 4.0). The graphs should be used only after administering the protocol given in Appendix D on a given child.

Representation of the mean scores of a given child with reference to established norms:

The x axis represents the number of tasks and the y axis represents different sections used in the protocol. The graph indicates the mean scores and the maximum scores. The mean score is indicated by a vertical line placed in the horizontal bars representing various tasks. The investigator can interpret whether the child is performing optimally or not by matching the scores obtained by the child with the mean scores indicated in this graph and understand whether the child is performing at or below average / above average levels on the protocol. A score on the vertical line of a horizontal bar for a task represents average performance (matching the mean of the group). A score which falls to the left of the vertical line represents below average performance for the task and a score which falls to the right of the vertical line represents above average performance for the task. A child whose performance falls in the below average performance range (i.e to the left side of the vertical line) could be at risk for praxis breakdown. Thus the graph helps in identifying suspected apraxia of speech (sCAS) in young Kannada speaking children in the age range of 2.6 - 4.0 years. Some bars in the graphs shows optimum performance i.e the mean is at the right most edge. So such bars allows the investigator to look for only below average performance. This is very evident in the graph showing the performance of children in the age group of 3.6 - 4.0 years.

*PERFORMANCE GRAPH FOR 2.6 – 3.0 YEARS



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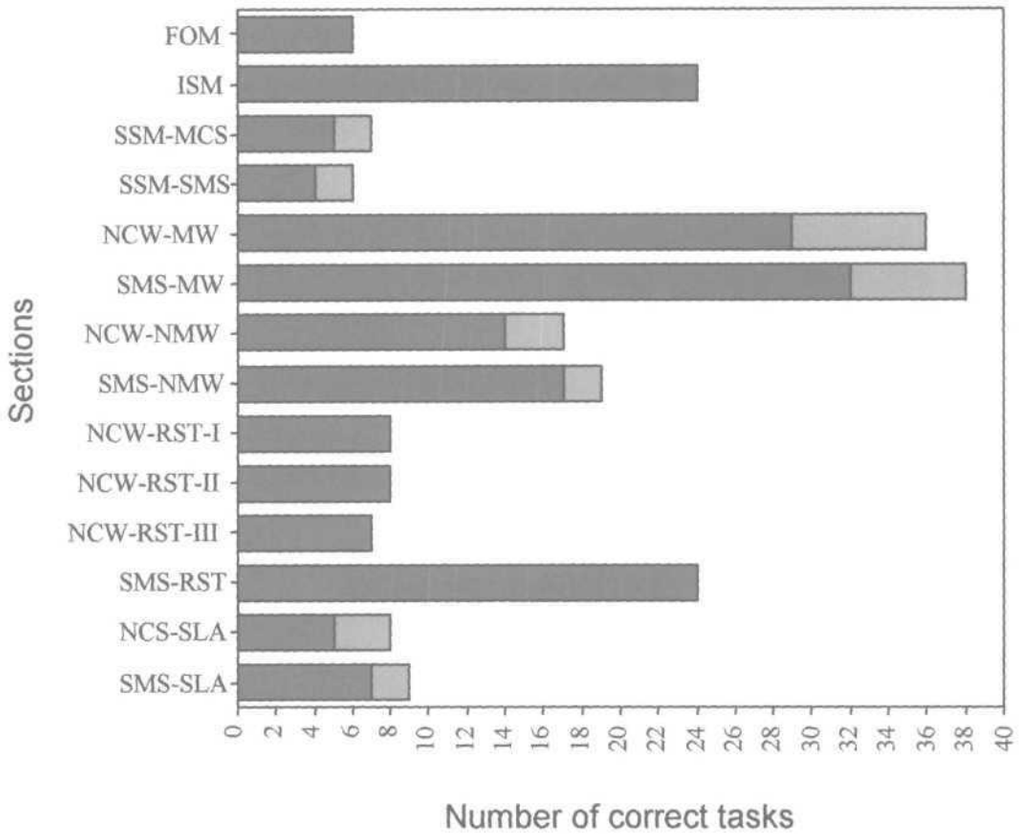
* **FOM**- function of the oral mechanism for speech, **ISM**- Isolated speech movements, **SSM-MSC**- sequential speech movements; motor control score, **SSM- SMS**- sequential speech movements- sequence maintenance score, **NCW-NW**- number of correct words- meaningful words, **SMS-MW**- sequential maintenance score- meaningful words, **NCW-NMW**- number of correct words- non meaningful words, SMS-NMW- sequential maintenance score- non meaningful words, **NCW-RST I**- number of correct words- relational words speech timing I, **NCW-RST-II**- number of correct words- relational words speech timing II, **NCW-RST III**- number of correct words- relational words speech timing III, **SMS-RST**- sequence maintenance score- relational words speech timing, **NCS-SLA**- number of correct sentence- sentence level assessment, **SMS-SLA**- sequence maintenance score- sentence level assessment.

*PERFORMANCE GRAPH OF 3.0 – 3.6 YEARS



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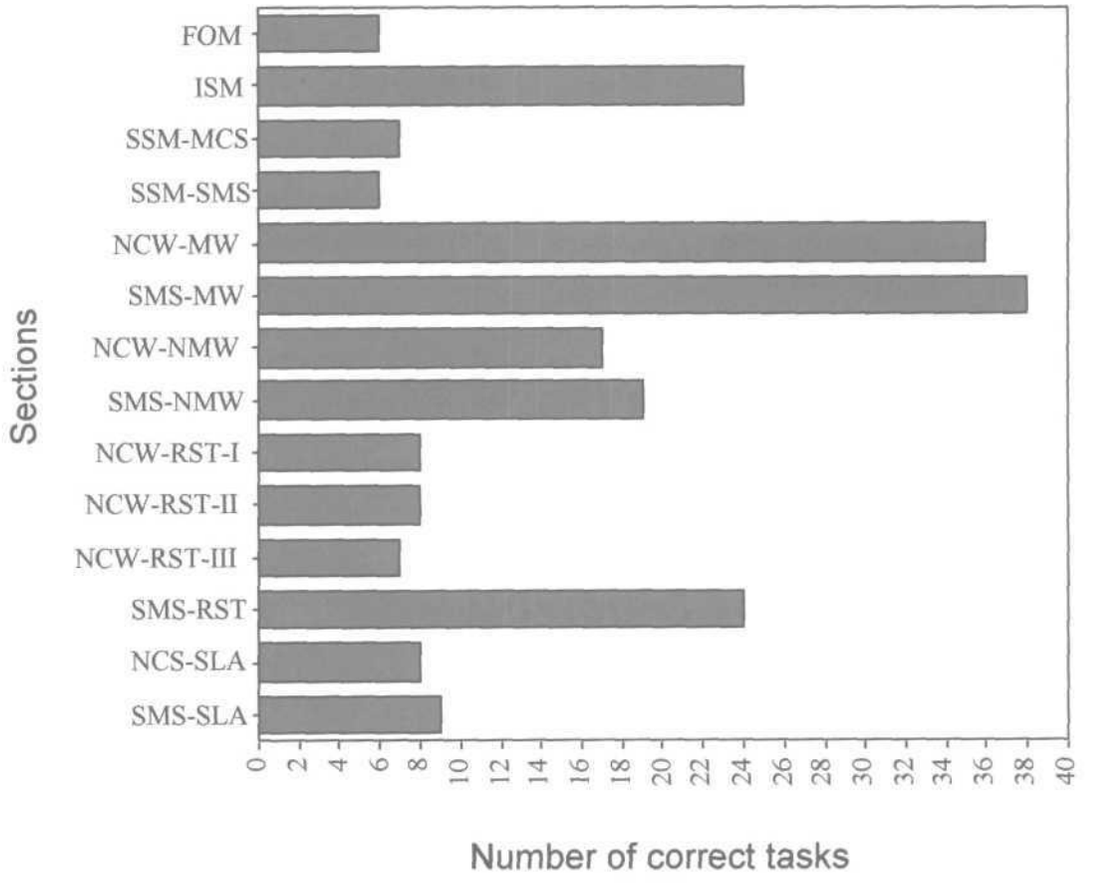
* **FOM**- function of the oral mechanism for speech, **ISM**- Isolated speech movements, **SSM-MSC**- sequential speech movements; motor control score, **SSM- SMS**- sequential speech movements- sequence maintenance score, **NCW-NW**- number of correct words- meaningful words, **SMS-MW**- sequential maintenance score- meaningful words, **NCW-NMW**- number of correct words- non meaningful words, SMS-NMW- sequential maintenance score- non meaningful words, **NCW-RST I**- number of correct words- relational words speech timing I, **NCW-RST-II**- number of correct words- relational words speech timing II, **NCW-RST III**- number of correct words- relational words speech timing III, **SMS-RST**- sequence maintenance score- relational words speech timing, **NCS-SLA**- number of correct sentence- sentence level assessment, **SMS-SLA**- sequence maintenance score- sentence level assessment.

*PERFORMANCE GRAPH OF 3.6 – 4.0 YEARS



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* **FOM**- function of the oral mechanism for speech, **ISM**- Isolated speech movements, **SSM-MSC**- sequential speech movements; motor control score, **SSM- SMS**- sequential speech movements- sequence maintenance score, **NCW-NW**- number of correct words- meaningful words, **SMS-MW**- sequential maintenance score- meaningful words, **NCW-NMW**- number of correct words- non meaningful words, SMS-NMW- sequential maintenance score- non meaningful words, **NCW-RST I**- number of correct words- relational words speech timing I, **NCW-RST-II**- number of correct words- relational words speech timing II, **NCW-RST III**- number of correct words- relational words speech timing III, **SMS-RST**- sequence maintenance score- relational words speech timing, **NCS-SLA**- number of correct sentence- sentence level assessment, **SMS-SLA**- sequence maintenance score- sentence level assessment.