STABILITY OF SPEECH ARTICULATORY ERRORS FROM CHILDHOOD TO ADULTHOOD IN CEREBRAL PALSIED POPULATION

PRASANNA KUMAR. E.

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Final Year M.Sc., (Speech and Hearing),
University of Mysore, Mysore.

ALL INDIA INSTIT UTE OF SPEECH AND HEARING
MANASAGANGOTHRI
MYSORE - 570006

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Dedicated to……

My Guide,
Dr. M.Jayaram
&
all my Teachers

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CERTIFICATE

This is to certify that this dissertation entitled "**STABILITY OF SPEECH ARTICULATORY ERRORS FROM CHILDHOOD TO ADULTHOOD IN CEREBRAL PALSIED POPULATION**" is a bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student (Register No. M2K17).

Dr. M. Jayaram
Director

All India Institute of Speech and Hearing,
Mysore-570 006

Mysore,

May, 2002

CERTIFICATE

This is to certify that this dissertation entitled **"STABILITY OF SPEECH ARTICULATORY ERRORS FROM CHILDHOOD TO ADULTHOOD IN CEREBRAL PALSIED POPULATION"** has been prepared under my supervision and guidance. It is also certified that dissertation has not been submitted earlier in any University for the award of any Diploma or Degree.

Guide

Mysore,

May, 2002

Dr.M.Jayaram
Director,
All India Institute of Speech & Hearing,
Mysore-570 006

DECLARATION

This dissertation entitled **"STABILITY OF SPEECH ARTICULATORY ERRORS FROM CHILDHOOD TO ADULTHOOD IN CEREBRAL PALSIED POPULATION"** is the result of my own study under the guidance of Dr. M.Jayaram, Director, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier in any other University for the award of any Diploma or Degree.

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INTRODUCTION

Cerebral Palsy is a non-progressive disorder of motor control caused by damage to the developing brain during pre-, peri-, or early post-natal periods (Dillow, Dzienkowski, Smith and Yucha, 1996; Hardy, 1994; Love, 1992).

Motor disability in cerebral palsy affects speech sound articulation, voice, prosody of speech and intelligibility of speech thereby hindering oral communication. The neuromuscular involvement may affect speech in over 75 percent of the cerebral palsy population (Lehroff, 1958).

Cerebral palsy encompasses many different types and degrees of speech-related activities. Boone (1972) groups the speech-related dysfunctions in dysarthria under the following dimensions:

- Pitch variations
- Loudness variations
- Laryngeal and resonance quality variations
- Respiratory variations
- Prosodic variations
- Overall general impression of intelligibility and bizarreness

Love (1992) reported similar spcech-related ubnormulities in cerebral palsy. In fact, he favors this approach as it offers the clinician a ready description of the patient's speech behaviour while a classification and labelling such as

spastic or athetoid speech may not help to locate the differences and abilities of individual cases.

Methods of Speech Error Characterization

Traditionally, the articulatory errors in disordered speech have been described using the sound-by-sound analysis. The procedure mainly involves sampling the phonetic inventory of the client in the word-initial, medial and final positions, and classification of errors as substitutions, omissions, distortions and additions of sound. Each error is viewed primarily as a problem in motor production as a separate entity needing remediation. These traditional procedures are so simple in their conceptual framework that they are used by most speech pathologists even today.

In the past two decades, however, much emphasis has been placed on such approaches like pattern analysis, which include analysis of place-voice-manner productions, distinctive feature and phonological processes. According to Stampe (1979), "a phonological process is a mental operation that applies in speech to substitute for a class of sounds or sound sequences presenting a common difficulty to the speech capacity of the individual, an alternative class identical, but lacking the difficult property".

Phonological process analysis provides a more comprehensive and descriptive framework for error analysis because they describe the structural as well as the systemic simplifications in the speech pattern and whenever necessary, take account of contextual factors influencing production of sounds as well. Phonological process analysis may provide a parsimonious means of selecting those classes of phonemes which need immediate attention and intervention.

Speech Errors in Children with Cerebral Palsy

Despite the neuromuscular limitations, most children with cerebral palsy do develop some degree of speech and establish perceptual and motor links by means of which they evaluate and modify their sound production (Netsell, 1986).

Several researchers have reported, in detail, the speech articulatory errors of children with cerebral palsy. The approaches adopted are either the traditional sound-by-sound analysis (Byrne, 1959; Clement and Twitchell, 1959; Hixon and Hardy, 1964; among others) or pattern analysis like phonological process analysis (Milloy and Morgan-Barry, 1990, among others).

Byrne (1959) reported that the errors more frequently involved the tongue-tip complex sounds in the cerebral palsied children. Errors also occurred on lip complex, back of tongue, tongue-tip simple and bilabial sounds.

Furthermore, the extent of errors decreased from final position to initial position consonant sounds. In general, Byrne (1959) found that children with spastic or athetoid cerebral palsy developed articulatory skills in the same manner, as did normal children, but that they were significantly delayed.

McMahon, Hodson and Alley (1983) noted that liquid deviations (including gliding, vowelization and omission), cluster reduction, syllable reduction and omissions of prevocalic singleton obstruent and postvocalic singleton obstruents occurred more frequently.

Speech Errors in Adults with Cerebral Palsy

There are relatively few studies which have specifically described the nature of speech deficits in adults with cerebral palsy. Platt, Andrews and Howie (1980) analyzed the articulatory errors in terms of place-manner-voicing and reported that within-manner errors (place or voicing errors, or both) exceeded between-manner errors by a substantial degree.

Lakshmi (2001) reported that fronting, topping, gliding of liquids, devoicing, vocalization, final consonant deletion, initial consonant deletion, backing and vocalic support of final consonant and consonant harmony processes were the most frequently observed features in the speech of adults with spastic cerebral palsy.

Parallels in the Speech Sound Articulatory Errors in the Speech of Children and Adults with Cerebral Palsy

A comparison of the speech articulatory features of the speech of children and adults with cerebral palsy has not been the subject of much enquiry.

Platt et al (1980) compared their data on the speech of adult cerebral palsied with those of Byrne (1959) on children and reported fairly stable features from childhood to adulthood at the level of phonemic articulatory accuracy. That is, despite the differences in absolute percent correct values, Platt et al (1980) reported that the articulatory profiles were strikingly similar between the two groups (adults and children) across place and manner features. However, the two studies-Byrne (1959) and Platt et al (1980)-differ substantially in their methodological formulations.

Statement of **the Problem**

Though the results of the comparison of the findings of Platt et al (1980) in adults and Byrne (1959) in children appear to suggest a qualitatively similar profile of specific deficits in the two populations, the comparison suffers from methodological limitations. Therefore, the present study attempts to verify the hypothesis that the specific residual deficits in speech sound articulation in adults

are qualitatively similar to the articulation profiles in children while the absolute levels of phonemic accuracy may or may not differ.

Objectives

The primary objectives of the present study were to

a) verify the hypothesis that despite the level of phonemic accuracy, the specific residual speech sound articulatory errors in adults with spastic CP are qualitatively similar to those found in the speech of children with spastic cerebral palsy, and if yes, then

b) to see if the similarities of errors arrived through both a phonological process analysis and traditional sound-by-sound analysis, can be characterized or grouped to aid in speech therapy

A secondary objective of the study was to describe the speech articulatory errors found in both children and adults with spastic cerebral palsy

Need for the study

Most children with cerebral palsy survive into adulthood. Yet the speech of adult cerebral palsied has only been infrequently studied (Andrews, Platt and Young, 1977; Lakshmi, 2001). There is a need to study neuromotor speech disorders for what they can reveal about the neuromotor control of speech production. The details of speech of children with cerebral palsy cannot be taken

as evidence of the eventual course of speech in the adults, although one can expect similarities. The clear need is to study the speech of the cerebral palsied adults.

Platt, Andrews, Quinn and Young (1980) compared their data on the speech of adult cerebral palsied with those of Byrne (1959) in children. They reported that despite the obvious differences in absolute percent correct values, striking similarities existed between the speech errors of the two groups. They appeared to conclude from this that at the level of phonemic articulatory accuracy, the dysarthria accompanying cerebral palsied appears to have fairly stable features from childhood to adulthood. Obviously, this attempt to compare data from two studies, different in their methods of study, suffers from methodological limitations. Therefore, the present study aims to put this hypothesis into a more vigorous empirical test.

The few studies which have investigated the speech of adult cerebral palsied have demonstrated that the adult cerebral palsied remain severely impaired in their precision of articulation and speech intelligibility. The results of this study could identify the specific features of deviant articulations (residual speech defects) which require specific therapeutic intervention in both adults and children.

This study is also of theoretical interest The stability or otherwise of the speech sound errors from childhood to adulthood probably points to the neuromotor limitations inherent to the speech production in persons with cerebral palsy. The results of this study may throw light on the neuromotor integrity for speech production.

Chapter 2

REVIEW

Cerebral palsy is defined as a nonprogressive disorder of motion and posture due to brain insult or injury, occurring in the period of early brain growth and generally less than 3 years of age (Lord, 1984). The condition results in a wide variety of motor disabilities, dysarthria being one of them. Generally speaking, this disorder constitutes the most common developmental motor impairment (Best, Biggie and Sirvis, 1994; Love, 1992).

The lack of volitional motor control for speech is among the central clinical features of cerebral palsy. However, cerebral palsy's symptom complex is characterized by a host of neurological malfunctions. These dysfunctions include disturbances in cognition, perception, sensation, language, hearing, emotional behaviour and feeling besides seizures (Love, 2000). Any or all of these additional dysfunctions may compound the developmental dysarthria and/or interfere with communicative performance of the child with cerebral palsy.

The pattern of development of speech and the specific characteristics of speech deviations have been the focus of research in cerebral palsy. However, the speech of adults with cerebral palsy is relatively less focused upon (Platt, Andrews, Young and Quinn, 1980, Lakshmi, 2001; among others) than the speech of cerebral palsied children (Irwin, 1972; Byrne, 1959; among others).

Articulatory Acquisition in Children with Cerebral Palsy

The development of speech in children with cerebral palsy has been the primary concern of many speech-language pathologists. Studies have indicated that speech and language develop slowly in this group. Although retarded, there is evidence to say that, acquisition of articulatory skills follows the same sequential pattern observed in normal children (Denhoff and Holden, 1951; Irwin, 1956; Byrne, 1959).

Irwin (1956) reported an increase in the type and frequency of vowels and consonants in the utterances of both normal and cerebral palsied children with age. The pace of acquisition in normals, however, far surpassed that of the cerebral palsied group. Irwin (1956) noticed that, as far as mastery of speech sound elements is concerned, there was no strong statistical evidence that differences existed among spastics, athetoids and tension athetoids with respect to the four measures of vowel, consonant, vowel frequency and consonant frequency types. However, mastery of speech sounds increased with increase in age.

Byrne (1959) studied the development of speech-language in spastic and athetoid cerebral palsied children in the 2-7 year age group. She studied 81 phonetic unit which included 7 words, 5 diphthongs, 60 consonantal, and 9

consonantal-blend responses. The 60 consonants included 22 word-initial, 19 word-medial and 19 word-final sounds. Speech sounds were tested in the order of vowels, diphthongs, initial, medial and final consonants, and consonantal blends. The results of this study are summarized in Table 1.

Table 1: The results of Byrne (1959) on the development of speech in children with spastic and athetoid cerebral palsy.

	Spastics			Athetoids		
Age (in years)	Vowels dipthongs	Consonants	Blends	Vowels dipthongs	Consonants	Blends
2	4.6	6.3	0.0	3.5	3.0	0.0
3	12.0	56.4	8.2	10.0	37.0	5.0
4	11.7	59.4	9.0	11.0	51.0	6.7
5	11.8	59.4	9.0	11.7	48.7	7.2
6	12.0	59.7	9.0	11.8	57.3	7.5
7	12.0	60.0	8.8	12.0	55.1	8.0

It can be seen from Table 1 that the accuracy of production of vowel was close to normal. The vowels, which required neutral tongue positions, such as [L] and [ae], were more frequently produced accurately than those which required the tongue tip. The following indicates the list of

consonantal sounds which reached the 75 percent level of proficiency according to age groups.

In the initial position

2 year old	None of the children reached the 75 percent level for any sound.
3 year old	Achieved correct production for 11 sounds i.e. [w], [b], [j], [m], [d], [n] [h], [g], [p], [k] and [t]
4 year old	[w], [bj, [j], [g], [d], [n], [k]
5 year old	[w] only
6 year old	[w], [b], [j], [g], [m], [h]
7 year old	[w], [b], [j], [m], [d], [n] [h], [g], [p], [k] [f], [v]

Medial position

Sounds in the word-medial position were less accurately produced than those in the word-initial position.

2 year old	Failed to achieve the 75 percent level for any sound
3 year old	[b], [n], [g]
4 year old	[n], [d]
5 year old	
6 year old	[m] only
7 year old	[b], [n], [g], [d], [n], [p], [k], [t]

Final position

Few sounds in the final position reached the 75% level in any age group. Only the 3 and 7 year old achieved this level for any consonant. Both groups were proficient in the use of [n], [ŋ], [p], [b], [t], and [k]. In addition, the 3-year old group correctly produced the [m] and [f] and 75 percent of the 7- year olds attained the [d].

Other salient features from the Byrne (1959) study were -

a) proficiency in the production of different group of sounds followed the developmental schedule. Vowels were correctly produced more than 85% of the time, while diphthongs were correctly produced more than 80% of the time. One half of all consonants and less than one-fourth of the consonant blends were accurate,

b) proficiency in consonantal production followed an orderly pattern of development. Bilabials were most frequently produced correctly followed by tongue-tip simple, back of tongue, lip complex and tongue tip complex sounds. Initial sounds were more frequently produced correctly than

medials, and the medials more often than the final sounds if they were consonants, and

c) scores on consonant articulation did not increase with age. The 2- year olds had the lowest while the 5-year olds had the next lowest scores. The 3-year olds attained higher scores than children in most of the other age groups. Byrne (1959) opined that factors other than age, like intelligence, might have influenced her test results.

Types of Analysis of Speech Articulatory Errors

Studies which have looked into the analysis of speech articulatory features and errors in the speech of both children and adults with cerebral palsy have followed the traditional sound-by-sound analysis or pattern analysis like place-voice-manner, distinctive feature and phonological process analysis. All these methods have their own advantages and disadvantages. The following is a brief review of these methods.

Traditional Analysis

Assessment and intervention of articulatory disorders has traditionally focused on individual sound errors. The procedure mainly involves sampling of the phonetic inventory of the client in the word-initial, medial and final positions, and classifying errors as substitutions, omissions, distortions and additions of sound.

This approach has been employed commonly in evaluating both functional and organic disorders of speech articulation. Though this approach has been successful to some degree, therapeutic methods based on these principles have often failed to bring about clinically significant improvement in those individuals demonstrating multiple articulation errors (Crary and Comeau, 1981). The efficacy of these methods in guiding the speech-language pathologists in their therapy, which is less than adequate, has resulted in the development of other frameworks of speech analysis, mainly pattern analysis.

Pattern Analysis

The identification of "pattern of errors" in those cases where multiple errors are observed has been the focus of attention in the last 2 decades. In these procedures, the clinician reviews the speech samples to categorize errors according to commonalities or pattern.

Systems of pattern analysis, whether based on a place-manner-voice approach, or distinctive feature analysis, or the more recent phonological process analysis, attempt to determine if these patterns or relationships in speech sound error productions differ from the adult standard.

1) Place-Voice-Manner Analysis

This analysis describes error patterns according to a rather broad classification system of phonetic features. Place-manner-voicing characteristics of each error sound are compared to those representing the norm. This comparison can then be examined to determine if any patterns emerge within the sound system of the client. In this context, patterns are defined as instances of frequent use of specific place-manner-voicing features.

This type of analysis is relatively easy to perform and fast, but, it allows only a superficial visualization of error patterns. The place-voice-manner analysis is designed only to classify substitutions errors. However, it is not designed to analyze sound distortions, deletions, assimilations and changes in syllable structure.

2) Distinctive Feature Analysis

Distinctive feature analysis compares the phonetic features of the target sound with the phonetic features of its substitution. It is somewhat easy to ascertain the similarities and differences between target and substitutions as the distinctive feature system is binary. Another advantage of this method is that it allows for a comparison of several sound substitutions to the target phoneme. In addition, correctly and incorrectly realized features across several phonemes can be examined to see if patterns exist. A pattern is characterized by frequent use of one or more of identical distinctive feature(s), when the target sound and its deviant production are compared.

However, the distinctive feature analysis is time consuming, and hence, not suitable for a speech-language pathologist in his/her busy clinical practice. Also, this procedure cannot account for deletions, assimilations or change of syllable structure.

3) Phonological Process Analysis

A phonological process analysis is a means of identifying the substitutions, syllable structures and assimilatory changes that occur in the speech of clients.

Each error is identified and classified as one or more of the phonological processes.

Patterns of errors are described according to the most frequent phonological processes present and/or to those that affect a class of sounds or sound sequences. Therefore, a phonological process analysis is a form of a substitution analysis that extends beyond a segment to include classes of sound, syllable structure and phonetic context.

According to Stampe (1979), "a phonological process is a mental operation that applies in speech to substitute for a class of sounds or sound sequences presenting a common difficulty to the speech capacity of the individual, an alternative class identical, but lacking the difficult property.

A phonological process or pattern deviation is typically defined as a systematic sound change or simplification that affects a class of sounds or a particular sequence of sounds (Bankson and Bernthal, 1993).

The underlying thesis of a phonological approach to studying deviant articulation is that the client has developed a set of phonological rules which simplifies his or her speech and sets it apart from community norms. The

purpose of phonological assessment is to ascertain these rules in as comprehensive a fashion as possible (Klein, 1996).

Several formal test protocols have been developed which attempt to allow the clinician to accomplish this goal. Some of these published procedures are -

- Crompton-Hutton phonological assessment (Crompton and Hutton, 1976).
- Phonological assessment: A multifaceted approach (Lund and Duchan, 1978).
- Phonological process analysis (Weiner, 1979).
- Natural phonological analysis (Shriberg and Kwiatkowski, 1980).
- Phonological assessment of child speech (Grunwell, 1985).
- Assessment of phonological processes - Revised (Hodson, 1986).
- Khan-Lewis phonological analysis (Khan and Lewis, 1986).
- Bankson-Bernthal test of phonology (Bankson and Bernthal, 1990).

Differences among the various published phonological assessment procedures are in terms of characteristics like the stimuli used, elicitation procedures employed, sample size, transcription of speech sample, process description, etc (Bankson and Bernthal, 1993). Also, the protocols of many researchers delineate somewhat different processes in terms of the labels used.

However, most of the assessment procedures have essentially similar processes in their framework.

Considering that phonological processes involve simplification in the sound production patterns used in speech, the occurrence of these processes in disordered speech, therefore, indicates that the speech disorders investigated are characterized by simplified speech production patterns. Studies have been reported which employed a pattern approach for identification and their elimination of phonological process in the speech of children with hard-of-hearing, and mentally retarded children (Ingram, 1976), and in children with developmental motor speech disorders such as developmental dysarthria (Milloy and Morgan-Barry, 1990).

Phonological processes provide a more comprehensive and adequate descriptive framework for error analysis because they describe the structural as well as systemic simplifications in the speech patterns. Phonological process analysis provides a parsimonious basis for selecting those classes of phonemes which need immediate attention and intervention. Hence, in the present study, phonological process analysis was used as the primary method of characterization of speech sound errors.

Speech Articulatory Errors in the Speech of Cerebral Palsied Children

Despite the neuromotor limitations, most children with cerebral palsy do develop some degree of speech and establish perceptual and motor links by means of which they evaluate and modify their sound production (Netsell, 1986). Inevitably, some of these modifications are maladaptive and may have resulted in problems at the phonetic level wherein sounds were distorted, where allophonic variants occurred, and where the phonetic inventory may have included sounds not normally present in the child's native language.

Byrne (1959) reported that, in the speech of cerebral palsy, the production of fricative and affricate manner was often incorrect, anterior tongue articulation was deficient, and a much higher frequency of misarticulation of consonants in the word-final position as compared with its word-initial position.

Clement and Twitchell (1959) studied dysarthria in cerebral palsy in terms of phonatory, respiratory and articulatory deficits and suggested a physiological interpretation of the deficits. 20 subjects (age 3-12 years) belonging to two groups of spastic quadriplegia and bilateral athetosis were evaluated. In terms of articulation, both the groups showed impaired production of lingua-dental sounds. Clement and Twitchell (1959) attributed this to the

stiffness of the peripheral speech musculature because of spasticity which in turn resulted in abnormalities of tongue placement. Uncontrolled movements of speech musculature were the reason for impaired lingua-dental sounds in athetosis.

Liang (1979) examined the applicability of natural phonological process analysis in describing the speech of a cerebral palsied child having multiple articulation disorder to see if the articulatory deviances could be explained within a linguistic framework. Results indicated that the phonological systems of the subject were systematic and rule-governed and that the processes operating upon the phonological system were attributable, albeit in part, to the deviant speech musculature.

McMahon, Hodson and Allen (1983) studied the phonological system of a group of 10 children (age 5.6 years) with spastic cerebral palsy. Their analysis indicated a deviation in liquid production (including gliding, vowelization and omission), cluster reduction, syllable reduction, prevocalic singleton obstruent omissions and postvocalic singleton obstruent omissions as the commonly occurring processes. Miscellaneous processes such as laterlization, postvocalic devoicing, assimilation, depalatalization and deaffrication were also observed in a majority of subjects.

Milloy and Morgan-Barry (1990) assessed the speech of a 9-year old subject with mild spastic quadriplegia using the Phonological Assessment of Child Speech (Grunwell, 1985). Phonological process analysis showed evidence of systemic simplification such as stopping of affricates, nasalization of approximants and devoicing combined with lateralization of all alveolar and palatal fricatives. Structural simplifications evident in speech were post-tonic weak syllable deletion, cluster reduction and some metathesis, sometimes combined with voicing and cluster reduction. The analysis indicated the coexistence of phonetic as well as phonological delay and deviant speech. While the phonetic deviances included the lateral realizations of fricatives and affricates, the phonological deviances were seen in word-initial devoicing, stopping of approximants and the occasional metathesis.

Several studies have confirmed that children with cerebral palsy demonstrated speech errors of both temporal and motor control (Crary and Comeau, 1981; McMahon, Hodson and Aller, 1983). Based on such evidence, Milloy and Morgan-Barry (1990) described the phonological processes relating to these difficulties. According to them, the phonetic and phonological processes related to temporal coordination include the following:

- Voicing difficulties, including devoicing of initial consonants,or voicing of unvoiced sounds.
- Prevocalic voicing

- Consonant cluster reduction
- Final consonant deletions

- Stopping of fricatives or frication of stops, weak syllable deletions.

Errors of phonetic placement (related to motor control) include the following:

- fronting
- backing
- stopping
- gliding
- lateral realization of apical and coronal fricatives

  vowelization of [l] and [r]
- nasalization

Kent and Netsell (1978) presented cineflurographic data on articulation of isolated vowels, VCV nonsense utterances, and short sentences of 5 subjects with athetoid cerebral palsy. Articulatory abnormalities were identified from tracing of vowel tract shapes and from displacement by time plots of articulatory events. The most frequent abnormalities were large ranges of jaw movement, inappropriate positioning of the tongue for various phonetic segments (especially because of a reduced range of tongue movement in the antero-posterior dimension), intermittency of velopharyngeal closure caused by an instability of

velar elevation, prolonged transition, times for articulalory movements, and retraction of the lower lip.

Speech Articulatory Errors in the Speech of Cerebral Palsied Adults

Most children with cerebral palsy survive into adulthood. Yet, the speech of adult cerebral palsied has only been infrequently studied (Andrews et al. 1977; Crary and Comeau, 1981; Lakshmi, 2001, among others).

Platt, Andrews and their associates have carried out the most systematic description of the residual errors in the speech of adult cerebral palsied population (both spastic and athetoid groups), after the developmental processes have been stabilized. In a series of investigations, they studied the intelligibility of the speech of cerebral palsied speakers with a Phonetically Balanced list of 50 words (Andrews, Platt and Young, 1977; Platt, Andrews, Young and Neilson, 1978; Platt, Andrews, Young and Quinn, 1980; Platt, Andrews and Howie, 1980).

Andrews, Platt and Young (1977) evaluated the factors affecting the intelligibility of cerebral palsied speech as it appears to the average listener. Orthographic transcriptions of naive listener responses to a phonetically balanced list of monosyllabic words uttered by 50 cerebral palsied males (age 17-55 years)

were translated into phonetic symbols and formulated into error patterns on word-initial and word-final consonants and compared to those identified by a trained listener. The same pattern of errors was identified by both the trained and naive listeners in respect of the predominant errors. More errors were identified on word-final consonants than on word-initial consonants while within-manner errors exceeded between-manner errors.

Platt et al (1980), in another study, examined the speech intelligibility and articulatory impairment of 32 spastic and 18 athetoid subjects. The speech sample consisted of production of a phonetically balanced list of monosyllabic words and reading of a standardized passage. Two estimates of speech intelligibility were obtained from naive listeners from recorded single words and prose. Diadochokinetic (DDK) syllable rates and percent correct articulation of selected phonemes (as identified through transcription by judges) were employed as indices of articulatory impairment. All subjects were, on an average, judged to be 50% intelligible on both the estimates. Group mean DDK rate was 2.9 syllables per second while 78% of phonemes were transcribed as correctly articulated. A place-manner analysis of the speech errors revealed deficits in specific phonemic features in terms of anterior lingual-place inaccuracy, reduced precision of fricative and affricate manners, and inability to achieve the extreme positions in the vowel articulatory space. Another finding of the study was that, even when the confounding effect of physical disability was taken into

considerations, the spastic speech was more intelligible and less articulatoriley impaired than athetoid speech. Also, the stopping process was found to be most detrimental to the speech intelligibility of both the groups.

Plutt, Andrews and Howie (1980) further analyzcd the articultory errors reported in Platt et al (1980) using a confusion matrix paradigm to identify errors in terms of place-manner and voicing. They found that within-manner errors (place, or voicing errors, or both) exceeded between-manner errors by a substantial degree, more so on final consonants. The predominant within-manner errors occurred on fricatives in both word-initial and final positions. Within-manner errors on affricates, besides being devoicing errors, were also frequent in word-final position. The predominant between-manner initial position errors involved liquid-to-glide and affricate changes while affricate-to-fricative errors were dominant in the word-final position. Omission of phonemes was found to occur three times more frequently on word-final than on word-initial consonants.

Crary and Comeau (1981) used phonological process analysis to evaluate the articulation errors of an adult subject demonstrating spastic cerebral palsy of congenital origin. The subject had been judged to be "fairly intelligible", though, multiple sound errors were present in his speech. The spontaneous speech sample was used for phonological process analysis. Results indicated that the process of fronting, stopping, final consonant deletion and gliding of liquids

occurred on a higher percentage of words across the subjects. In general, the errors belonged primarily to the manner class of fricatives, affricates, stops, nasals and liquids. In terms of place of articulation, however, it was found that the retroflex and palatal phonemes were more affected than the velar, alveolar and dental phonemes while the bilabials remained unaffected. The combined results of phonetic analysis and phonological process analysis showed that the majority of the sounds substituted could be explained either as fronting or stopping phonological process, though other processes were also apparent.

Lakshmi (2001) characterized the articulatory errors of spastic cerebral palsied, both through traditional sound-by-sound analysis (substitutions, omissions and additions) and phonological process analysis. 12 subjects with spastic cerebral palsy, in the age group of 17 to 26 years, served as subjects. Responses on a picture-word articulation test and narration of a story constituted the speech sample. Fronting, stopping, gliding of liquids, devoicing, vocalization, final consonant deletion, initial consonant deletion, backing, vocalic support of final consonant and consonant harmony were the different phonological processes observed in the speech sample.

Parallels and Differences in the Speech Articulatory Errors Between Children and Adults with Cerebral Palsy

Platt et al (1980) compared articulatory features of cerebral palsied adults with those of Byrne (1959) on children aged two to seven years. The "percent subjects correct" (the percentage of accurate productions by the subjects) data on phonemes reported by Byrne (1959) were arranged into the same place and manner groupings as the adult data. In agreement with Byrne's (1959) findings on children, Platt's (1980) results on adults showed a much higher frequency of misarticulation of consonants in the word-final as compared to the word-initial position. Furthermore, the production of fricative and affricate manners was often incorrect, and anterior tongue articulations were deficient, a finding also reported by Byrne (1959). It was demonstrated that while adults acquired greater accuracy in speech articulation, the residual deficits of consonantal place and manner features in dysarthric cerebral palsied adults was qualitatively similar to the profiles of like features in children. However, there was one exception to this observation. In contrast to the findings of Irwin (1956) and Byrne (1959), both of whom reported that voiceless consonants in word-initial positions were less accurately articulated by children than their cognate pairs of voiced phonemes, Platt et al (1980) reported a marked reversal of this feature in the speech of adults. Based on the comparison of their data on adults with that of Byrne (1959), Platt et al (1980) hypothesized that certain articulatory feature, may extend from childhood to adulthood, which may reflect the neuro muscular

involvement or which may have an implication for neuromotor maturation required for production of speech. However, these findings may not accurately highlight the issue of continuity of articulatory features due to methodological limitations. The studies, which looked into the articulatory behaviour of adult cerebral palsied are far and few in between (Platt et al 1980). Hence, there is a need to study the articulatory behaviors of cerebral palsied adults and to investigate what it can reveal about the continuity of articulatory deviations from childhood to adulthood.

Chapter 3

METHOD

The present study was taken up with an aim to verify the hypothesis that

the specific residual deficits in speech sound articulation in adult cerebral palsied are qualitatively similar to those in cerebral palsied children. The characterization of articulatory profile is proposed to be carried out through both traditional sound-by-sound and the phonological process analysis approaches.

Subjects

Two groups of individuals with spastic cerebral palsy served as subjects for the study. Group 1 included nine children in the age range of 5 to 10 years (mean age 8.2 years) while group 2 included nine adults in the age range of 17 to 30 years (mean age 22.7 years). The subjects were either enrolled in special schools or were part of vocational training centers for the cerebral palsied. In fact, most of the subjects of this study came from a day-care rehabilitation center for multiple disabled. Many of these subjects had undergone a few sessions of speech therapy or were undergoing speech therapy. Generally speaking, almost all the subjects had a variable history of speech therapy. Neither was speech therapy a consistent aspect of the training of the subjects nor that the subjects had not undergone any speech therapy. Adult subjects in this study had not had speech therapy for quite a long time in contrast to the children.

Selection Criteria

Only those subjects who fulfilled the following criteria were considered for inclusion in the study.

Subjects who had been diagnosed as having spastic cerebral palsy by a qualified neurologist.

Subjects who were native speakers of Telugu and were using the verbal mode or speech as their sole method of communication.

Subjects who had no associated hearing or visual deficits.

Subjects who had IQ scores of 70 or more.

No special tests were conducted to ensure that the subjects selected fulfilled the inclusion criteria mentioned above. Instead, information on neurological diagnosis, hearing and visual acuity, history and present status of speech therapy, and IQ scores were obtained from the medical records maintained at the institutions where the subjects were enrolled. Particulars of age, sex, motor involvement, speech involvement and status of schooling/vocational training of the subjects of the study are given in Table 2 and 3 for children and adults, respectively.

Table: 2 Characteristics of spastic children of this study

Subject	Age/Sex	Motor involvement	Speech involvement
1.	6yrs/M	Quadriplegia	Severe
2.	8yrs/M	Dip leg ia	Moderate
3.	7yrs/M	Diplegia	Moderate
4.	10 yrs/M	Diplegia	Mild
5.	9yrs/M	Quadriplegia	Severe
6.	7yrs/M	Diplegia	Mild
7.	8yrs/M	Quadriplegia	Moderate
8.	9yrs/F	Triplegia	Mild
9.	10yrs/M	Diplegia	Moderate

Table: 3 Characteristics of the Spastic Cerebral Palsied Adults

Subject	Age/Sex	Motor involvement	Speech involvement
1.	20yr/F	Diplegia	Moderate
2.	19yr/M	Diplegia	Moderate
3.	27yr/M	Diplegia	Severe
4.	27yr/F	Quadriplegia	Moderate
5.	19yr/M	Diplegia	Moderate
6.	22yr/M	Diplegia	Mild
7.	24yr/M	Diplegia	Severe
8.	22yr/M	Quadriplegia	Moderate
9.	19yr/M	Quadriplegia	Severe

Material

Sample of speech obtained was the responses of subjects on the Test of Articulation and Discrimination in Telugu (TADT-Padmaja, 1988). The TADT consists of 80 pictures designed to test the sounds of Telugu either in the word-initial or word-middle and word-final position. The pictures (or words) included in the test serve to test 10 vowels, 34 consonants and 4 consonant clusters. Five words are repeated in the test.

Procedure

Test Environment and Sample of Speech

The subjects were seated comfortably and tested individually by the experimenter in a quite room. Each picture card, of the size 5" x 5", was presented to the subject with the instruction to name the same. If the subject could not identify the picture correctly, verbal prompts were given in the form of questions, descriptions etc, to elicit a naming response, but such instances were very few. When the subjects were unable to name the picture, even with cues, such instances being very rare again, they were encouraged to repeat the word after the experimenter. The pictures were presented with an interval of 15 seconds between two successive cards.

The responses of the subjects were audiotape recorded (SONY-MZ-R30) for further analysis. In this manner, each subject produced a total of 80 words including five words, which occurred twice in the test.

Transcription of the Speech Material

The experimenter along with a speech pathologist who was a native speaker of Telugu transcribed the recorded speech material. The recorded speech material was listened to as many times as required until the experimenter and the second speech pathologist were one hundred percent agreed on the transcription. Both International Phonetic Alphabet (IPA revised edition, 1993) and extension IPA (revised edition, 1994) markers were used for phonetic transcription of the recorded speech material.

The reliability of the transcriptions of the experimenter and the other speech pathologist was determined by asking a phonologist (who was experienced in the field of communication disorders) to transcribe 10 percent of the recorded material for each subject and computing a product moment correlation between the two judgments for that portion of the speech sample. A Product Moment correlation of 0.91 was obtained between the two sets of transcriptions.

Analysis

Sound-By-Sound Analysis

From the transcribed speech sample sound-by-sound analysis was done in the word-initial, word-medial, word-final positions- Errors in the subject's production on the given target sound were described as substitutions, or omissions, or distortions or additions. The results were recorded in the following format.

Target sound (1)	Stimulus word (2)	Syllable structure of (2) (3)	Subjects production (4)	Syllable structure of (4) (5)	Error type S/O/D/A (6)

Phonological Process Analysis

An informal procedure given for phonological process analysis was followed in this study. The procedure recommended by Newman and Creaghead (1988) is an eclectic method of analysis wherein an adequate and representative sample of the speech of subjects is recorded, transcribed and analyzed in a series of steps for the identification of phonological processes.

The analysis of the transcribed speech sample was carried out as follows:

- the syllable structure of the stimulus word and the subject's production was analyzed,
- the errors in the subject's production were classified into substitutions, omissions or additions,

Distortion errors were not considered for further analysis. However, an attempt was made to reallocate the distortion errors to the category of substitution error type. If this was not possible, then they were retained as distortion errors, but no further analysis of these was done.

The substitutions, omissions and additions were examined for phonological processes. Grunwell's (1985) definition of phonological processes was adopted for the examination of the phonological processes present in the speech sample of the subjects. In cases where it was not possible to examine the errors using the list of processes given by Grunwell (1985), the same were described following Ingram (1981).

The results of phonological process analysis were recorded in the following format:

Stimulus Word (1)	Syllable structure (2)	Subject's production (3)	Syllable structure of (3) (4)	Error type S/O/D/A phonemes involved (5)	Phonological process involved (6)

The phonological processes were tabulated and then the number, percent, and frequency of occurrence of each process was computed. The percentage of occurrence of a process was computed by the following formula:

$$\text{Percentage of occurance of a phonological process} = \frac{\text{Number of times the process occurred given sample of speech}}{\text{Maximum number of times the process can occur in the (TADT)}} \times 100$$

Frequency of occurrence of phonological processes was defined as the number of subjects showing a particular deviant process.

Between Group Comparisons

The results of both the traditional sound-by-sound analysis and the phonological process analysis were compared between the children and adults. While the former comparison was not subjected to any statistical test, the results of phonological process analysis were compared by computing a 't' value.

Chapter 4

RESULTS

The objectives of the present study were to —

a) verify the hypothesis that despite the level of phonemic accuracy, the specific residual speech and articulatory errors in adults with spastic cerebral palsy are qualitatively similar to those found in the speech of children with spastic cerebral palsy and if yes, then

b) to see if the similarities observed through both a phonological process analysis and traditional sound-by-sound analysis can be grouped to aid in speech therapy.

A secondary objective of the study was to describe the speech articulatory errors found in both children and adults with spastic cerebral palsy.

The entire speech sample obtained through an articulation test, which consisted of 80 single words, was analyzed through both traditional sound-by-sound analysis and phonological process analysis.

Traditional Sound-by-Sound Analysis

The total number of articulatory errors in terms of substitutions, omissions, distortions and additions for each subject are shown in Tables 4 and 5, for spastic children and adults, respectively.

Table 4 : The results of sound-by-sound analysis for articulatory errors in children.

Subject	Error Type			
	Substitution	Omission	Distortion	Addition
1	39	16	9	-
2	34	17	11	-
3	35	16	10	4
4	29	11	9	-
5	44	13	9	2
6	28	14	13	-
7	42	11	6	4
8	36	10	14	-
9	39	10	13	2
Total	326	118	94	12

Table-5: The results of sound-by-sound analysis for articulatory errors in adults

	Error type			
Subject	Substitution	Omission	Distortion	Addition
1	34	10	8	-
2	30	11	9	-
3	29	13	10	-
4	32	16	12	2
5	31	12	9	-
6	26	13	8	-
7	39	15	9	4
8	25	10	12	-
9	43	10	9	2
Total	289	110	77	8

It can be seen from Tables 4 and 5 that the substitution errors were predominant in the speech of both children and adults. Omissions also occurred with a high frequency followed by distortion and addition errors. Additions were the least frequent, occurring in the speech of only 4 children and 3 adults.

The articulatory errors, as observed in a traditional sound-by-sound analysis, were further analysed in terms of manner and place of articulation, and are tabulated in Tables 6 and 8 (classification according to manner of articulution) and 7 and 9 (classification according to place of articulation) for children and adults, respectively.

Table 6: Classification of articulatory errors in the speech of children according to manner of production.

Subject	Number of articulatory errors occurred	Manner				
		Stops	Liquids	Fricatives	Nasals	Affricates
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	55	21	11	11	9	4
2	51	22	7	9	5	8
3	51	22	10	8	3	8
4	40	21	6	7	2	4
5	57	28	10	8	7	4
6	42	20	6	5	4	7
7	53	25	10	7	5	6
8	46	22	9	5	6	4
9	49	26	9	6	4	4
Total	444	207	78	66	45	49

Table 7: Distribution of errors in the speech of children according to place of articulation

Subject	No.of errors	Place							
		Alveolar	Bilabials	Velar	Retro flex	Palatal	Dental	Labiodental	Glottal
(1)	(2)	(3)	(4)	5)	(6)	(7)	(8)	(9)	**(10)**
1	55	18	5	9	9	6	5	2	1
2	51	15	7	8	8	6	4	3	-
3	51	15	6	7	9	7	5	2	-
4	40	11	4	8	8	4	4	1	-
5	57	16	8	9	9	7	4	2	1
6	42	13	5	6	8	5	4	1	-
7	53	16	5	9	9	6	5	3	-
8	46	13	3	8	10	5	4	3	-
9	49	14	5	6	9	6	6	3	-
Total	444	131	48	70	79	52	41	20	2

Table 8: Distribution of errors is the speech of adults according to manner of production.

Subject	No.of errors occurred	Manner				
		Stops	Liquids	Frica-tives	Nasals	Affri-cates
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	44	28	6	4	-	6
2	41	26	4	5	-	6
3	42	22	2	7	6	5
4	48	25	8	6	3	6
5	43	20	6	6	5	6
6	39	20	7	3	3	6
7	54	26	9	7	7	5
8	35	15	6	5	4	5
9	53	26	10	8	4	5
Total	399	208	58	51	32	50

Table 9: Distribution of errors in the speech of adults according to place of articulation.

Subject	No. of errors occured	Place							
		Alveolar	Bilabials	Velar	Retroflex	Palatal	Dental	Labiodental	Glottal
0)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	44	13	4	9	8	5	3	2	
2	41	13	3	7	6	6	4	2	-
3	42	11	4	7	9	5	4	2	-
4	48	16	4	8	8	6	4	2	-
5	43	14	4	8	8	6	3	-	-
6	39	14	3	8	7	4	1	-	-
7	54	11	2	10	8	5	4	4	-
8	35	11	3	7	7	3	2	2	-
9	53	15	5	9	9	6	3	4	2
Total	399	118	32	73	70	46	26	18	2

An analysis of the distribution of errors (manner of articulation) revealed that the errors belonged predominantly to the manner class of stops in both children and adults. Errors on liquids, fricatives, affricates and nasals followed, in that order, in both children and adults. While this overall pattern in articulatory errors in terms of manner class of sounds holds good for both children and adults, some differences were also observed. For example, while 46% of the articulatory errors occurred on stops in children, it was 52% in the case of adults, but whether this was statistically significant was not tested.

Similarly, the percentage of articulatory errors on nasals was high in children compared to adults, but this is again outside the scope of statistical significance.

In terms of place of articulation, alveoler sounds accounted for roughly 30% of the articulatory errors in both the groups. Next to this, retro flex and velar sounds were misarticulated to a greater extent than other class of sounds (palatal, bilabial, dental, labiodental and glotal sounds). The distribution of scores confirms that, in general, this pattern of articulatory errors holds goods for both children and adults, although there was some difference with regard to dental sounds (statistical significance of the difference was not tested, however).

Type and Percentage of Occurrence of Phonological Processes

The following diderail phonological processes were identified lo occur from the transcribed speech sample of both the groups (adults and children); stopping, fronting, gliding of liquids, devoicing, vocalization, backing, initial consonant deletion, cluster reduction, weak syllable deletion, consonant deletions. The percentage of occurrence of these processes are given in Tables 10 and 11, for children and adults, respectively.

Table 10 : Percentages of occurrences of different phonological percentage process in children.

	Processes in %									
Subject	MCD	ICD	Devoicing	Stopping	Backing	Fronting	Gliding	a	WSD	
0)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	7	8	-	25	25	100	13	50	35	75
2	7	15	12	33	25	63	25	13	25	15
3	4	4	12	25	-	63	25	38	50	75
4	4	8	-	13	33	50	25	25	-	100
5	15	12	18	33	25	100	13	-	-	75
6	-	12	-	12.5	33	35	-	25	25	100
7	7	8	12	33	62	50	38	25	-	75
8	7	4	-	25	75	38	25	38	-	75
9	-	8	12	33	33	50	13	50	25	50
Avg										

MCD - Medial Consonant deletion; ICD - Initial consonant deletion
WSD - Weak syllable deletion; CR - Cluster reduction

Table 11 : Percentage of occurrence of different phonological process in adults.

Subject	Processes in %									
	MCD	ICD	Devoicing	Stopping	Backing	Fronting	Gliding	Vocalization	WSD	CR
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	7	4	6	33	17	50	25	-	13	75
2	11	4	-	-	25	50	25	25	25	75
3	7	8	12	13	17	37	13	-	25	100
4	15	12	6	33	25	62	25	-	13	75
5	7	8	-	25	17	75	13	25	-	100
6	7	15	18	42	33	50	-	13	-	50
7	19	8	-	25	17	62	38	25	25	75
8	11	12	-	-	25	50	13	13	38	50
9	4	8	6	33	33	75	-	25	25	100
Avg %	**9.77**	**8.77**	**5.33**	**22.66**	**23.22**	**56.77**	**16.88**	**14**	**18.22**	**77.77**

The percentage of occurrence of a phonological process was computed as follows:

1) Identification of maximum number of times each process (potential opportunity to occur) can occur in the entire speech sample

(Table 10, column 5, row 1) which occurs only 25% of the time. However, considering the fact that there were only 4 chances for cluster reduction to occur in the speech sample compared to the chances of occurrence of a stopping process (17 chances in this particular sample), the occurrence of a stopping process should be considered to have greater implications for speech or speech intelligibility. Therefore, the percentage of occurrence of different phonological processes have been given in decreasing order (from column 2 to 11, in Tables 10 and 11) with reference to the chance of occurrence of different phonological processes. Thus medial consonant deletion, the potential for its occurrence being the highest in the present speech sample, has been shown in column 2 while cluster reduction which has a potential to occur the least in the present speech sample (only 4 times) has been shown in column 11.

Table 12 : Shows mean, standard deviations (SD) and 't' values for the significance of difference mean, between children and adults with regard to a number of phonological process.

Phonological Process	Subject (N=9)	Mean	S.D.	't' value
Backing	Children	34.55	21.97	1.48
	Adults	23.22	6.66	
Cluster reduction	Children	71.11	25.83	-0.62
	Adults	77.77	19.54	
Devoicing	Children	7.33	7.21	0.63
	Adults	5.33	6.32	
Fronting	Children	61	24.02	0.47
	Adults	56.77	12.71	
Gliding	Children	19.66	11.01	0.49
	Adults	16.88	12.54	
ICD	Children	8.77	3.66	0
	Adults	8.77	3.66	
MCD	Children	5.66	4.52	-1.88
	Adults	9.77	4.73	
Stopping	Children	25.83	8.29	0.55
	Adults	22.66	15.1	
Vocalization	Children	29.33	16.53	2.27*
	Adults	14	11.58	
WSD	Children	17.77	18.55	-0.05
	Adults	18.22	12.71	

* Indicates significant at 0.05 level ($p<0.05$)

It can be seen from Table 12 that except the mean percentage for vocalization, no other mean percentage for any phonological process was

significantly different between spastic children and adults. The mean percentage of occurrence of vocalization was significantly higher ($p<0.05$) in children compared to that of spastic adults indicating that vocalization is a problem in children which reduces significantly as they grow older.

The similarities and differences in the speech sound articulatory deviation in the speech of spastic cerebral palsied children and adults based on both the traditional sound-by-sound analysis and phonological process analysis are shown in Figures 1 to 3.

Figure 1 : Comparision of Manner of Articulatory Errors

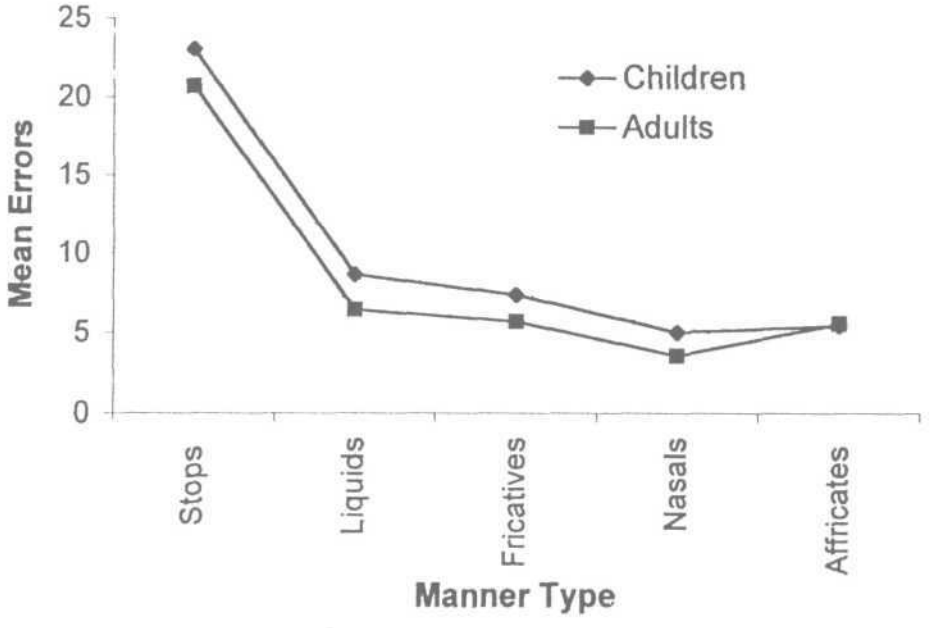
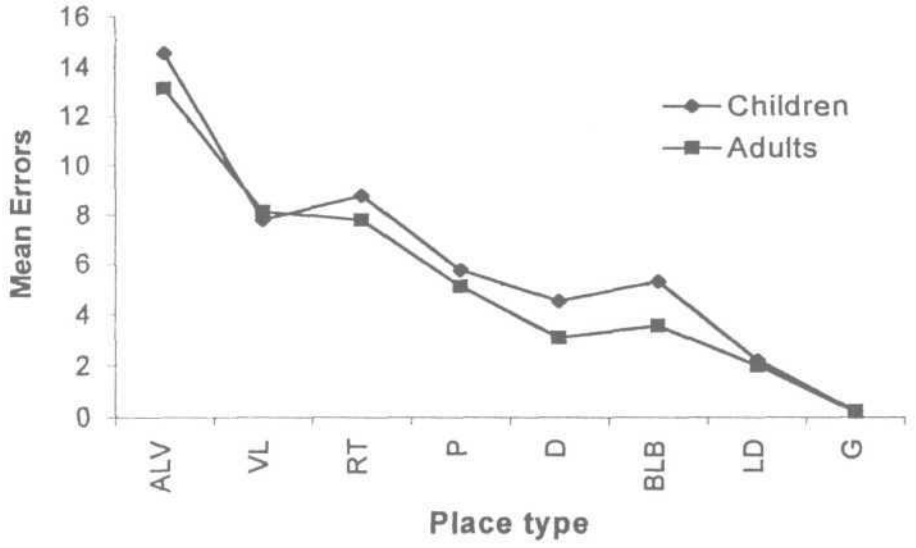


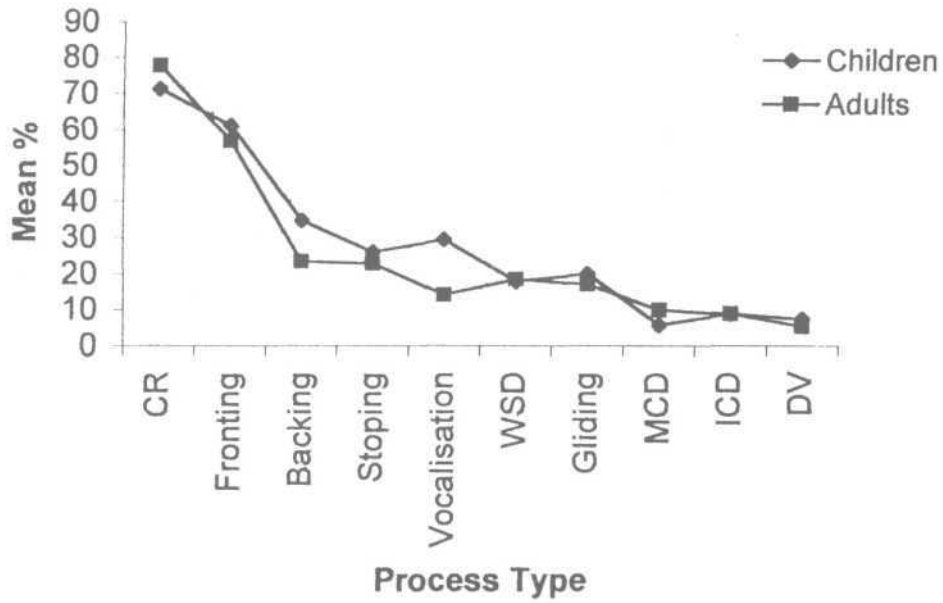
Figure 2: Comparision of Place of Articulatory Errors



ALV- Alveolar, VL- Velar, RT- Retroflex, P- Palatal, D- Dental,BLB-Bilabial, LD- Labio Dental, G- Glottal.

Comparision of articulatory deviations between children and adults arrived through sound-by-sound analysis, interms of manner and manner of articulation revealed similar type of features.

Figure 3 : Comparision of Phonological processes

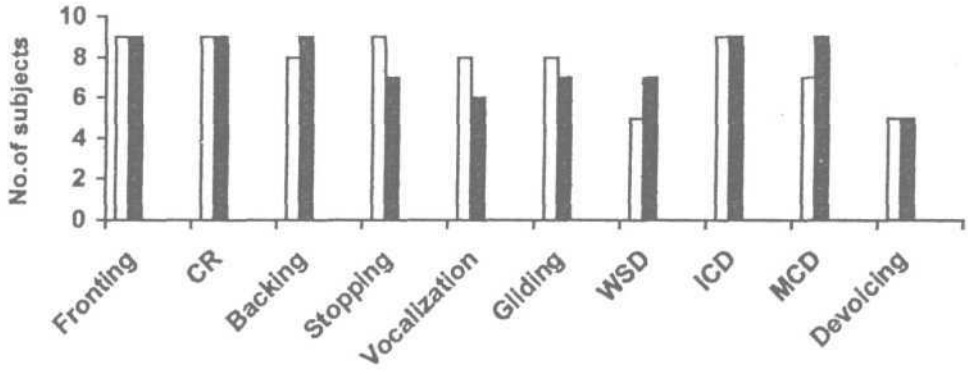


It can be observed from Figure 3, that both the groups showed occurrence of similar processes. However, children showed greater "strength" with regard to most of the phonological processes. However, only the difference in mean percentage with respect to vocalization was statistically significant between children and adults (see Table 12).

Frequency of Occurrence of Phonological Process

The number of subjects, in both the groups, showing the occurrence of **a** given phonological process is shown in Figure 4.

Figure 4 : Frequency of occurrence of phonological processes in both the groups.



□ indicates the no. of children in whom the given process occurred.

▒ Indicates the no. of adults in whom the given process occurred.

Figure 4 indicates that all phonological processes were seen in all the children and adults. A visual inspection of the data in Figure 4 shows that phonological processes like stopping, vocalization and gliding were seen in lesser number of adults than children while phonological processes like backing, WSD, MCD were observed to occur in lesser number of children than adults. But, the statistical significance of this difference was not tested in either case.

Combined Sound-by-Sound and Phonological Process Analysis

A combined analysis of the results of both the traditional sound-by-sound analysis (only substitutions and omission, however) and the phonological process analysis was carried out. The results of this analysis are shown in Table 13 (substitution errors in children), Table 14 (omission errors in children), Table 15 (substitution errors in adults) and Table 16 (omission errors in adults). These tables give the substitution or omission errors and characterization of their phonological processes (simplification processes).

Table 13: Substitution errors and their description of phonological processes (simplification processes) in children.

Subject	No .of substitution errors	Stopping	Fronting	Backing	Gliding of liquids	Vocalization	Devoicing
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	17	3	8	3	1	4	-
2	15	4	5	3	2	1	2
3	15	3	5	-	2	3	2
4	13	2	4	4	2	2	-
5	19	4	8	3	1	-	3
6	11	2	3	4	-	2	-
7	20	4	4	5	3	2	2
8	17	3	3	6	2	3	-
9	16	4	4	4	1	4	2
Total	143	29	44	32	14	21	11

Table 14: Deletion errors and their description of phonological processes in children.

Subject	No. of deletion errors	ICD	CR	WSD	MCD
(1)	(2)	(3)	(4)	(5)	(6)
1	10	2	3	3	2
2	11	4	3	2	2
3	9	1	3	4	1
4	7	2	4	-	1
5	10	3	3	-	4
6	9	3	4	2	-
7	7	2	3	-	2
8	6	1	3	-	2
9	6	2	2	2	-
Total	75	20	28	13	14

Table 15: Substitution errors their description of phonological processes (simplification processes) in adults.

Subject	No .of substitution errors	Stopping	Fronting	Backing	**Gliding of liquids**	Vocalization	Devoicing
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	13	4	4	2	2	-	1
2	11	-	4	3	2	2	1
3	10	4	3	2	1	-	2
4	12	2	5	3	2		1
5	14	3	6	2	1	2	-
6	11	5	4	4	-	1	3
7	15	3	5	2	3	2	-
8	9	-	4	3	1	1	-
9	17	4	6	4	-	2	1
Total	112	25	41	2	12	10	9

Table 16: Deletion errors their description of phonological processes in adults.

Subject	No. of deletion errors	ICD	CR	WSD	MCD
(1)	(2)	(3)	(4)	(5)	(6)
1	7	1	3	1	2
2	9	1	3	2	3
3	10	2	4	2	2
4	11	3	3	1	4
5	9	2	4	-	3
6	8	4	2	-	2
7	12	2	3	2	5
8	10	3	2	3	2
9	9	2	4	2	1
Total	85	20	28	13	24

The results in these tables should be interpreted as follows: the number 17 (Table 13, row 1, column 2) indicates that substitution errors occurred 17 times and that 3 of these errors (column 3) can be identified as stopping process, 8 of these errors (column 4) can be identified as fronting process in the phonological analysis, and so on. The results in other tables should be interpreted in a similar manner.

It can be seen from the above tables that a majority of the substitution errors can be explained as fronting or backing or stopping processes in both children and adults. Outside this, vocalization processes accounted for a major

Chapter 5

DISCUSSION

The present study was an investigation into the continuity or otherwise of speech articulatory errors from childhood to adulthood in persons with spastic cerebral palsy. The primary objective was to see whether the articulatory errors in the speech of persons with spastic cerebral palsy have stable features from childhood to adulthood. A secondary objective was to describe the articulatory errors through the traditional sound-by-sound analysis as well as phonological process analysis.

Two groups of subjects were included in the study. Group 1 consisted of 9 spastic cerebral palsied children in the age range of 5-10 years while Group 2 included 9 spastic cerebral palsied adults in the age range of 17-30 years. Care was taken to ensure the homogeneity of both the groups except age. Neurological diagnosis (spasticity), IQ level (above 70), visual and hearing acuity, language (Telugu), absence of any associated problems, and speech therapy status was controlled in the subjects included in the study. Speech therapy was not a consistent aspect of the training of the subjects, but all subjects had undergone speech therapy at their day care centers. Also, as in almost all studies which have investigated neuromuscular impairment, the present study too could not ensure 100 percent homogeneity in terms of the nature and extent of impairment, as well

us the overall squclac of the impairment among the subjects of the two groups (Tables 2 and 3).

An adequate sample of speech was obtained from both the groups by recording their responses on a picture word articulation test. The correctness of the transcribed speech sample was verified. From the transcription, articulatory errors (substitutions etc) and the phonological processes were identified by subjecting it to both traditional sound-by-sound analysis and phonological processes analysis. Traditional sound-by-sound analysis is a quick and simple process. Though phonological process analysis is time consuming and complicated, it provides a more parsimonious means of identification of phonemes particularly where multiple errors occur. Hence, in the present study, both these methods were used to describe the articulatory errors.

Traditional Sound -by-Sound Analysis

The articulatory errors identified in a traditional sound-by-sound analysis showed a preponderance of substitutions in the speech of both children and adults. Omissions also occurred with high frequency followed by distortions in all the subjects. Only a few subjects showed phoneme additions in both the groups.

Further analysis of these errors in both the groups in terms of manner and place (Tables 6-9) was carried out. Manner of articulation analysis revealed that these errors occurred primarily on the manner class of stops in both children and adults. Place of articulation analysis revealed that the errors involved alveolar, velar and retroflex stops than any other group of sounds. However, some caution should be exercised in interpreting these results. The higher articulatory errors on stops may be due to the more frequent occurrence of stops in the speech sample (TADT - Padmaja, 1988) where stops occurred nearly 30 times in the 80 word sample. A significant percentage of articulatory errors also occurred on liquids and fricatives in both the groups. A greater percentage of articulatory errors involved the stop consonants in the speech of adults compared to the speech of children (Table 6). Whether these differences was statistically significant or not was not put to test, however. A significant percentage of articulatory errors also occurred on liquids and fricatives in both the groups. This may indicate a failure in the fine adjustment of articulators because of neuromuscular involvement. Fine tuning of the articulators is essential to the production of liquids, fricatives and affricates.

Place of articulation analysis of articulatory errors revealed that alveolar sounds accounted for nearly 30% of the errors followed by velar and retroflex sounds. This was true for both children and adults. In general, a similar pattern of articulatory errors seemed to occur in the speech of both children and adults, but

for the variation in the percentage of errors involving different class of sounds. This was observed in both manner and place of articulation analysis.

The results of the present study on children are not in agreement with those of Byrne (1959) who found high percentage of errors on manner class of fricatives and affricates. A greater proportion of articulatory errors in the speech of spastic children in the present study seemed to involve the manner class of stops. Methodological differences between these two studies in terms of type of speech material and the variable history of speech therapy, however, preclude a comparison of the results of these two studies. Similarly the results of this study on the speech of adults are not in agreement with those of Platt et al (1980) who reported reduced precision of fricative and affricate sounds in contrast to the greater difficulty the subjects of this study had on stop consonants. This may be due to methodological differences between the two studies. The differences between the two studies have to do with the higher occurrence of stop sounds in the sample elicited, lower occurrence of fricatives and affricates in Telugu language, and smaller sample size in the present study.

Phonological Process Analysis

The number of subjects who did not evidence a given phonological process was minimal. For example, only one subject did not manifest

vocalization (among children) while only one subject (among adults) did not show backing. Most subjects in this study, in both the groups, showed the same phonological processes of fronting, backing, stopping, gliding, weak syllable deletion, vocalization, medial and initial consonant deletion, devoicing, and cluster reduction. Of these processes, subjects in both the groups showed a high percentage of fronting, stopping and backing.

However, the results of the statistical analysis (t scores: Table 12) showed that both children and adults manifested the same degree of different phonological processes. The mean percentage of different phonological processes was not significantly different between the two groups, vocalization being an exception. Children showed a significantly higher percentage of vocalization than adults. This could be due to the fact that production of vowels is easy and different class of sounds are replaced or vocalized. For example, vocalization of liquids and nasals which require fine articulatory adjustments was in the subjects of the present study.

The higher degree of vocalization seen in children of the present study may also be due to the fact that a higher number of children (8) showed vocalization while only 6 adults manifested these features. This would result in a lower group mean for adults than children, thus increasing the probability of statistical significance. However, a perusal of the results in Tables 14 and 16

(results of combined analysis : sound-by-sound and phonological analysis) which shows that there indeed was lower occurrence of vocalization in adults (8.9%=10/l12) compared to children (14.8% - 21/143). It probably shows that spastic children take recourse to vocalization when they find articulation of some consonant difficult.

The results of the present study on phonological processes in children are in consonance with those of McMahon, Hodson and Allen (1983) who reported a high percentage of liquid deviations including gliding, vowelization, and syllable reduction. Similarly, the results of the present study is in agreement with those of Milloy and Morgan-Barry (1990) who reported high occurrence of fronting, backing, gliding and vocalization in the speech of children.

The phonological processes noted in the speech of adults of this study have also been reported earlier in adults (Crary and Comeau, 1981; Lakshmi, 2001). However, the results of the present study differ from those of Lakshmi (2001) with regard to final consonant deletion, and vocalic support of final consonant. These processes were not observed in the present study. This could be explained as due to the difference in the language. Telugu language has vowel ending syllable structure. Hence, the chances of final consonant detection are almost nil. Lakshmi (2001) studied speech articulatory errors in Tamil speaking spastic population.

Parallels and Differences between Children and Adults

The comparison of articulatory deviations in the speech of children and adults in the present study showed nearly similar articulatory features in both the groups. This was true whether it was the traditional sound-by-sound analysis or the phonological process analysis. Though the statistical significance of the difference between the two groups was not tested, a visual inspection of the data revealed that the differences in articulatory errors between children and adults were quantitative rather than qualitative. An exception to this was the higher percentage of vocalization seen in children than in adults as has been explained earlier.

In general, the results of this study support the initial hypothesis of Platt et al (1980) that at the level of phonemic articulatory accuracy, the dysarthria accompanying the cerebral palsy appears to have fairly stable features from childhood to adulthood. The adult spastic cerebral palsied in the present study showed the same articulatory features as children except that they showed lower number of errors than children.

A visual inspection of the data further suggests that adult spastics acquire somewhat greater accuracy in speech articulation than children, but the difference between children and adults was very little. Children had greater degree of difficulty on manner class of stops, and place categories of alveolar,

reflex and velar. So were the adult spastics. Similarly, both children and adults manifested phonological processes of fronting, backing and stopping. This apparent stability of phonetic inadequacies and phonological processes from childhood to adulthood probably point to the neuromotor limitations which are inherent to the speech production of persons with cerebral palsy.

There is one exception to this apparent absence of qualitative differences between children and adults. Spastic children in this study demonstrated a greater "strength" of vocalization process compared to the adults. This being the only study, to the best of our knowledge, which has attempted a comparative study of phonological processes in children and adults, the finding on vocalization (specifically the differences between children and adults) needs to be replicated.

The continuity or stability of articulatory errors and their features from childhood to adulthood should guide the speech therapist in his planning of speech therapy. Also, the stability of errors from childhood to adulthood, and only minor differences in the absolute number of articulatory errors in the speech of children and adults also suggests on the effectiveness of speech therapy for persons with cerebral palsy. Though the subjects in this study had variable history of speech therapy, the fact is that they all had speech therapy. More studies are warranted in this area which would not only throw light on the efficacy of speech therapy for cerebral

pulsied persons, but which will also have implicution for the neuromotor basis of speech production in persons with cerebral palsy.

Chapter 6

SUMMARY AND CONCLUSIONS

The purpose of this study was to describe the speech articulatory errors in the speech of children and adults with spastic cerebral palsy and to see if there is continuity, from childhood to adulthood, if phonemic articulatory accuracy and the occurrence of phonological processes.

Speech samples, from 18 subjects (9 children and 9 adults) with spastic cerebral palsy, in the form of responses on the Test of Articulation and Discrimination in Telugu (Padmaja, 1988) were recorded. This is a test with 80 items in it.

The responses of the subjects were transcribed by an experienced linguist and a speech-language pathologist. The articulatory responses were analyzed both through a traditional sound-by-sound analysis and a phonological process analysis (Newman and Creaghead, 1988).

Traditional sound-by-sound analysis showed that both children and adults manifested a large number of substitutions (more than 60%). Omissions and distortions, in that order, accounted for nearly 35% of the articulatory errors with the rest being sound additions. Manner and place characterization showed that

children and udulls had difficulty with manner class of stops (45%) and place categories of alveolars, retroflex and velars.

Phonological process analysis indicated that both children and adults had a 'strong' presence of fronting, backing and stopping processes. Children had greater presence of vocalization than adults ($p<0.05$). Other differences between children and adults were of quantity rather than quality.

The combined results of phonetic and phonological process analysis showed that a majority of the sounds substitutions could be explained either as fronting, stopping or backing, though other processes were apparent. The results of the combined analysis were interpreted to point to the economy of the approach to the description of articulation errors as well as intervention process.

The results were interpreted to mean that there is stability of articulatory errors from childhood to adulthood at the level of phonemic accuracy and phonological processes. These findings have implications for the neuromuscular basis of speech as well as therapeutic intervention for persons with cerebral palsy.

Limitations of the study pertain to the small number of subjects investigated in the study. Therefore, the statistical validity of the findings of this study is suspect. Also, getting a homogenous population was extremely difficult.

Further studies can aim to control for severity of the neurological lesion underlying cerebral palsy. Variable history and status of speech therapy of the subjects of this study is also a limitation, but the obtained results indicated that status of speech therapy had no significant influence on the result of this study.

Further Research

The present study investigated the articulatory errors in the spastic population. Studies are warranted on other clinical types of cerebral palsy like athetosis. A demonstration of articulatory stability in other languages will have greater theoretical and practical value for neuromotor maturation or neuromuscular basis of speech disorders in persons with cerebral palsy. Similar studies can be carried out in different languages of this country which will shed light on the universality of phonological process as well as their deviations.

Studies could also be undertaken to investigate the implications of phonological processes their degree as well as topology-on the intelligibility of speech. The results of such a study will also help in formulating therapy plan for persons with cerebral palsy. A longitudinal study can also be formulated to see if the same articulatory features continue despite therapy.

Studies could also be designed to investigate the acoustical and kinematic basis of those phonological processes which are stable (seen in both children and

adults) and to see what it can reveal about the neuromotor organisation for the production of these articulatory features.

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