APPLICABILITY OF MAYO CLINIC CLASSIFICATION OF DYSARTHRIA IN CHILDREN WITH SPASTIC AND HYPERKINETIC CEREBRAL PALSY

(REGISTER NO. M 9917)

A dissertation submitted in part fulfillment of the second year M.Sc (Speech and Hearing), University of Mysore, Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MANASAGANGOTHRI, MYSORE-570 006

MAY 2001

Dedicated to

My Dear Parents

With pride, joy & love

&

To my dear

Sis Manju

Certificate

This is to certify that this dissertation entitled *"Applicability of Mayo Clinic Classification of Dysarthria in Children with Spastic and Hyperkinetic Cerebral Palsy"* is the bonafide work done in part fulfillment of the degree of Master of Science (Speech and Hearing) of the student (Register No. M 9917).

Mysore

May, 2001

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Speech & Hearing
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Certificate

This is to certify that this dissertation entitled *"Applicability of Mayo Clinic Classification of Dysarthria in Children with Spastic and Hyperkinetic Cerebral Palsy"* has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

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Declaration

This dissertation entitled *"Applicability of Mayo Clinic Classification of Dysarthria in Children with Spastic and Hyperkinetic Cerebral Palsy"* is the result of my own study under the guidance of Dr. R. Manjula, Clinical Lecturer, Department of Speech Pathology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any other University for the award of any Diploma or Degree.

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CONTENTS

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"The brain is the organ of destiny. It holds within its humming mechanism secrets that will determine the future of the human race. Speech might be called the human brain's first miracle. . . . . . Speech it was that served to make man what he is, instead of one of the animals."

Wilder Graves Penfield,
The Second Career, 1963

INTRODUCTION

Speech is a unique, complex, dynamic motor activity through which we express our thoughts and emotions and respond to and control our environment (Duffy. 1995). In other words, speech is the externalized expression of language (Netsell, 1982).

Normal speech requires the integrity and integration of a number of cognitive, neuromuscular and musculoskeletal activities. Disturbance in any of the above systems results in a speech disorder. Speech impairment as opposed to language impairment, is caused by lesion or dysfunction of the motor control centers of the peripheral or central nervous system or a combination of both systems (Love, 1995).

Motor speech disorders can be defined as disorders of speech resulting from neurologic impairment affecting the motor programming or neuromuscular execution of speech. They encompass apraxia of speech and the dysarthrias (Duffy, 1995). Dysarthria refers to a group of speech disorders characterized by disturbances in dimensions of strength, speed, tone, steadiness, accuracy and range of movement in the muscles of speech mechanism (Love, 1995).

A well known association of dysarthria with congenital encephalopathy (cerebral palsy) was recognized by Morley. Court and Miller as early as 1954. Meitus and Weinberg (1983) also observed that abnormalities of motor control for speech can be a part of several diverse neurological problems in children with cerebral palsy.

Cerebral palsy is defined as the non-progressive movement disorder that stems from an insult to the cerebral level of central nervous system during the prenatal or perinatal period (Yorkston, Beukelman and Bell, 1988). Since the neurological damage is incurred before the emergence of speech and before the mastery of communication skills, the observed effects on speech and other motor behaviours reflect complicated interacting variables influencing learning (Darley, Aronson and Brown, 1975). This makes it very difficult to study the speech characteristics of cerebral palsy or to classify the various types of cerebral palsy depending on the speech characteristics. Hence, most of the classification system are based on the physiological pattern of the movement disorder.

Studies by Abbs, Hunker and Barlow, (1983) and Brown (1984) suggests that the involvement of limb movements and the speech musculature may not correlate and hence the speech disturbance cannot be inferred based on the physiological classification of cerebral palsy. Considering the speech of cerebral palsy and few studies carried out by several authors on spastic and athetoid (hyperkinetic) cerebral palsy, we can conclude that most of the speech deviations are similar to that of the adults with dysarthria which is acquired due to neural damage (Rutherford, 1944; Leith, 1954; Berry and Eisenson, 1956; Irwin, 1955 and 1972; Byrne, 1959; Clement and Twitehell, 1959; Hardy, 1961 and 1964; Lencione, 1968; Boone, 1972; Darley, Aronson and Brown, 1975; Platt, Andrews, Young and Quinn, 1980a; Platt, Andrews and Howie, 1980b; Chengappa, 1991; Mary, 1991; Hemalatha, 1994). Most of the above studies were based on perceptual evaluation or informal observations on individuals and groups of children with cerebral palsy during the clinical, diagnostic or intervention process.

Based on the above studies, we can therefore, assume that standard evaluation systems used with adults with neurogenic speech disorders should also hold good in classification of the developmental dysarthria in children with cerebral palsy. In clinical practice, it is generally seen that the Mayo clinic classification of dysarthria proposed by Darley, Aronson and Brown (1969a) has been widely used in classifying the speech disturbance of cerebral palsy also. Theoretically, the Mayo clinic classification system (Darley, Aronson and Brown, 1969a) is relevant and applicable to dysarthric conditions in adults since it was established and standardized only on these population.

Applicability of Mayo clinic classification to any disorder with developmental disability needs to be critically viewed. Studies on the development of speech motor control (Euguchi and Hirsch, 1969; Kent, 1976; Netsell, 1979, Edwards, 1992; Smith and Goffman, 1998) suggest that maturational changes take place in the developmental period. Lencione (1968) and Stark (1985) also suggested that the neurological signs and symptoms as well as the speech characteristics change on par to the maturation of the nervous system. The observation of these studies imply that the speech deficits in children with cerebral palsy may also be expected to show a developmental trend and in this sense would be different from the speech deficits of adults with dysarthria. Substantiating this viewpoint, Rosenbek and La Pointe (1985) state that classification by age of onset in dysarthria in a state of evolution (child) may require different remedial approaches from those used with dysarthria in a state of dissolution (adult). Typically, the symptoms, course and causes differ between congenital dysarthria and acquired dysarthria. Furthermore, a study by Van Mourik, Catsman-Berrevoets, Yousef-Bak, Paquier and Von Dongen (1998) also suggests that the Mayo clinic classification system does not hold good for acquired childhood dysarthria. They recommended that a different classification system should be evolved specifically for children with due consideration given to the age related changes that are expected in this group.

Thus, the observations of the developmental dysarthrias (Lencione, 1968; Stark, 1985 and Van Mourik et al., 1998) leads one, to question the applicability of Mayo clinic classification system on the following lines:

- Does the classification system, which was developed solely on the adult model serve to describe the congenital developmental dysarthrias seen in a condition such as cerebral palsy?
- Is the classification system, more suitable in describing the speech clusters of children with cerebral palsy of older age group compared to the younger age group?

As an attempt to answer these questions, the following study was undertaken:

Aim:

The present study aims to determine the applicability of Mayo clinic classification of dysarthria in children with cerebral palsy.

Methodology:

Thirty four children with cerebral palsy (22 spastic type and 12 athetoid type) were included in the study. The speech samples of these children were recorded for 5 minutes using Sony minidisk digital tape recorder (MZ-R55) individually in a silent room. Three judges were chosen for the study to perceptually evaluate the speech sample on a 5-point equal-appearing interval scale. All the 38 parameters proposed by Darley, Aronson and Brown (1969a) were included in the study. A pilot study was carried out wherein the judges were familiarized with perceptual evaluation of the speech of four children (2 spastics and 2 athetoids). After establishing a "good" inter judge reliability, perceptual rating of the test sample was carried out. The ratings were marked on a response sheet twice with an interval of two weeks period by each judge in order to calculate the intrajudge reliability. Interjudge reliability was also scored. The raw data was further subjected to statistical analysis.

Implications of the study:

Review of literature suggests that clinically, there is no comprehensive assessment procedure available to classify cerebral palsy based on the speech characteristics exhibited. The classification system proposed by Darley, Aronson and Brown (1969a) is the most commonly cited and highly relevant clinical tool in perceptually classifying the different types of dysarthrias in adults. Although clinicians have often used this system more or less informally to classify the dysarthrias in children, its applicability to childhood dysarthrias, specifically the cerebral palsied needs to be thoroughly examined. The present study aims to examine the applicability of a part of the classification system of Darley, Aronson and Brown (1969a) to spastic and athetoid variety of cerebral palsied. If found applicable, the study would facilitate perceptual classification of spastic and athetoid varieties of cerebral palsy based on the prominent speech characteristics.

Once the speech dimensions are identified, it would help us in determining the subsystem errors and the respective physiological aspects involved in each of the dimension. This in turn will help clinicians in planning the goals or therapeutic activities for a child with spastic or athetoid type of cerebral palsy.

Limitations:

* Due to time restrictions, only two types of cerebral palsy have been considered in the study.
* The severity or the topography of the disorder in the spastic and athetoid variety was not controlled.

REVIEW OF LITERATURE

Motor speech disability refers to speech impairment caused by a lesion or dysfunction of motor control centers in either the peripheral or central nervous systems or in a combination of both systems (Love, 2000). The neurological impairment may affect the motor programming or neuromuscular execution of speech (Duffy, 1995). Motor speech disorder encompasses two broad categories: i) Dysarthria and ii) Apraxia of speech.

Dysarthria is a collective name for a group of speech disorders resulting from disturbances in muscular control over the speech mechanism due to damage to the central or peripheral nervous system. It designates problems in oral communication due to paralysis, weakness or incoordination of the speech musculature (Darley, Aronson and Brown, 1969a).

Dysarthria can be seen due to congenital cause (e.g., cerebral palsy) or due to acquired cause (e.g., Parkinson's disease, multiple sclerosis). The term "Dysarthria" has been widely used to designate adult disorders of speech. In children, the disorder of similar kind has been popularly designated as "developmental dysarthria". Frequently "developmental" is used as the disorder emerges as the child matures (Ingram, 1969). The adjective "developmental", has important implications i.e., in addition to suggesting a possible congenital basis for the disorder, this term reminds clinicians of the potential for disruption of more than one developmental process (Crary, 1995). Developmental dysarthria is a neurogenic speech impairment caused by dysfunction of the motor control centers of the immature central and/or peripheral nervous systems and marked by disturbances of strength, speed, steadiness, coordination, precision, tone and range of movement in the speech musculature (Love, 2000).

The speech of these children are usually subjectively described with some terms which are derived from the descriptions of motor disturbances of the limbs and trunk, eg., weak or slow, unsteady, hypotonic or hypertonic. There are a number of significant differences in physiologic and neurophysiologic control for the subsystems that govern speech movements and limb movements (Abbs, Hunker and Barlow, 1983) and hence, the terms used for limb movements may not always be appropriate for oral motor deviations. Further, motor speech impairments are not always completely predictable on the basis of limb impairment in dysarthric individuals, i.e., children with mild cerebral palsy may have severe dysarthria, and speech may be relatively unaffected and generally intelligible even to strangers in children with severe spastic quadriplegia (Brown, 1984).

Developmental dysarthrias are characterized as congenital or acquired disorders in terms of whether the underlying cause of the dysarthria is a disease present at birth or one that had an onset later in the pediatric period (0-15 years). Cerebral palsy is one of the most common conditions with developmental dysarthria. It is also one of the most commonly reported conditions as evident from the literature.

Cerebral palsy can be defined as a non-progressive motor disorder that stems from an insult to the cerebral level of the central nervous system during the prenatal or perinatal period (Yorkston, Beukelman and Bell, 1988). The incidence of cerebral palsy is between 2 and 2.5/1000 with a prevalence of about 400.000 school-aged children (Erenberg, 1984; Lord, 1984) in western countries. Although the precise prevalence of dysarthria in cerebral palsy is unknown, it is a very frequent sequelae of the neurologic disorder. Various studies have reported varied degree of its incidence. In the earlier studies, Wolfe (1950) and Achilles (1955) respectively reported 31 to 59% and 88% of defective speech in children with cerebral palsy. Because of the neuromuscular involvement in many children with cerebral palsy, 70% of them have speech defects (Denhoff and Robinault, 1960). ASHA in 1980 has reported the incidence of dysarthria in children to be 1-2/1000. Love and Webb (1996) reported 75 to 85% of dysarthria in cerebral palsied children. All these studies have been in Western countries and there are no incidence figures available in India as of now regarding cerebral palsy.

The syndromes are often not as clear cut in the children as they are in adults. Many of the pathologies seen in children are much more diffuse than the focal pathology seen in adults. In adults, vascular lesions, tumor and trauma will produce localized discrete lesions within the brain, while in children, it is more likely that asphyxia, jaundice, infection and trauma will produce more diffuse lesions (Brown, 1976). Therefore, abnormalities of motor control for speech can be a part of several diverse neurological problems in children with cerebral palsy. The associated dysfunction include disturbances in cognition, perception, sensation, language, hearing, emotional behaviour, feeding and seizure control (Love, 1964). In some cases even when language is intact, expressive skills may be severely disordered, largely because of neuromuscular impairments, which affects the functioning of the articulators as well as other organs of speech production mechanism, such as respiratory, phonatory and resonatory systems (Barnes, 1983).

Although no universal classification systems of the clinical types of cerebral palsy exists, many experts and speech pathologists currently accept the classification based on the different predominating patterns of motor involvement. Based on this, Erenberg (1984) classified cerebral palsy into four major types; spastic, athetoid, ataxic and mixed.

According to the classification system proposed by Hardy (1983), cerebral palsy includes:

A] Disorders of muscles tone:

1. Hypotonicity
2. Hypertonicity - Spasticity.
Rigidity and
Tension

B] Disorders of movement:

1. Hyperkinesia
2. Hypokinesia

C] Disorders of coordination:

1. Ataxia.

It may be noted that some of the older classification systems also include subtypes such as Tremor, Rigidity, Atonic/Flaccid variety, mixed and unclassified (Denhoff and Robinault, 1960). Clinically three major types are most commonly identified: Spastic cerebral palsy (70%) is most frequent, followed by athetoid (10%) and ataxia (10%). Some have also reported tremor variety to be present in around 10% (Evans, 1947; Woods, 1956; Brandt and Westergaard-Nielsen, 1956; Anderson, 1957).

Dysarthria in children are less well studied than those found in adults (Stark. 1985). However, there are few studies conducted on children with cerebral palsy and on careful observation, they show similar areas of involvement and symptoms as in adults (Stark, 1985; Hemalatha, 1994). These studies pertaining to spastic and athetoid (hyperkinetic - slow) variety are discussed in the following section.

Speech characteristics of cerebral palsy:

In general, delayed speech and language and articulatory problems due to poor motor control as a consequence of central nervous system impairment may be seen. Although cerebral palsied population is a heterogenous one. a common characteristic is dysarthric speech. Among the voice problems, most often encountered problem in children with cerebral palsy is deviations in quality, such as nasality, breathiness or hoarseness. One may also find associated disturbance in intensity, rate and pitch. There is a clear-cut evidence of reduced speech intelligibility in children with cerebral palsy, like in adults and show problems of respiration, phonation, resonance, articulation and prosody (Tikofsky and Tikofsky, 1964; Darley et al., 1969a and Boone, 1972).

Various studies on cerebral palsy have suggested that spastics as a group, have fewer hearing and speech/language problems than athetoids, who have more difficulty with speech (Heltman and Peacher, 1943; Denhoffand Holden, 1951; Dunsdon, 1952; Byrne, 1959; Woods, 1969; Stark, 1985; Chengappa, 1991; Feldman, Janosky, Scher and Wareham, 1994; Hemalatha, 1994). Blumberg in 1955 studied 13 spastics and 12 athetoids and found that speech of children with spastic cerebral palsy was better than that of children with athetoid cerebral palsy with respect to loudness, phonation and general control.

Respiratory function:

Respiration is the process, which provides the source of energy for the production of speech sounds. Cerebral palsy may affect not only the muscles, which innervate pharyngeal, laryngeal and respiratory function, but may also involve the brain centers of respiratory regulation. Therefore, the task of rapid inhalation and prolonged exhalation is often disturbed in children with cerebral palsy which is essential for speech (Hull, 1940; Hardy, 1961; Me Donald and Chance, 1964; Lencione, 1968). The abnormalities of respiration i.e., inability of the patient to extend his exhalation for phonation in children with cerebral palsy suggest that the inefficient valving of the air stream would prevent them to generate as much intraoral pressure as needed for speech production (Hardy, 1961).

Hardy (1964) reported that children with spastic quadriplegia had reduced respiratory reserve and subsequently lowered vital capacities. These abnormalities were attributed to spasticity of abdominal and thoracic wall muscles (Hardy, 1983). This results in short phrasing of utterances. He believes that only when there are laryngeal, velopharyngeal or articulatory dysfunctions, overall speech function may become clinically impaired. Clement and Twitchell (1959) reported of shallow inspiration and forced expiration. The rhythm of respiration is also spasmodic or broken, often interrupting the flow of speech. Similar observations were also given by Rutherford (1944), Berry and Eisenson (1962) and Boone (1972).

The respiration in children with athetoid cerebral palsy is often very rapid and irregular (Davis, 1987). In children with athetosis, lack of stability and extension of the vertebral column as well as delayed head balance and sitting posture result in breathing patterns of the neonate that persist into later childhood (belly breathing). There is reduced volume of air during inhalation due to reverse breathing and belly breathing in these children (Westlake and Rutherford, 1961; Hardy, 1983 and Love, 2000). The reverse breathing may be due to the involvement of thoracic wall muscles more than the abdominal wall muscles. In children with athetoid cerebral palsy, there is shallow inspiration, which may differ at times and seem essentially uncontrolled. Expiration *is* also forced, but seems more uncontrolled and reveals sudden bursts of breath. In this type, there may be jerky and uncontrolled rhythm, although it is usually continuous (Rutherford, 1944; Palmer, 1952; Achilles, 1955; Clement and TwitchelL, 1959; Mc Donald and Chance, 1964; Lencione, 1968).

Laryngeal function:

The control of the position and tenseness of the vocal cords by the muscular activity influences the pitch, intensity and quality of the voice. The laryngeal blocks occur usually as a part of more generalized neuromuscular dysfunction. When the child attempts to produce controlled exhalations for speech, the increased tension, which may occur, may also spread to the laryngeal musculature causing various types of laryngeal spasms (Lencione, 1968).

At the phonatory level, these patients experience adductor or abductor spasms, which will shut off phonation or result from using inappropriate pitch levels as there is no adequate subglottal airflow and air pressure (Evans, 1947; Mc Donald and Chance, 1964; and Boone, 1972). Berry and Eisenson (1956) reported whispered, hoarse phonation in speakers with cerebral palsy.

In spastic developmental dysarthria, the pitch is generally high with a monotone in any given range. The intensity of the voice is weak and forced which may be in- agreement to the force of the breath stream or breathing abnormalities. The quality is breathy and forced with a partly nasal resonance (Rutherford, 1944; Clement and Twitchell, 1959; Berry and Eisenson, 1962; Ingram, 1966; Boone, 1972; Chengappa, 1991; Mary, 1991; and Love, 2000). Few studies have also reported strained strangled voice and intermittent dysphonia which can be attributed to the laryngeal stenosis as a result of hypertonic vocal folds (Love, 2000). In spite of these abnormalities, children with spastic cerebral palsy are reported to have fair smoothness in their voice (Clement and Twitchell, 1959).

Rutherford (1944) and Leith (1954) concluded that children with athetoid cerebral palsy demonstrate a monotonous pitch level. Clement and Twitchell (1959) described the voice of athetoid speakers as low in pitch with weak intensity, exhibiting a forced, and throaty voice quality. The vocal tone is not smooth flowing and is seen with voice tremors and uncontrolled variations (Chengappa, 1991; and Mary, 1991). Hardy (1983), has suggested that in some severely involved children with athetoid cerebral palsy, air rushes through the voca] tract with no phonation occurring. These results obtained for children with athetoid cerebral palsy were further supported by Berry and Eisenson (1962) and Boone (1972).

Velopharyngeal function:

Resonance is the acoustic process by which components of the vocal tone are damped or amplified as they pass the pharyngeal, oral and nasal cavities. Velopharyngeal valve separates the pharynx from the nasal cavity and many resonance problems are the result of aberrant patterns of its neuromuscular function (Mc Donald and Chance, 1964; Yost and Mc Millan, 1980). Boone (1972), reported resonance problems in children with cerebral palsy and related it to the malpositioned tongues, palates and mandibles e.g., palatal -movements may be sluggish or absent causing problems of nasal emission and hypernasality. This was also reported by Evans (1947).

Ingram and Bam (1961), reported hypernasality and nasal escape as a common problem in children with spastic cerebral palsy. Netsell (1969), found certain deviations in palatopharyngeal competence that resulted in nasal abnormalities. Clement and Twitchell (1959) also reported abnormal nasal resonance in children with spastic cerebral palsy. In children with athetoid cerebral palsy, abnormal pharyngeal resonance has been often observed (Clement and Twitchell, 1959). Carr (1959) and Hardy (1961) reported that the velopharyngeal function is inconsistent and uncoordinated in athethoid speakers.

Chengappa (1991) and Mary (1991) have also reported that the resonance abnormalities result ultimately in the reduction of speech intelligibility. Currently it is believed that management of velopharyngeal impairments not only resolves resonance problems but also improves articulation and airflow throughout the speech mechanism, therefore overall speech performance (Hardy, 1983).

Articulatory function:

Articulation refers to the modification of the vocal tones by the tongue, lips and soft palate in order to produce vowels and consonants. The rapid coordinated movement patterns of the articulators (mandibular, labial and lingual) are extremely susceptible to neuromuscular breakdowns, as in cerebral palsy and hence misarticulation results (Mc Donald and Chance, 1964).

Lencione (1953) and Byrne *(1959)* reported that though the articulation development was delayed in children with cerebral palsy, it always followed the phonemic acquisition pattern of normal children.

Studies have identified that the speech sounds involving tongue tip and voiceless sounds were most frequently misarticulated by children with cerebral palsy compared to other speech sounds and voiced cognates respectively (Irwin, 1955; Byrne, 1959; Farmer, 1980). Voiced for voiceless substitutions may occur because voiceless sounds may be physiologically easier for children with cerebral palsy (Hardy, 1965) due to vocal tract coordination difficulties required in valving the air stream for impounding intraoral breath pressure for voiceless sounds (Hardy, 1961).

Irwin (1972) conducted an extensive study on the articulatory aspects and found that the dental and glottal sounds were most difficult compared to the labial phonemes. For the manner of articulation, the nasals were easier compared to fricatives and glides. He also found that omission errors tended to exceed substitution of phonemes, a finding that is the reverse of the finding in the normal children. The articulatory errors seen in children with spastic cerebral palsy were more consistent when compared to the articulation errors seen in children with athetoid cerebral palsy (Rutherford, 1938; Evans, 1947).

Clarke and Hoops (1980) found children with spastic cerebral palsy to be better than children with athetoid cerebral palsy in articulatory ability, intelligibility and reading rate. The above fact was also supported by various other studies (Irwin, 1955; Byrne, 1959; Chengappa, 1991; Mary, 1991, Workmger and Kent, 1991). Irwin (1972) found that children with spastic paraplegia made fewer errors than did children with spastic hemiplegics, and hemiplegic made fewer errors than did children with quadriplegia.

The imprecise consonants and irregular articulatory breakdown in children with spastic cerebral *palsy* are due to spasticity, stiffness of peripheral speech musculature and inability to perform fine synchronous movements by tongue, lips, palate and jaw. Similar imprecise articulation and distortion of vowels in children with athetoid cerebral palsy are due to uncontrolled movements of speech musculature (Clement, and Twitchell, 1959; Mc Donald and Chance, 1964; Boone, 1972; Chengappa, 1991; Mary, 1991). Farmer (1980) reported that athetoid subjects used longer and more varied VOTs than compared to spastic subjects. This reveals that athetoids may require more time to coordinate vocal tract gestures particularly to build up adequate oral pressure for voiceless stops.

The articulatory performance of adult speakers with cerebral palsy has also been studied to some extent. Platt, Andrews, Young and Quinn (1980) and Platt, Andrews and Howie (1980) reported that articulatory patterns of adults with spastic and athetoid cerebral palsy was not different. They reported more articulatory errors for fricatives and affricates with a predominance of within manner errors. This supports the view that adults with dysarthria due to cerebral palsy have phonemic competence, but lack articulatory precision. Devoicing of voiced consonants was predominant, unlike in children. More errors occurred in word-final as compared to word-initial position. They also found that at any condition, speech of children with spastic cerebral palsy is more intelligible and less articulatorily impaired than the speech of children with athetoid cerebral palsy. This is similar to the results found in developmental dysarthrias (Byrne, 1959; Clement and Twitchell, 1959 and Lencione, 1966).

Prosodic function:

Prosody refers to the rate and rhythm of speech. Intonation, stress and melodic variations in individual speech patterns are all elements of prosody. Any abnormalities in one or more of the above mentioned systems would also affect the prosodic aspects of speech.

Rutherford (1944); Chengappa (1991) and Mary (1991) have reported that rate and rhythm are impaired in children with cerebral palsy. Because of the characteristic motor disorders which are part of cerebral palsy, many of the patients cannot move their articulators fast enough or breathe in a controlled fashion sufficient to enable them to speak as rapidly as normals (Boone, 1972; Darley et al., 1975). Studies have reported that spastics had slow rate, laboured production, spasmodic and broken rhythm. Particularly, spastics were found to have, reduced stress contrasts and atypical intonation patterns (Hardy, 1983; Mary, 1991). Darley et al. (1975) demonstrated that the hypertonicity in spastic cerebral palsy also reduces the range of movement of laryngeal muscles, thus causing alterations in prosody.

Children with athetosis were found to have slow rate of speech with inappropriate voice stoppages but rhythm was jerky and uncontrolled (Rutherford, 1944; Chengappa, 1991; and Mary, 1991). Speech was also found to be explosive, in hyperkinetic cerebral palsy. Mary (1991) also reported prolonged phonemes and repetitions of phonemes in children with athetoid cerebral palsy along with other dysprosodic patterns. The above finding is also reported by Farmer (1972).

Thus, due to the overall performance deficits and variations of the subsystems in a child with cerebral palsy, the speech intelligibility is impaired, depending on the severity of the neuromuscular disturbance. Farmer (1980) concluded that one of the important factor underlying the poor intelligibility of cerebral palsied speakers is the distortion caused by increased speech duration. Platt et al. (1980 reported that speech intelligibility in adults with spastic cerebral palsy is better than that of adults in athetoid cerebral palsy. This is in accordance with the studies carried out on children with cerebral palsy (Byrne, 1959; Clement and Twitchell, 1959; and Lencione, 1966).

As the above review of literature suggests, all the subsystem errors occur in children with cerebral palsy, similar to the errors seen in dysarthric adults. Most of the above mentioned studies were documented based on objective and subjective methods. Amongst the subjective methods, perceptual tasks have been often employed by many investigators to describe the error types in the speech of the children with cerebral palsy. Despite these, perceptual tasks employed, there is no standardized classification system for the speech of children with cerebral palsy. The descriptions have often been made on individuals and groups of developmental dysarthrias during the clinical diagnostic or intervention process. Also, it may be seen that most of the studies describe only few aspects of speech and no consolidated report based on the speech characteristics of cerebral palsied incorporating all the dimensions of speech is employed. The neuromuscular damage of adult dysarthrias also are expected to result in similar speech subsystem errors and can be hence referred, in order to study developmental dysarthrias.

Motor speech disorders can be studied in a number of ways, all of which contribute to their characterization. Perceptual evaluation is one of the methods which are based primarily on the auditory perceptual attributes of speech. Though perceptual judgements have been considered "subjective", it has its advantages. Moll (1964) argued that the ultimate test of speech acceptability is based on its acceptability to listeners. Deviations detected by instruments are of no consequence to communication unless listeners judge the speech to be deviant. Thus, speech is ultimately defined by listener's perception. This was also supported by Netsell (1984) and Mc Neil (1986). As it does not involve elaborate instruments, they have found to be more feasible and convenient. Studies have also reported perceptual evaluation to have high content validity and time economy. Darley Aronson and Brown (1969a and b, 1975) pioneered the modern use of auditory perceptual assessment to characterize the dysarthrias and to identify the clusters of characteristics that are associated with lesions in the different portions of the central and peripheral nervous system. This is called Mayo Clinic Classification of dysarthria and is most widely used by clinicians and researchers in this field even today. They have characterized six types of dysarthrias based on this system, which gave an impetus to the physiological studies from the 1970s to the present.

The advantages of the Mayo clinic systems are as follows:

This system

- is greatly helpful in evaluation and development of appropriate therapeutic plan (Duffy, 1994)
- is found to be consistent with other medical professional reports of the underlying physiological aspects, and provides a basis for communication between professionals in diagnosing the disease and identifying the site of lesion (Strand and Yorkston, 1994).
- allows the evaluation to be detailed, quick, accurate and consistent in the description of individual's dysarthric characteristics (Simmons and Mayo, 1997).

Gentil (1990) studied speech characteristics using perceptual and acoustic analysis and found that acoustic analysis supports the perceptual observations of speech in dysarthrics. Riza (1998) also found that perceptual and acoustic features of children with cerebral palsy correlated with each other. This view is also supported by Kent, Weismer, Kent, Vorperian and Duffy (1999). Although some investigators refute the above view points (Rosenbek and La Pointe, 1978; Ludlow and Bassich, 1984; Orlikoff, 1992; Thompson and Murdoch, 1995), based on the results of large number of studies and wide clinical experience, it is needless to say that perceptual judgements are clinically significant and helpful for diagnostic purposes and for intervention purposes (Darley, 1984).

Speech characteristics of adult dysarthrias:

Darley et al. (1969a and b) analyzed speech samples of 212 adults with dysarthria categorized into 7 different groups based on the medical conditions (bulbar palsy, pseudobulbar palsy, cerebellar disorders, parkinsons, dystonia, choreoathetosis and amyotrophic lateral sclerosis). Audio-recorded speech samples of the'Grandfather'passage for 30 sees were subjected to perceptual evaluation. Thirty eight speech dimensions, which were related to pitch, loudness, voice and resonance, respiration, prosody and articulation, were analyzed. Two overall dimensions intelligibility and bizarreness were also included. Distinctive features for each type of disorder and "clusters" of deviant speech characteristics were identified. Based on this classification system the subjects were grouped under six different types of dysarthrias - spastic, ataxic, flaccid, hypokinetic, hyperkinetic and mixed dysarthria. This classification is considered to be one of the most useful systems to describe dysarthria in different subtypes.

Darley et al. (1969 a & b) reported the following speech characteristics in spastic dysarthria [pseudobulbar palsy (PBP)] and hyperkinetic dysarthria (dystonia):

Spastic dysarthria:

In spastic dysarthria, tongue and lip, though of normal size and clearly not atrophied, move slowly and with limited range, and rapid alternating movements are markedly slowed and performed effortfully. Imprecise consonants, monopitch and monoloudness appear with reduced stress. Phonatory changes include harsh voice and strained strangled voice, low pitch and pitch breaks. Breathy voice may also be heard. Slow rate with short phrases and excess and equal stress reflect the sluggish activity of the speech mechanism. Hypernasality is present to a lesser degree. The four major clusters seen are prosodic excess, articulatory resonatory incompetence, prosodic insufficiency and phonatory stenosis (Darley et al. 1969b).

Similar features are also reported by Rosenbek and La Pointe (1978), along with respiratory difficulties in PBP as in children with spastic cerebral palsy. Based on another perceptual scale Frenchay Dysarthria Assessment (FDA), Enderby (1986) has demonstrated, poor tongue movement, lack of control of volume and poor intelligibility of speech. This observation is also supported by Hirose, Kiritani and Sawashima (1982) and Love and Webb (1996). Acoustic studies by Kent and Kent (2000) also report similar phonatory stenosis due to laryngeal hyperfunction.

Metter (1985) suggested that the spasticity seen in PBP and cerebral palsy resulted in reduced synchrony between respiratory muscles leading to a rapid, shallow and irregular breathing pattern. Duffy (1995) has also commented on the resemblance of respiratory difficulties in children and adults. Slow rate of speech in spastics is also supported by various authors (Hirose et al., 1982; Linebaugh and Wolfe, 1984; Dworkin and Aronson, 1986). This explains the prosodic abnormalities seen in spastic dysarthria (Thompson, Murdoch and Theodows, 1997). Aronson (1990) and Darley et al. (1975) have reported respiratory abnormality and reduced vital capacity in both children and adults with spastic dysarthria. These studies have also reported effortful grunt, strained strangled voice, monoloudness, reduced stress, inappropriate stress, hypernasality, consonantal imprecision and vowel distortion.

Hyperkinetic (slow variety) dysarthria:

In case of hyperkinetic slow variety (dystonia), Darley et al. (l969b) have suggested spasms in the oral musculature and the larynx of dystonias. The speech abnormalities revealed by perceptual evaluation were interference with articulation, alteration of phonation and then the prosodic changes. In this group, excess loudness variations, slow rate of speech were also reported. The clusters of speech deviations for hyperkinetic slow variety of dysarthria are articulatory inaccuracy, prosodic excess, prosodic insufficiency and phonatory stenosis.

The articulatory abnormalities noted in adults with athetosis include wide range of jaw movements, inappropriate tongue placement, intermittent velopharyngeal closure, retraction of the lower lip and prolonged transition time for articulatory movements (Kent and Netsell, 1978). In adults with athetoid cerebral palsy, articulatory study also reveals intact phonetic competence with poor intelligibility. This suggests lack of neuromuscular control for articulatory precision (Platt et al,,1980). Dworkin (1991) attributed poor posture, neck and trunk rigidity, shallow inhalations, reduced exhalation control and rapid breaths as reasons for poor speech intelligibility in hyperkinetic dysarthria.

The abnormal involuntary movements significantly contribute to dysarthria that is observed (Neilson and O'Dwyer, 1984). Duffy (1995) is of the opinion that the deviant speech are the product of abnormal rhythmic or irregular and unpredictable, rapid or slow involuntary movements. Love and Webb (1996) states that poor respiratory reserve and patterns, dilator and constrictor spasms of larynx, involuntary movements, excessive articulation imprecision results in poor speech intelligibility in athetoid dysarthria. Kent and Netsell (1978) found that adults with athetosis had trouble achieving velopharygeal closure.

All the above studies and reports reveal similarities between adult and developmental dysarthrias, though no study has compared the two group's performance directly. Hemalatha (1994) has compared the profiles of children with cerebral palsy to that of the adult dysarthrias of spastic and extrapyramidal type on the FDA (Enderby, 1986). She found more similarities in their pattern of performance, but developmental dysathrias performed poorer than adult dysarthrias in all the tasks.

Stark (1985) has also suggested that dysarthria in children and adults is accompanied by significant restriction of oral nonspeech movements such as voluntary lateralization of the tongue and protrusion and retraction of the lips.

This suggests somewhat similar speech characteristics to be executed by both the groups. In both adults and in children with dysarthria, vowels are more correctly produced than consonants. This is reported by Lencione (1953) and Byrne (1959) in children and in adults by Huntingdon, Harris, Shankweiler and Sholes (1967). This may be because, the degree of precision required for production of consonants is greater than that required for vowel production.

Based on the review of literature, we can hypothesize that, as the speech characteristics are similar in developmental and adult dysarthrias, the perceptual classification system proposed and standardized on adults by Darley et al. (1969 a & b) should also hold good in classifying the dysarthrias in children with cerebral palsy.

The above view is however, debatable based on the observations of studies on the development of speech motor control in normals. The speech patterns in children change overtime due to the influence of growth and maturation, language development and a myriad of other factors. Netsell (1979) hypothesized that acquisition of speech motor skill is a continuous but nonlinear process. According to him, the acquisition of speech motor control is complete at around the age of 11 years. The concept of non-linearity was further supported by Smith and Goffman (1998). Similar views are expressed by other investigators, but there is no consensus regarding the age at which speech motor acquisition is complete (Euguchi and Hirsch, 1969; Kent, 1976; Robin and Klee, 1987; Edwards, 1992). Overall, it has been concluded that the adult like pattern appears only around 12 years of age. Studies regarding the disordered population also reveal maturational changes.

Denhoff and Robinault (1960) put forth evidences that the neurogenic signs and symptoms in children with cerebral palsy changes as the nervous system matures and that one must be cautious in delimiting the neurogenic variations of the many types of cerebral palsy during the period from birth through adolescence. Stark (1985) has also observed that developmental forms of dysarthria in children may show amelioration with age at least up to adolescence, though no further evidence has been proposed. The evidence from developmental studies also support that lesions incurred during maturation of speech motor control may result in speech deficits different from the speech deficits of adults.

Darley et al. (1975) observed that the conditions seen in children with spastic cerebral palsy are not directly analogous to those observed in adults with pseudobulbar palsy. In children, though the major symptoms are of spasticity, they also include evidence of cerebellar or basal ganglia damage.

The motor disorder in such instances is more properly designated as "mixed", and the sensory, perceptual and intellectual problems frequently associated are likely to blur the effect of the motor impairment on speech production.

Van Mourik, Catsman-Berrevoets, Paquier, Yousef-Bak, and Van Dongen (1997) also reviewed the literature and reported differences between acquired childhood and adult dysarthrias. They studied the characteristics in detail and suggested that the acquired childhood dysarthria may require its own classification system.

A study by Van Mourik, Catsman-Berrevoets, Yousef-Bak, Paquier and Van Dongen (1998) on acquired childhood dysarhtria revealed differences between the speech characteristics of adult and childhood dysarthria. Van Mourik et al. (1998) studied the perceptual speech characteristics of acquired childhood dysarthria with cerebellar and brainstem tumors in the age range of 5 to 14 years using the Mayo clinic classification system. They found differences in the speech characteristics of acquired childhood dysarthria in ataxic group, but the characteristics of flaccid dysarthria in acquired childhood disorders resembled the characteristics of flaccid dysarthria in adults. These discrepancies were explained based on the results of perceptual evaluation of three judges who independently rated the speech sample recorded, using a four point rating system. The parameters considered included thirty six of the thirty eight dimensions except for the two overall performance dimensions given by Darley et al. (1969^. hi cerebellar group, it was found that only slow speech rate was prominent and distinctive. Other speech features, which are thought to be characteristic of ataxic dysarthria in adults were absent or only mildly impaired if present (scanning speech and irregular articulatory breakdown). They concluded that although the Mayo clinic classification system is a good instrument to describe the acquired childhood dysarthria, the adult cluster model of speech features as proposed by Darley et al. (1969 a & b) in distinct dysarthria types is not suitable for pediatric age groups. Based on their observation, they suggested that the utility of Mayo clinic classification system in describing the speech characteristics of developmental dysarthria should be systematically studied.

Review of literature, suggests age related variations in dysarthria. One of the few extensive reviews of childhood dysarthria concluded that "definite similarities to adult dysarthria were not evident and that acquired childhood dysarthria requires its own classification" (Van Mourik et al., 1997). Additional support for this conclusion appeared in a study of children with cerebellar and brainstem tumors based on Mayo clinic classification (Van Mourik et al., 1998). As far as dysarthria is concerned, Mayo clinic classification is most widely used in order to classify according to the speech characteristics in both developmental and acquired variety. However, despite some general similarities in symptomatic factors, it is not clear that the developmental and adult forms reflect the same mechanism of impairment. Therefore, it may be unwise to impose clinical nosology for adults onto children. Disorders that affect speech motor learning in children may be fundamentally different from the disorders that disturb previously acquired speech motor skills in adults (Kent, 2000). Hence, the recent literature attests to an increasing awareness of the need for developmentally appropriate assessment and treatment tools. Since Mayo clinic classification has already been standardized in adult population and as mentioned above is most widely used clinically, this study uses the same to check for its applicability in the developmental group of dysarthrias with cerebral palsy.

METHODOLOGY

Aim:

Primary aim was to study the applicability of Mayo clinic perceptual classification system which is a classification system proposed by Darley, Aronson and Brown (1969a) for adult dysarthria, in perceptually classifying the speech dimensions of children with spastic and hyperkinetic (slow variety-athetoid) cerebral palsy between the age range of 8 to 16 years.

The secondary aim of the study was

i) to determine the perceptually deviant speech dimensions and their degree in the speech of children with spastic and athetoid cerebral palsy;

ii) to observe salient developmental changes in the speech characteristics of children with spastic and athetoid cerebral palsy below and above 12 years of age.

Subjects:

Twenty English speaking children with spastic cerebral palsy and ten English speaking children with athetoid cerebral palsy were selected in two groups, Group 1 and Group 2 respectively. The subjects were chosen from special schools; "Spastic Society of Karnataka", Bangalore; "Dada Amar

Society for Cerebral Palsied", Bangalore; "JSS Sahana", Mysore **and** from "All India Institute of Speech and Hearing," Mysore.

Age range:

Based on the review of studies on the development of speech motor control (Enguchi and Hirsch, 1969; Kent, 1976; Netsell, 1979; Robin and Klee, 1987; Edwards, 1992), it was hypothesized that adult like speech motor control is attained by 12 years of age. Hence, two groups of subjects, one consisting of children who were 4 years below 12 and other consisting of children who were 4 years above 12 years were considered for the study in both the Groups 1 and 2. In summary, the age of the subjects ranged from 8-16 years. The distribution of the subjects included in the study were as follows:

Table 1: Distribution of subjects.

Groups	Age groups	Age range in years	Number of subjects
Group 1	Group A	8-11.11	8
	Group B	12-16	12
Group 2	Group C	8-11.11	6
	Group D	12-16	4

Subject selection criteria:

a) Only subjects **with confirmed medical diagnosis** of **spastic and athetoid** cerebral palsy were included.

b) Those subjects assessed as having moderate to severe/profound mental retardation as an associated disorder were not included.

c) Only subjects with no exposure or maximum of two years or less exposure to speech therapy were considered for this study.

d) Subjects with significant hearing problem and/or visual problem were not included in the study.

e) Only subjects with verbal comprehension ability adequate for following the instructions and verbal expression ability of around *3-4*word phrases were included in the study.

Test procedure:

Test material:

The speech material used for the study was picture naming and narration.

Picture naming:

Around 30-40 pictures of functional objects were presented to the subjects and the subjects were instructed to name them one by one.

Narration:

Story narration or narration of their daily routines was elicited to obtain spontaneous speech sample.

Reading sample could not be obtained in this study, as all the children had not yet learned to read. This differed from Mayo clinic study which considered reading of a standard passage as the speech material.

Recording:

Test set up:

All the children in the study were seated comfortably in a chair in a silent room, away from noise. Audio recordings were done individually for each child with only the investigator and the child in the room, in order to avoid any distractions during recording. The pictures were placed in front of the child on a table such that he/she could see the picture clearly.

Speech recording:

The speech samples were recorded in a single sitting for all subjects, on a Sony recordable minidisk (MDW-74), using a Sony portable minidisc digital tape recorder (MZ-R55) with a unidirectional microphone. The total time taken for the **recording** for each subject varied from 20-30 minutes approximately.

Data transfer:

The speech sample of the subjects excluding the investigator's sample and any other extraneous noise were transferred to another tape after randomizing the sample. These were further used for analysis in the study. Four subjects' sample (2 spastic and 2 athetoid) were recorded separately for the use in pilot study.

Perceptual analysis:

The Mayo clinic classification system given by Darley, Aronson and Brown (1969a) was used in this study for describing the speech dimensions of children with spastic and athetoid cerebral palsy. This system consisted of 38 dimensions. For statistical purpose, these dimensions were grouped into seven domains in this study [pitch, loudness, voice quality (laryngeal + resonatory dimensions), respiration, articulation and overall dimensions which includes **intelligibility** and bizarreness]. The domains were also **adopted** from the earlier system except for the dimension voice tremor which was included in the domain voice quality rather than in pitch domain. This was done considering that loudness fluctuations also contributed to perception of voice tremors. A key note as suggested in the original study of Darley, Aronson and Brown (1969a) with the descriptions of all the dimensions and the classified domains are given in the Appendix A.

A 5-point equal appearing intervals scale (0 - normal; 1 - mild abnormality; 2 - moderate abnormality; 3 - severe abnormality and 4 - profound abnormality) was used in this study as compared to the 7-point rating scale used in the study of Mayo clinic (0 — normal to 7 — severe deviation from normal). This was done to facilitate ease of perceptual judgements. It was ensured that it would not affect our results because the presence of a deviant speech characteristics is generally more important to differentially diagnose than its severity (Duffy, 1995).

Selection of judges.

Three qualified speech language pathologists who had a minimum of 5 years of experience with motor speech disorders were considered as judges for the study (Judges 1, 2 and 3). The judges were requested to listen to the speech sample of each subject and were asked to rate the sample one by one on a 5-point rating scale for all the 38 dimensions used in the study on a response sheet (Appendix B). On the contrary, in Mayo clinic study, the judges rated a single dimension of all the subjects at a time. The judges of this study were blind to the subject details except for knowledge of age and sex of the children, as they had to perceptually evaluate the pitch dimensions. The judges were allowed to listen to the sample any number of times until they were satisfied with their ratings. They were also given the keynote for reference during judgement (Appendix A).

Pilot study:

In order to familiarize the judges to the 38 dimensions and to ensure good reliability between and within the judges, a pilot study was carried out. This was done prior to the judgement of the actual test sample. The speech sample of four subjects which were recorded separately was used for the pilot study. All the three judges listened to the speech sample together. The judges mutually discussed the criteria in order to arrive at a consensus of the rating on each of the 38 speech dimensions.

Perceptual analysis of the test sample:

After the pilot study, perceptual analysis of the test sample was undertaken. Here, the judges perceptually analyzed the test speech sample. The test environment and criteria used for judgement was the same as in pilot study. To determine the stability of the ratings, the speech sample of all the subjects were rated twice by the judges on all the speech dimensions. The second analysis was carried out by all the three judges two weeks after the first evaluation. All the judgements were made in a single sitting, each sitting lasting for approximately 4-5 hours. All the judgements were carried out in a single room individually without mutual consultation by each of the judges.

Statistical analysis and result compilation:

A] Analysis of perceptual judgement:

The intrajudge and interjudge reliability were measured using Pearson's product-moment correlation irrespective of the type of cerebral palsy for each of the domains of the classification system.

The raw date of all the judges were fed to the computer and the software program SPSS (Statistical Presentation System Software - Windows version 10) was used for further statistical analysis. Even though the reliability measures were good, the mean scores of all the six judgements (first and second judgement by three judges) in total were considered for further analysis in order to infer the stability of judgements.

Master score sheets were formulated by taking the mean of the ratings of six judgements for each subject on all 38 parameters. This was done separately for children with spastic and athetoid cerebral palsy depending on their age and subgroups considered in this study.

Once the master sheets were formulated, means for each dimensions and their ranks were computed for the Groups 1 and 2 as a whole and also for the subgroups (A, B, C and D) considered. This was done in order to determine the most deviant dimensions seen in each of the groups and subgroups considered. Further, correlation coefficients using Pearson's product-moment correlation were determined for each of the dimensions with the two overall dimensions (intelligibility and bizarreness). This was carried out in order to check for the dimensions which contributed maximally towards intelligibility and bizarreness in the perceptual judgements of the speech of cerebral palsied in Groups 1 and 2.

These results are tabulated and discussed in the subsequent chapter under the following sections:

B] Spastic cerebral palsy

1. Speech characteristics
2. Comparison with adult data (Darley, Aronson and Brown, 1969a).
3. Developmental changes
4. Correlation with overall dimensions.

C] Athetoid cerebral palsy

1. Speech characteristics
2. Comparison with adult data (Darley, Aronson and Brown, 1969a).
3. Developmental changes
4. Correlation with overall dimensions.

D] Comparison of spastic vs. athetoid speech

E] Summary

RESULTS AND DISCUSSION

Review of literature on the comparative characteristics of adults and childhood dysarthrics reveal that contradictions do exist regarding the use of an adult assessment system for developmental dysarthria (Lencione, 1968; Stark, 1985; Van Mourik et al., 1997 and 1998). To be specific, Mayo clinic perceptual classification system which was originally developed for adult dysarthrics (Darley et al., 1969a) has been widely used to classify children with cerebral palsy also. Adoption of the adult classification system to children has been carried out as a clinical routine without substantial scientific evidence. Hence, this study was taken up to examine the applicability of the above mentioned system in classifying the children with spastic and athetoid cerebral palsy.

Aim:

- To determine the perceptually deviant features in each of the two types of cerebral palsy i.e., spastics and athetoids.
- To check for the dimensions which contribute maximally towards the perception of intelligibility and bizarreness in both the groups.
- To study, the developmental changes in both the groups, if any.

The results of the study are presented under the following sections:

A] Analysis of perceptual judgements

B] Spastic cerebral palsy:

1. Speech characteristics.
2. Comparison with adult data (Darley, Aronson and Brown, 1969a).
3. Developmental changes.
4. Correlation with overall dimensions.

C] Athetoid cerebral palsy:

1. Speech characteristics.
2. Comparison with adult data (Darley, Aronson and Brown, 1969a).
3. Developmental changes.
4. Correlation with overall dimensions.

D] Comparison of spastic vs. athetoid speech.

E] Summary.

A] Analysis of perceptual judgement

The intrajudge and interjudge reliability of each of the judgements were calculated using Pearson's product-moment correlation. For statistical purposes, all the 38 parameters were divided into seven domains (Appendix

B) and the correlation coefficients for each of the judgement conditions were computed for all the seven domains.

The intrajudge reliability measures obtained for all the three judges (Judgesl, 2 and 3) are presented in Table 2. The results from Table 2 reveal that reliability is high for voice quality domain (which includes laryngeal and resonatory dimensions) compared to the other domains. It may also be seen from the Table 2 that the correlation coefficients for the interjudge reliability, was poorer for pitch domain followed by loudness domain. This indicates poor reliability in judges ratings for these two domains.

Table 2: Correlation coefficients (r) for intrajudge reliability across the domains.

Judges	Pitch	Loudness	Voice quality	Respi-ration	Prosody	Articu-lation	Overall
1	0.48	0.50	0.82	0.72	0.62	0.76	0.74
2	0.64	0.69	0.87	0.81	0.82	0.67	0.74
3	0.47	0.71	0.89	0.88	0.86	0.61	0.79

Table 3 depicts the values of correlation coefficient between all the three judges (Judges 1, 2 and 3) during first evaluation (a) and second evaluation (b)

Table 3: Correlation coefficients (r) for interjudge reliability across the domains.

Judgement conditions	Pitch	Loudness	Voice quality	Respi-ration	Prosody	Articu-lation	Overall
la vs2a	0.38	0.68	0.81	0.80	0.61	0.50	0.76
2a vs 3a	0.36	0.55	0.81	0.81	0.69	0.62	0.76
la vs 3a	0.60	0.54	0.79	0.89	0.77	0.75	0.79
Ibvs2b	0.67	0.40	0.73	0.73	0.66	0.61	0.64
2bvs3b	0.72	0.45	0.73	0.78	0.70	0.60	0.67
lb vs 3b	0.31	0.57	0.69	0.70	0.76	0.60	0.75

Similar to the intrajudge reliability measures, interjudge reliability between all the three judges for both the evaluations (first and second) is computed. On an average, it is found that reliability scores or correlation coefficients have been higher for respiratory domain followed by voice quality domain as seen in intrajudge reliability measure. Similar to the intrajudge reliability measures, the poor correlation coefficients are obtained for pitch domain followed by loudness domain. This also suggests that high variability is seen for pitch related and loudness related dimensions between judges.

From results in Table 3, it is seen that the reliability scores are low for most of the conditions for second evaluation when compared to the first evaluation. This may be explained due to the carry over effect of the pilot study over the first evaluation. The pilot study carried out before the first evaluation probably help the judges to set up a mental criterion which was clearly defined and quantified and this in turn helped in better reliability scores for the first evaluation. This is in agreement with a similar effect reported by Duffy (1995) in his study.

The higher reliability scores for the dimensions of voice quality, respiration and overall dimensions (intelligibility and bizarreness) suggests that these were either normal or grossly deviant in the speech samples which enabled the judges to rate them more reliably. The inherent characteristic variations of pitch and loudness dimensions, would have probably contributed to the poor reliability in the perceptual judgement of these two domains. The study by Zyski and Weisiger (1987) also report poor overall reliability in the perceptual judgements of speech dimensions (approximately 0.56). They also state that greater the number of speech domains included for judgement, poorer will be the reliability scores. They propose that reliability improves if the judges have to rate only the most deviant speech dimensions of a given disorder. Selection of 38 dimensions in this study may also be considered to be more and in this sense could have hindered the judgement.

Comparison with the reliability reports of Darley, Aronson and Brown (1969a):

The intrajudge and interjudge reliability scores reported by Darley et al. (1969a) in their study was approximately 0.80 to 0.95 for all the selected speech dimensions. In this study, the intrajudge reliability scores ranged from

0.47 to 0.89 across the domains and interjudge reliability ranged from 0.31 to 0.89 across the domains. As already stated the lower reliability scores were basically for the domains pitch and loudness. The differences in this study when compared to Darley et al. (1969a) can be attributed to the following reasons:

1) Darley et al. (1969a) collected speech samples from a reading task whereas in the current study elicited speech samples were obtained from children. It *is* a well known fact that in elicited speech samples continuity of speech is limited when compared to that of reading sample. This could have probably led to poor reliability judgements in this study compared to that of Darley etal. (1969a).

2) It is not clear from the results reported by Darley et al. (1969a) as to the reliability for speech dimension in specific domains. In this study, attempt is made to check the reliability for each domain was established. This difference in reliability measure between the two studies is not comparable and hence it would be difficult to infer that the reliability scores in this study are poorer than the study by Darley et al. (1969a).

3) The judges in the study by Darley et al. (1969a) had the knowledge of the diagnostic category of the speech samples which they rated. In contrast, in

this study the judges were blind to the diagnosis or any other personal demographic data of children being rated except for age and sex. According to Simmons and Mayo (1997), knowledge of the diagnostic category of the speech samples by the judges has a definite positive effect on the clinical rating of the patients' speech. Lack of such knowledge by judges in this study probably contributed to the poor reliability in judgement.

4) The subject group in the study by Darley et al. (1969a) were only adults with well identified focal lesions or specific pathologies. In contrast, the subject group of this study included cerebral palsied children where lesion is known to be nonfocal and the pathology is limited to spasticity and athetosis. It is well identified that the mixed diagnosis, complicating medical factors and coexisting language disorders have an adverse effect on judgement tasks (Simmons and Mayo, 1997). In the cerebral palsied children of this study, the implications of an inherent diffused lesion presumed to be characteristic of the disorder may have influenced the judgement of speech samples and this in turn, would have contributed to poor reliability scores.

5) In the study by Darley et al. (1969a), the judges were asked to rate a single dimension of all the subjects at a time, whereas in this study all the dimensions of a single subject were rated by the judges at a time. However, it may be noted that no restrain was imposed on the judges in listening to the sample as many times as possible.

Considering the above experimental conditions in mind, although the correlation coefficients are greater than 0.60 and are satisfactory, to comment on the stability of the measures, the mean of the six ratings (3 judges x 2 evaluation) was subjected to further statistical treatment. Computer Software Program, SPSS (Statistical Presentations System Software - Windows version 10) was used for further analysis. Mean ratings for all the dimensions of all the subjects were computed and master score sheets were prepared separately for children with spastic and athetoid cerebral palsy depending on their age distribution. Results of this analysis are tabulated and discussed in detail for children with spastic and athetoid cerebral palsy.

B] Spastic cerebral palsy

1) Speech characteristics:

This group included 20 children in the age range of 8-16 years (8 children in 8-11.11 years and 12 children in 12-16 years). The children were not classified based on the topography or severity of neuromuscular impairment. All children with speech disturbance were included in the study. Table 4 gives the details regarding the most deviant speech dimensions along with their mean value. Mean here is defined as the sum of the ratings on the master score sheet on one dimension divided by the number of subjects considered. Any dimension with a mean value of one and above are considered as most deviant. According to this criteria, all the speech dimensions greater than one are listed and rank ordered based on their mean values.

Table 4: Dimensions of speech judged most deviant in children with spastic cerebral palsy

Rank	Dimension	Mean
1	Short phrases	2.45
2	Imprecise consonants	1.88
3	Slow rate	1.58
4	Irregular articulatory breakdown	1.17
5	Strained-strangled voice	1.15
6	Reduced stress	1.08
7	Distorted vowels	1.04

The results in Table 4, show that based on order of rank, the three dimensions significantly contribute towards the perceptual judgement of spastic speech are short phrases, imprecise consonants and slow rate. It may also be noted here that, two of these dimensions i.e., short phrases and slow rate belong to the prosodic domain and imprecise consonants belong to articulatory domain. Besides these, there are other dimensions of these two domains that have occurred in the lower rank orders and they include irregular articulatory break down and distorted vowels as part of articulatory domain; reduced stress as part of prosodic domain and strained strangled voice as part of voice quality domain. In summary then, in spastic cerebral palsy, the dimensions of prosody and articulation are most deviant.

Hardy (1983) and Lencione (1968) observed that reduced respiratory reserve and subsequent lowered vital capacity are seen due to spasticity of abdominal and thoracic wall muscles, this they say, leads to shorter utterances in children with spastic cerebral palsy. The short phrases which is found to be dominent in spastics is further in consonance with the observation of Love (2000) who states that in children with spasticity, more air volume per syllable is utilized than in normal children. He further states that poor valving of the air stream results in a limited respiratory support for speech and short phrasing of utterance. This further explains the dimension of reduced/slow rate in these children (Boone, 1972; Darley et al., 1975).

The imprecise consonants and irregular articulatory breakdown noted in spastic children is in accord with various studies conducted on similar group by several investigators (Clement and Twitchell, 1959; Mc Donald and Chance, 1964; Boone, 1972; Chengappa, 1991; Mary, 1991). They reason that the spasticity of muscles, stiffness of peripheral speech musculature and inability to perform fine synchronous movements by tongue, lips, palate and jaw may result in articulatory deviations in speech.

The strained strangled voice can also be attributed to the laryngeal stenosis as a result of hypertonic vocal folds (Love, 2000). The alterations in prosody has been cited by several investigators (Boone, 1972; Darley et al., 1975; Hardy, 1983; Mary, 1991; Love and Webb, 1996). They attributed the same to hypertonicity, which reduces the range of movement of laryngeal muscles and articulatory musculature.

Though the dimensions related to pitch, loudness and resonance were found to be deviant in children with spastic cerebral palsy in several studies (Rutherford, 1944; Evans, 1947; Clement and Twitchell, 1959; Berry and Eisenson, 1962; Me Donald and Chance, 1964; Ingram, 1966; Hardy, 1983; Chengappa, 1991; Mary, 1991), these dimensions are not found to be deviant in this study. This may be because of the heterogeneity of the group considered i.e., in terms of topographical distribution. Ingram and Bam (1961) and Hardy (1983) reported such deviations only in hemiplegics or diplegics. Though Rutherford (1944); Boone (1972); Hardy (1983) have reported respiratory abnormalities, it was not observed to be true in this study. The absence of these, in this study may be reasoned to be due to reduced severity or due to poor representation of this feature in audio recording.

2) Comparison of results with adult data (Darley, Aronson and Brown, 1969a):

Differences are noticed between the most deviant dimensions obtained for spastic children in this study and that reported by Darley et al. (1969a) for acquired spastic dysarthrics. Apart from the dimensions seen in children, (Table 4) pitch related dimensions (monopitch, low pitch), monoloudness, hypernasality and harsh voice were reported in the adult group. The basic underlying difference in the site of lesion i.e., focal site of lesion in the adults and diffused lesion in children, may be considered as a reason for these differences observed. Further, the group considered in the study by Darley et al. (1969a) were of pseudobulbar palsy, whereas the underlying neurological lesion for the disorders of children considered in this study is not known. Because of this reason, Darley et al. (1975) themselves are of the opinion that the condition observed in spastic cerebral palsy in children are not directly analogous to those observed in adults with pseudobulbar palsy.

3) Developmental changes:

The most deviant dimensions are tabulated for younger and older age groups separately in order to study the developmental changes in Table 5a and Table 5b.

Table 5a: Dimensions of speech judged to be most deviant in children with spastic cerebral palsy in the age range of 8-11.11 years.

Rank	Dimension	Mean
1	Short phrases	2.56
2	Imprecise consonants	1.77
3	Slow rate	1.61
4	Strained-strangled voice	1.10
5	Irregular articulatory breakdown	1.02

Table 5b: Dimensions of speech judged to be most deviant in children with spastic cerebral palsy in the age range of 12-16 years.

Rank	Dimension	Mean
1	Short phrases	2.37
2	Imprecise consonants	1.96
3	Slow rate	1.56
4	Irregular articulatory breakdown	1.26
5	Reduced stress	1.24
6	Strained-strangled voice	1.18
7	Distorted vowels	1.11

From Tables 5a and 5b, it is seen that the first three most deviant dimensions in both the younger and older age groups are that of short phrases, imprecise consonants and slow rate of speech. It is also noticed that two of the dimensions i.e., reduced stress and distorted vowels are seen in older age group in addition to the dimensions seen in younger age group.

Darley et al. (1969a) also reported of these two dimensions (viz., reduced stress and distorted vowels) along with other speech dimensions in their adult group of spastic dysarthria. In this study, the older group (12-16 years) have exhibited the speech dimensions at least in part as those of adults reported in Darley et al. (1969). Identification of more dimensions as being deviant in the older age group compared to the younger age group probably suggest that either the judges were more confident in identifying the speech dimensions of older age groups, or speech dimensions of the older age group is more perceptible when compared to those of younger age group. Although it is too early to conclude based on the data available in this study, it may be presumed that there is a developmental trend in the perceptual identification of speech dimensions of younger and older spastic children, thus supporting indirectly the view proposed by Lencione (1968) and Stark (1985). Since the subjects were not grouped into discrete groups, but grossly classified as younger and older groups, it is not possible to explain the type of developmental changes that occurred in terms of speech dimensions. However, based on the data available, it may be presumed that there is a developmental trend and this needs to be probed further.

4) Correlation with overall dimensions:

Correlation coefficients were calculated between 36 dimensions of pitch, loudness, voice quality, respiration and articulation domains and the two overall dimensions (intelligibility and bizarreness) using Pearson's product-moment correlation. This was done, in order to infer the dimensions which contribute maximally for the perception of intelligibility and bizarreness. Since this consideration was exclusive of the developmental changes, children with spastic cerebral palsy were considered as a single group for this analysis.

Table 6 illustrates the dimensions which contribute for the perception of intelligibility and bizarreness in a hierarchy. One the dimensions which are of significance at 0.05 level or below are reported.

From Table 6, it is clear that many dimensions contribute for the perception of bizarreness compared to intelligibility. For the perception of intelligibility the most important dimensions are of articulation and prosody. In case of bizarreness along with the dimensions of articulation and prosody, voice quality dimensions also play a major role. Similar results were also reported by Darley et al. (1969a) for the group of adults with pseudobulbar palsy. This suggests that, though the most important deviations that describe the speech of adults and children with spasticity vary, the domains which contribute for the overall measures are similar in both the groups.

Table 6: Correlation between individual dimensions and two overall dimensions in Spastic Group

Intelligibility				Bizzarreness	
	Correlation	Significance		Correlation	Signficance
Dimensions	Coefficient	level	Dimensions	Coefficient	**level**
Imprecise consonants	0.900	0.000	rregular articulatory breakdown	0.854	0.000
Vowels distorted	0.828	0.000	Vowels distorted	0.844	0.000
Irregular articulatory breakdown	0.824	0.000	mprecise consonants	0.760	0.000
Reduced stress	0.723	0.000	Reduced stress	0.719	0.000
Inappropriate silences	0.630	0.003	Slow **rate**	0.709	0.000
Slow rate	0.613	0.004	Voice stoppages	0.699	0.001
Variable rate	0.606	0.005	Alternating loudness	0.675	0.001
Increase of rate in segments	0.599	0.005	Variable rate	0.667	0.001
Nasal emission	0.593	0.006	ncrease of rate in segments	0.612	0.004
Hypemasality	0.552	0.012	Excess and equal stress	0.599	0.005
Increase of rate overall	0.516	0.020	Short rushes of speech	0.597	0.005
Loudness overall	0.508	0.022	Increase of rate overall	0.574	0.008
Monoloudness	0.504	0.024	Hoarse (wet) voice	0.573	0.008
Monopitch	0.475	0.034	Loudness (overall)	0.551	0.012
			Inappropriate silences	0.548	0.012
			Harsh voice	**0.547**	**0.012**
			Excess loudness variation	0.544	0.013
			Intervals prolonged	0.535	0.015
			Grunt at end of expiration	0.526	0.017
			Strained-strangled voice	0.525	0.017
			Nasal emission	0.507	0.022
			Breathy voice (transient)	0.501	0.024
			Hypemasality	0.476	0.034
			Forced inspiration-expiration	0.465	0.039

Based on the statistical measures, Darley et al. (1969a) have reported only around seven most contributing dimensions for the intelligibility and around 11 dimensions for bizarreness. But, in this study, it is seen that there are more number of dimensions contributing to both the overall dimensions. This may be due to the severity of involvement of most of the speech subsystems in children. Hence, almost all the dimensions seem to contribute for the perception of these overall dimensions. This suggests that, clinicians should consider dimensions of all domains prior to perceptually evaluating intelligibility and bizarreness in children with spastic cerebral palsy.

C] Athetoid cerebral palsy

1) Speech characteristics:

This group consisted of children of whom six belonged to the younger age group (8-11.11 years) and four belonged to older age group (12-16 years). All the children who were included for the study were children with athetoid quadriplegia. The children exhibited characteristic involuntary movements and speech deviations. The speech characteristics are hypothesized to be similar to the adults of hyperkinetic slow variety in Mayo clinic study. Table 7 shows the most deviant dimensions of this group and their mean values.

Table 7: Dimensions of speech judged most deviant in children with athetoid cerebral palsy.

Rank	Dimensions	Mean
1	Short phrases	2.25
2	Imprecise consonants	1.95
3	Slow rate	1.50
4	Strained-strangled voice	1.45
5	Irregular articulatory breakdown	1.30
6	Distorted vowels	1.15
7	Prolonged intervals	1.12
8	Reduced stress	1.10
9	Prolonged phonemes	1.03

From Table 7, it can be delineated that in a hierarchy of rank order, short phrases, imprecise consonants and slow rate are the most deviant dimensions. It is also seen that strained-strangled voice which is the only dimension of voice quality domain along with irregular articulatory breakdown and distorted vowels of articulatory domain are also present. Besides these there are other dimensions of prosody (viz., prolonged intervals; reduced stress) and articulation (prolonged phonemes) which are ranked lower in the hierarchy. It is also seen that, though slow rate is a deviant dimension, two out of ten subjects are consistently rated to be fast by two of the judges. The sample size being very small, the feature of speech tempo may be inconsistent/idiosyncratic.

The uncontrolled and involuntary movements of speech musculature are usually quoted as the reason for deviant articulatory dimensions (Clement and Twitchell, 1959; Mc Donald and Chance, 1964; Boone, 1972; Chengappa, 1991; Mary, 1991; Love and Webb, 1996). The prosodic disturbance seen are also in accord to the results of Rutherford (1994); Chengappa (1991) and Mary (1991). Similar to the observations made in this study, Farmer (1972) and Mary (1991) also report the feature of prolonged phonemes in children with athetoid cerebral palsy. Westlake and Rutherford (1961) attributed short phrases which is found to be most deviant in this study also, to the respiratory errors. They opined that the respiratory abnormalities would result in reduction of the volume in the rib cage and thus the quality of inhaled air would be affected and hence lead to short phrases.

The single phonatory feature i.e., the strained strangled voice (also supported by Clement and Twitchell, 1959) can be attributed to spastic paralysis of the laryngeal system in congenital athetosis (Love and Webb, 1996). This further supports the fact of diffuse lesion wherein the involvement of both pyramidal and extrapyramidal systems are seen that results in mixed characteristics unlike in adults (Darley, Aronson and Brown, 1975).

It is noticed from Table 7 that dimensions of the domains of pitch, loudness, respiration and voice quality except for strained-strangled voice are not affected in children with athetoid cerebral palsy. This is in disagreement with several reports by Rutherford (1944); Blumberg (1955); Clement and Twitchell (1959); Kent and Netsell (1978); Hardy (1983), and Brown (1984). Though the reason for the differences cannot be clearly identified, it can be attributed to the small sample size, poor reliability in pitch and loudness related dimensions and also to the absence of visual cues for the ratings of respiratory dimensions.

2) Comparison of the results with adult data (Darley, Aronson and Brown, 1969a):

Certain differences are seen between the results of this study and that of Mayo clinic study. The major differences seen are the absence of dimensions related to pitch, loudness and voice quality (harsh voice and voice stoppages). The major deviations such as articulatory dimensions and prosodic dimensions are consistent in both the studies, especially the features of prolonged phonemes and prolonged intervals. The strained-strangled voice seen in children is also supported by Dworkin (1991). The minimal difference between the two neurological groups (athetoids in children and dystonia in adults) may in itself be the contributing factor for the differences seen. But, as both the conditions reflect a hyperkinetic (slow) type of disorder and the underlying pathology being in the nervous system, certain similarities in the dimensions are seen. These reasons may be cited to explain the articulatory and prosodic deviations which are seen due to any neuromuscular breakdown (Me Donald and Chance, 1964; Darley, Aronson and Brown, 1969a).

3) Developmental changes:

The most deviant dimensions are tabulated for younger and older age groups separately in order to study the developmental changes in Table 8a and 8b.

Table 8a: Dimensions of speech judged to be most deviant in children with athetoid cerebral palsy in the age range of 8-11.11 years

Rank	Dimensions	Mean
1	Short phrases	2.11
2	Imprecise consonants	1.81
3	Strained-strangled voice	1.56
4	Slow rate	1.42
5	Reduced stress	1.31
6	Irregular articulatory breakdown	1.28
7	Audible respiration	1.08
8	Forced inspiration-expiration	1.06
9	Distorted vowels	1.00

Table 8b: Dimensions of speech judged to be most deviant in children with athetoid cerebral palsy in the age range of 12-16 years

Rank	Dimensions	Mean
1	Short phrases	2.46
2	Imprecise consonants	2.17
3	Slow rate	1.63
4	Distorted vowels	1.37
5	Prolonged intervals	1.33
5	Prolonged phonemes	1.33
5	Irregular articulatory breakdown	1.33
6	Strained-stranded voice	1.29
7	Excess and equal stress	1.00

From Tables 8a and 8b. it is seen that in both the younger and older age groups, short phrases and imprecise articulation are the most deviant dimensions in the first two positions. The other deviations seen clearly differentiates the two age groups. Apart from the strained-strangled voice, slow rate, irregular articulatory breakdown and distorted vowels, certain dimensions are seen to be specific in each group. From Table 8a it is seen that reduced stress (prosodic domain), audible inspiration and forced inspiration-expiration (respiratory domain) are characteristic of the younger age group considered (8-11.11 years). The dimensions, prolonged intervals, prolonged phonemes, and excess and equal stress seem to be characteristic of the older age group (12-16 years). Comparing with the study by Darley et al. (1969a), it is seen that in particular, prolonged intervals and prolonged phonemes seen in older age group are also seen in dystonia in adults. The most characteristic dimensions in older age group (prolonged of phonemes, prolonged intervals and excess and equal stress) would not have been evident in younger age group due to the speech material that was used in this study. All children in the group were not very fluent in sentence level and hence the short phrases and absence of continuous speech would have resulted in not identifying the above mentioned dimensions in the younger age group (8-11.11 years). Caution needs to be imposed in the conclusions of these results as the number of subjects in younger and older age groups with athetoid cerebral palsy were unequal and less in number.

4) Correlation with overall dimensions:

In order to determine the features that contribute for the perception of intelligibility and bizarreness, correlation coefficients were computed between rest of the 36 dimensions and the two overall dimensions. Table 9 illustrates these dimensions which are listed in a hierarchy along with their significant levels.

Table 9: Correlation between individual dimensions and two overall dimensions in Athetoid Group

Intelligibility			Bizzarreness		
Dimensions	Correlation Coefficient	Signficance level	Dimensions	Correlation Coefficient	Signficance level
Vowels distorted	0.975	0.000	Strained-strangled voice	0.940	0.000
Imprecise consonants	0.965	0.000	Irregular articulatory breakdown	0.935	0.000
Irregular articulatory breakdown	0.953	0.000	Variable rate	0.925	0.000
Variable rate	0.902	0.000	Vowels distorted	0.888	0.001
Excess & equal stress	0.863	0.001	Short rushes of speech	0.879	0.001
Strained-strangled voiced	0.844	0.002	Imprecise consonants	0.875	0.001
Audible inspiration	0.841	0.002	Inappropriate silences	0.850	0.002
Inappropriate silences	0.824	0.003	Grunt at end of expiration	0.845	0.002
Grunt at end of expiration	0.823	0.003	Increase of rate overall	0.838	0.002
Forced inspiration-expiration	0.806	0.005	Audible inspiration	0.835	0.003
Intervals prolonged	0.801	0.005	Excess and equal stress	0.835	0.003
Hoarse (wet) voice	0.798	0.006	Forced inspiration-expiration	0.833	0.003
Slow rate	0.787	0.007	Increase of rate in segments	0.823	0.003
Short rushes of speech	0.779	0.008	Hoarse (wet) voice	0.792	0.006
Increase in rate overall	0.766	0.010	Excess loudness variation	0.787	0.007
Reduced stress	0.765	0.010	Reduced stress	0.778	0.008
Pitch level	0.760	0.011	Loudness decay	0.774	0.009
Increase of rate in segments	0.744	0.014	Alternating loudness	0.772	0.009
Loudness decay	0.743	0.014	Breathy voice (transient)	0.770	0.009
Voice stoppages	0.722	0.018	Voice stoppages	0.766	0.010
Prolonged phonemes	0.718	0.019	Voice tremor	0.744	0.014
Excess loudness variation	0.707	0.022	Loudness (overall)	0.738	0.015
Pitch level	0.706	0.022	Slow rate	0.713	0.021
Short phrases	0.705	0.023	Breathy voice consonants	0.713	0.021
Loudness (overall)	0.687	0.028	Pitch breaks	0.708	0.022
Breathiness (transient)	0.687	0.028	Prolonged intervals	0.707	0.022
Breathy voice (continuous)	0.665	0.036	Monopitch	0.679	0.031
Monopitch	0.659	0.038	Harsh voice	0.678	0.031
Harsh voice	0.652	0.041	Pitch level	0.658	0.038
Alternating loudness	0.636	0.048	Prolonged phonemes	0.657	0.039
			Short phrases	0.652	0.041

It is seen that almost all the dimensions which are selected for the study contributed for the overall dimensions of intelligibility and bizarreness in children unlike in adults (Darley et al., 1969a). Variations in the subjects may itself be attributed for the differences noticed. Consistent with the results of spastics, it is seen that almost all the dimensions contribute for the perception of overall dimensions. The reasons for the lack of deviations in pitch and loudness domains in this group can be attributed to the variability which is inherent in the dimensions of pitch and loudness of children noticed even in normal population.

D] Comparison of spastic vs. atbetoid speech

Though it was not in the purview of this study to compare between spastics and athetoids, based on the incidental findings, results are reported. Comparing the Tables 4 and 7 and Figure 1, it is seen that all the dimensions which are deviant in spastics are also found to be deviant in athetoids (short phrases, imprecise consonants, slow rate, irregular articulatory breakdown, strained-strangled voice, reduced stress and distorted vowels). This is in accord with several studies by Tikofsky and Tikofsky (1964); Mc Donald and Chance (1964); Lencione (1968); Boone (1972); Clement and Twitchell (1959) and Hardy (1961). Apart from these dimensions, it is also noticed that the dimensions such as prolonged intervals and prolonged phonemes are exclusively seen in athetoid children (Fanner, 1980).

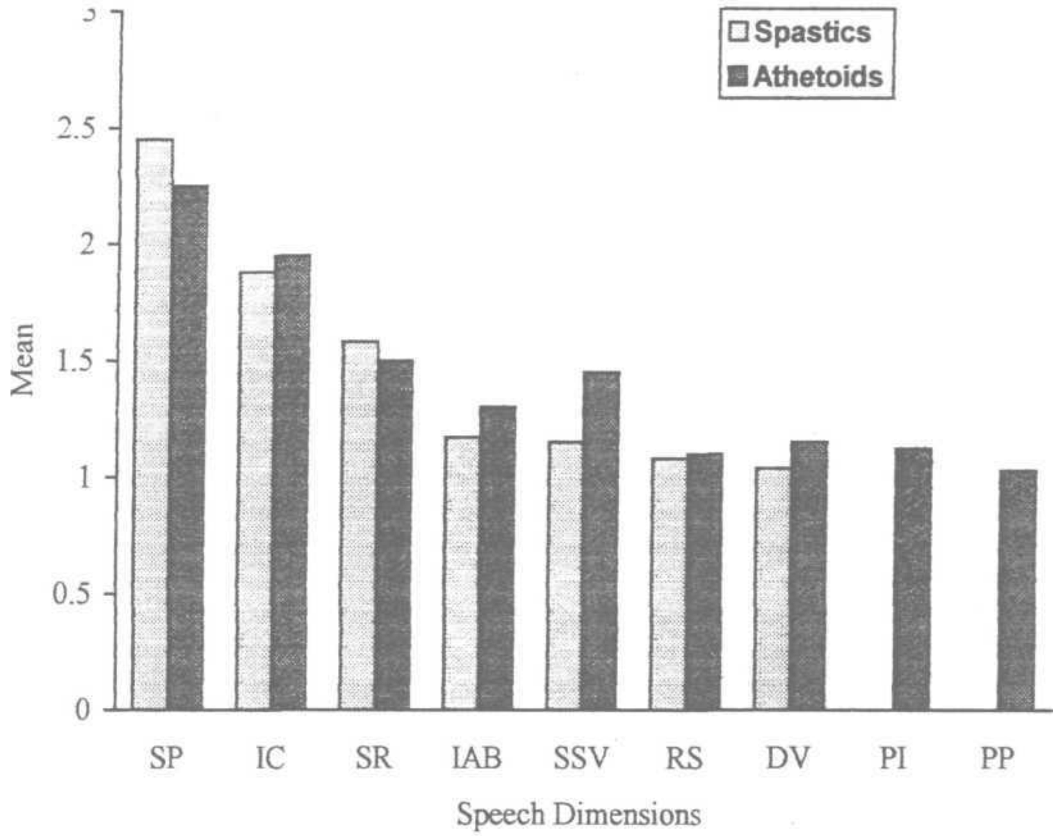

Figure 1: Deviant speech dimensions in spastic and athetoid cerebral palsy.

[SP=Short phrases, IC=Imprecise consonants, SR=Slow rate, IAB=Irregular articulatory breakdown, SSV=Strained-strangled voice, RS=Reduced stress, DV=Distorted vowels, PI=Prolonged intervals, PP=Prolonged phonemes]

Comparing this with that of Darley et al. (1969a), it is evident that major differences between these studies are in terms of pitch, loudness, resonatory and certain voice quality dimensions. Darley et al. (1969a) reported low pitch, Hypemasality, pitch breaks, breathy voice (continuous) and excess and equal stress to be characteristic of pseudobulbar palsy, whereas, irregular articulatory breakdown, inappropriate silences, prolonged intervals, prolonged phonemes, excess loudness variations and voice stoppages to be characteristic of dystonia. They also reported other common dimensions such as the dimensions of pitch (monopitch); loudness (mono- loudness); voice quality (harsh voice, strained-strangled voice; articulation (imprecise consonants, distorted vowels) and prosody (short phrases, reduced stress and slow rate) in both the groups. The absence of deviation in respiratory dimensions in Tables 4 and 7 are concurrent with the reports of Darley et al. (1969a). Low reliability scores for pitch and loudness domains restrict the scope of discussion of these dimensions in the study. Even though, respiratory abnormalities are not statistically significant, subjectively it was felt by the investigator that the respirator)' abnormalities did contribute considerably in the differentiation of the two groups (spastics vs. athetoid).

The other prominent observation of this study is that the deviations in respiratory domains are exclusively seen only in the younger group of athetoid children (8-11.11 years). The deviations are represented as audible inspirations and forced inspiration expiration. Presence of respiratory deviations are supported by the studies of Rutherford (1944); Palmer

(1952); Achilles (1955); Clement and Twitchell (1959); Mc Donald and Chance (1964); Lencione (1968). The absence of these in older age group may be attributed to the maturational changes in the respiratory subsystem that would have resulted in the regulation of the respiration during speech (Lencione, 1968; Stark, 1985).

The temporal dimensions of prolonged intervals and prolonged phonemes are exclusively seen only in case of older athetoid group (12-16 years). These results are supportive of the view by Farmer (1980) who suggests that athetoids may require more time to coordinate vocal tract gesture, particularly to build up adequate oral pressure for voiceless stops. The presence of prolonged intervals and prolonged phonemes are also reported by Darley et al. (1969a) in their adult group of hyperkinetic dysarthria. This may lead to hypothesize that the deviant dimensions of older age group of children correlate more with adult's speech as reported by Darley etal. (1969a).

This may also imply that these deviant dimensions may be of importance while considering the diagnostic or therapeutic intervention for older athetoid children. In both the groups studied, the absence of resonatory dimensions as being deviant in children may be because of the masking effect of other most deviant dimensions such as imprecise articulation slow rate and short phrases along with a few other dimensions. This is supported by the results presented in Tables 6 and 9 which depicts the dimensions contributing to the perception of intelligibility and bizarreness. Thus, it can be concluded that only based on articulatory or prosodic dimensions, differentiation of the two groups (spastics and athetoids) will not be possible. Voice quality, resonatory and specific prosodic dimensions are differentiating features between the groups. The above aspects are in support of the studies by Meyer (1982), Workinger and Kent (1991).

E] **Summary**

From the analysis of the results, it is evident that children with cerebral palsy cannot be classified purely based on Mayo clinic classification system. As the speech dimensions in Mayo clinic classification system are clearly defined and grouped explicitly, it can still be used to describe the speech characteristics of children with cerebral palsy. Further, the perceptual analysis serves as one of the best noninvasive and possible clinical measure for evaluating dysarthrias, especially in children. Supporting the views of Van Mourik et al. (1997 and 1998) and Bak, Van Dongen and Arts (1983), it can be concluded from this study that, if Mayo clinic classification system is to be used in children with cerebral palsy, it needs to be standardized for this population. This attests to the need of an extensive study similar to Darley et al. (1969 a & b) in children with cerebral palsy grouped into smaller and discrete age groups.

SUMMARY AND CONCLUSIONS

Dysarthria has been defined as a speech disorder resulting from impairment to the neural mechanisms that regulate the movements of speech (Netsell, 1984). Two main categories seen in this disorder are the one in adults and the one seen in children during the developmental period. Developmental dysarthria is by far the most common of the motor speech disorders and is most frequently seen in children with cerebral palsy.

Cerebral palsy is simply the name given to the motor manifestations of nonprogressive brain damage sustained during the phase of active brain growth (Brown, 1984). The most challenging task for a speech language pathologist is to classify the type of dysarthria seen in these children with cerebral palsy, due to the diffuse lesion that results in myriad of several associated problems. These associated problems along with underlying language deficiency results in the use of classification systems based on the physiological pattern of the movement disorder (Denhoff and Robinault, 1960; Hardy, 1983; Erenberg, 1984). These classification systems are however debated by the studies, which discuss the correlation of limb movements and speech musculature (Abbs, Hunker and Barlow, 1983; Brown, 1984). Further, objective instrumental evaluation is not possible in children for many obvious reasons. Therefore, generally clinicians rely on subjective or perceptual analysis to assess the speech subsystems in these children (Darley, Aronson and Brown, 1975).

Due to lack of a comprehensive classification system for developmental dysarthrias, informally clinicians make use of Mayo clinic classification system proposed by Darley, Aronson and Brown (1969 a & b-and 1975) for adult dysarthrias. But, review of literature on the studies of developmental speech motor control (Euguchi and Hirsch, 1969, Netsell, 1979; Smith and Goffman, 1998), cerebral palsy (Lencione, 1968; Stark, 1985; Darley, Aronson and Brown, 1975) and acquired childhood dysarthria (Bak, Van Dongen and Arts, 1983; Van Mourik et al., 1997 and 1998) raises many questions regarding the applicability of Mayo clinic classification system in cases of developmental dysarthria. The present study pursues this question and attempts to check for the applicability of Mayo clinic classification system.

The aim of the study was to check for the applicability of Mayo clinic classification system in children with cerebral palsy. The study comprised of 30 children with spastic (20) and athetoid (10) cerebral palsy. Speech samples (picture naming and narration) were recorded from all the children individually in a silent room using a Sony minidisk digital tape recorder (MZ-R55). Three experienced judges were selected for the perceptual evaluation. They were made to rate the 38 speech dimensions of Mayo clinic classification system using a 5-point equal appearing interval scale on a response sheet. The judgements were made by all the three judges twice in order to calculate the intrajudge reliability. Prior to this evaluation, a pilot study was carried out in order to familiarize the judges with perceptual evaluation. The results of this study indicate the following:

A] Analysis of perceptual judgements:

The intrajudge and interjudge reliability varied from 0.31 to 0.89 across the domains for all the three judges. The dimensions related to pitch and loudness domain are found to have poor reliability, whereas the domains voice quality and respiration are found to have high reliability. The difference between the reliability scores compared to Darley et al. (1969a) study was discussed and attributed to various methodological differences between the studies.

B] Spastic cerebral palsy:

In children with spastic cerebral palsy dimensions of articulation and prosody are found to be most deviant along with strained-strangled voice which belongs to voice quality domain. In general, though these studies correlate with the reports of several investigators (Rutherford, 1944; Clement and Twitchell, 1959; Berry and Eisenson, 1962; Lencione, 1968; Hardy, 1983; Chengappa, 1991) it is seen that compared to reports of the study on adults by Darley et al. (1969a), certain differences are noticed. The major differences are related to pitch, loudness and resonatory dimensions. The poor reliability scores during the perceptual judgement for pitch and loudness dimensions may be attributed to the inherent variations in these dimensions seen in individuals and diffuse nature of the disorder in the subjects of the study as against those of Darley, Aronson and Brown (1969a). Subgrouping the children further into younger (8-11.11 years) and older (12-16 years) age groups, it is seen that short phrases, imprecise consonants and slow rate of speech is common in both the groups. Similar to the observation by Darley et al. (1969a), the reduced stress and distorted vowels are seen in older age group of children. This study also supports the developmental trend in case of spastic cerebral palsy similar to Lencione (1968) and Stark (1985).

The dimensions considered under the domain of articulation and prosody contributes for the perception of intelligibility whereas, voice quality along with articulatory and prosodic dimension contributes for bizarreness. Compared to the study by Darley et al. (1969a), it is seen that more number of dimensions plays a critical role in the perception of overall (intelligibility and bizarreness) dimensions. This suggests the involvement of most of the speech subsystems in children.

C] Athetoid cerebral palsy:

Short phrases, imprecise consonants and slow rate are the most deviant dimensions of this group. Strained-strangled voice is also seen along with other articulatory dimensions (irregular articulatory breakdown, distorted vowels and prolonged phonemes) and prosodic dimensions (prolonged intervals and reduced stress). Although these findings support the results of various investigators (Rutherford, 1944, Clement and Twitchell, 1959; Farmer, 1980; Chengapa, 1991), they differ from the reports of Darley et al. (1969a) in dystonia in adults. Here again, the differences are seen in terms of pitch, loudness and voice quality (harsh voice and voice stoppages) domains. The observed differences may in part be attributed to the difference in the pathologies in athetoid and dystonia. The developmental differences, comparing the subgroups (8-11.11 years vs. 12-16 years) revealed that the dimensions of respiratory domain (audible inspiration and forced inspiration-expiration) were exclusively seen in younger age group (8-11.11 years). The older age group (12-16 years) exhibited prolonged phonemes and prolonged intervals which was in part comparable to the adult data by Darley et al. (1969a). The number of dimensions contributing to the perception of intelligibility and bizarreness suggests that clinicians should carefully interpret the results on intelligibility in athetoid children considering all the dimensions of speech without excluding any.

D] Comparison of spastic vs. athetoid speech:

With the limitation of reduced number of subjects, the data was compared between the two groups considered (spastic vs. athetoid). It is seen that though several dimensions overlap between both the groups (short phrases, imprecise consonants, slow rate, irregular articulatory breakdown, strained-strangled voice, reduced stress and distorted vowels), the presence of prolonged intervals and prolonged phonemes in athetoids differentiates this group from spastics. The results of this study also reveal the fact that, clinicians should not consider just the articulatory dimensions in order to differentiate between spastics and athetoids, but dimensions of other domains also need to be considered.

Considering the results obtained and comparing with that of Darley et al. (1969a), it is concluded that the applicability of Mayo clinic classification system to children with cerebral palsy (spastic and athetoid) is limited. But, considering the various advantages of perceptual evaluation in dysarthria in general (Moll, 1964; Netsell, 1984 and Mc Neil, 1986) and that of Mayo clinic classification system (Darley et al., 1969 a & b), it can still be exploited to describe the speech characteristics of children with cerebral palsy. Though this study shows some developmental trend especially in athetoid children, further studies are required to establish perceivable age related changes in children with cerebral palsy. The study enlists the perceptually deviant speech dimensions which in turn would help determine the underlying physiological aspects involved in spastics and athetoids and thus aid in planning the intervention goals.

Recommendations for future research:

* A similar study could be carried out including all the types of cerebral palsy on a large sample of subjects.
* Delineation of developmental changes can be attempted through a cross sectional or a longitudinal study on one or more types of cerebral palsy, taking smaller age groups of children.

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APPENDIX A

***Keynote:* Description of the speech dimensions considered**

{Borrowed from: Brown, F.L., Aronson, A.E., and Brown, J.R (1969a). Differential diagnostic patterns of dysarthria. Journal of Speech and Hearing Research, 12,246-269)

No.	**Dimensions**	**Description**
1	Pitch level	Pitch of voice sounds consistently too low or too high for individual's age and sex.
2	Pitch breaks	Pitch of voice shows sudden and uncontrolled variation (falsetto breaks).
3	Monopitch	Voioe is characterized by a monopitch or monotone. Voice lacks normal pitch and inflectional changes. It tends to stay at one pitch level.
4	Voice tremor	Voice shows shakiness or tremulousness.
5	Monoloudness	Voice shows monotony of loudness. It lacks normal variations in loudness.
6	Excess loudness variation	Voice shows sudden, uncontrolled alteration in loudness, sometimes becoming too loud, sometimes too weak.
7	Loudness decav	There is progressive diminution or decay of loudness.
8	Alternating loudness	There are alternating changes in loudness.
9	Loudness (overall)	Voice is insufficiently or excessively loud.
10	Harsh Voice	Voice is harsh, rough and raspy.
11	Hoarse (wet) voice	Wet, 'liquid sounding' hoarseness.
12	Breathy Voice (continuous)	Continuously breathy, weak and thin.
13	Breathy voice (transient)	Breathiness is transient, periodic, intermittent

14	Strained-strangled voice	Voice (phonation) sounds strained or strangled (an apparently effortful squeezing of voice through glottis)
15	Voice stoppages	There are sudden stoppages of voiced air stream (as if some obstacle along vocal tract momentarily impedes flow of air).
16	Hypernasality	Voice sounds excessively nasal. Excessive amount of air is resonated by nasal cavities.
17	Hyponasality	Voice is denasal
18	Nasal emission	There is nasal emission of air stream
19	Forced inspiration-expiration	Speech is interrupted by sudden, forced inspiration and expiration sighs
20	Audible inspiration	Audible, breath}[7] inspiration
21	Grunt at end of expiration	Grunt at end of expiration
22	Rate	Rate of actual speech is abnormally slow or rapid.
23	Phrases short	Phrases are short (possibly due to fact that inspiration occur more often than normal). Speaker may sound as if he has run out of air. He may produce a gasp at the end of a phrase
24	Increase of rate in segments	Rate increases progressively within given segments of connected speech.
25	Reduced stress	Speech shows reduction of proper stress or emphasis patterns
27	Variable rate	Rate alternately changes from slow to fast.
28	Intervals prolonged	Prolongation of interword or intersyllable intervals.
29	Inappropriate silences	There are inappropriate silent intervals,

30	Excess and equal stress	Excess stress on usually unstressed parts of speech, e.g. (1) monosyllabic words and (2) unstressed syllables of polysyllabic words.
32	Imprecise consonants	Consonant sounds lack precision. They show slurring, inadequate sharpness, distortions, and lack of crispness. There is clumsiness in going from one consonant sound to another.
33	Phonemes prolonged	There are prolongations of phonemes
34	Phonemes repeated	There are repetitions of phonemes
35	Irregular articulatory breakdown	Intermittent nonsystematic breakdown in accuracy of articulation.
36	Vowels distorted	Vowels sounds are distorted throughout their total duration
37	Intelligibility (overall)	Rating of overall intelligibility or understandability of speech
38	Bizarreness (overall)	Rating of degree to which overall speech calls attention to itself because of its unusual, peculiar, or bizarre characteristics.

APPENDIX B

Sample of the response sheet used in the study for first ten subjects

Sl. No.		Speech Dimensions ↓ / Subjects →	1	2	3	4	5	6	7	8	9	10
1	Pitch	Pitch level										
2		Pitch breaks										
3		Monopitch										
4	Loudness	Monoloudness										
5		Excess loudness variation										
6		Loudness decay										
7		Alternating loudness										
8		Loudness (overall)										
9	Voice quality (laryngeal+ respiratory)	Voice tremor										
10		Harsh voice										
11		Hoarse (wet) voice										
12		Breathy voice (continuous)										
13		Breathy voice (transient)										
14		Strained-strangled voice										
15		Voice stoppages										
16		Hypernasality										
17		Hyponasality										
18		Nasal emission										
19	Respiration	Forced inspiration-expiration										
20		Audible inspiration										
21		Grunt at end of expiration										
22	Prosody	Rate										
23		Short phrases										
24		Increase of rate in segments										
25		Increase of rate overall										
26		Reduced stress										
27		Variable rate										
28		Prolonged intervals										
29		Inappropriate silences										
30		Short rushes of speech										
31		Excess and equal stress										
32	Articulation	Imprecise consonants										
33		Phonemes prolonged										
34		Repeated phonemes										
35		Irregular articulatory breakdown										
36		Distorted vowels										
37	Overall	Intelligibility										
38		Bizarreness										

Key: 0=Normal, 1=Mild abnormality, 2=Moderate abnormality
3=Severe abnormality, 4=Profound abnormality