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AN ABSTRACT OF THE THESIS OF Meredith Kathryn Van Bommel for the
Master of Science in Speech Communication presented May 19, 1977.

Title: Predicting Synergy of Movement for Speech from Feeding Assess-
ment or Diadochokinesis in Cerebral Palsied Children.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:

Robert L. Casteel, Chairman

Merry Meek

Robert H. English

Steve A. Brannan

The normal development of articulation is built upon the normal development of motor skills (Morris, 1970). Cerebral palsy is caused by brain damage and is characterized by neuromuscular incoordination. This interferes with normal development of motor skills. It also may interfere with normal development of speech if dysarthria is present. Because of these factors, the synergy of movement of the oral muscles used in feeding, in speech and in execution of diadochokinetic movements

of the oral muscles is affected.

The purpose of the study was to determine whether or not the performance of feeding skill movements or the performance of diadochokinesis of the oral muscles was significantly related to the synergy of movement for speech. The end purpose of the design was to determine whether or not articulatory proficiency in cerebral palsied children might be predicted from a feeding skills or diadochokinetic test.

The specific hypotheses tested were as follows:

1. In cerebral palsied children there would be a significant positive correlation between the raw score on a feeding skills test and the raw score on an articulation test of /p, b, m/.
2. In cerebral palsied children there would be a significant positive correlation between the diadochokinetic rate and the raw score on an articulation test of /p, b, m/.

The subjects were twenty cerebral palsied children between the ages of 4 to 8 years whose speech diagnosis was dysarthria. The subjects were administered a feeding skills test, a word and sentence articulation test and a diadochokinetic test of the oral muscles.

The findings indicated that feeding skills are significantly related to ability to articulate words and sentences and further, speech-related diadochokinetic movements of the oral muscles are related to synergy of movement for speech at a highly significant level. When breaking down the data into homogenous groups for comparison of scores by sex, age, diagnosis and intelligence, males and females did not differ significantly in mean scores and also, age was not a consistent factor in abilities across all tests, but age was a factor in the increase of non-speech related diadochokinetic movements. Diagnosis,

by topography, revealed higher mean scores on all tests at a significant level for spastic diplegics in comparison with spastic quadriplegics. A trend towards higher scores for all tests was noted among subjects with normal intelligence as contrasted with subjects who were mentally retarded or developmentally delayed.

PREDICTING SYNERGY OF MOVEMENT FOR SPEECH FROM
FEEDING ASSESSMENT OR DIADOCHOKINESIS
IN CEREBRAL PALSID CHILDREN

by

MEREDITH KATHRYN VAN BEMMEL

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN SPEECH COMMUNICATION:
with an emphasis in
SPEECH PATHOLOGY/AUDIOLOGY

Portland State University
1977

TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

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TABLE OF CONTENTS

	PAGE
ACKNOWLEDGMENTS	iii
LIST OF TABLES	vi
 CHAPTER	
I INTRODUCTION AND STATEMENT OF PURPOSE	1
Introduction	1
Statement of Purpose	5
Definitions	5
II REVIEW OF THE LITERATURE	8
Vegetative Processes and Speech	8
Diadochokinesis	10
III METHODS AND PROCEDURES	14
Methods	14
General Plan	
Subjects	
Measurement Instruments	
Procedures	18
Testing Articulation	
Testing Feeding Skills	
Statistical Analyses of Data	
IV RESULTS AND DISCUSSION	23
Results	23
Discussion	25

CHAPTER	PAGE
V SUMMARY AND IMPLICATIONS	32
Summary	32
Implications for Clinic and Future Research	33
SELECTED BIBLIOGRAPHY	35
APPENDICES	38
A FEEDING SKILLS TEST FOR CEREBRAL PALSIED CHILDREN, AGES FOUR TO EIGHT	38
B PICTORIAL ARTICULATORY STIMULI FOR CEREBRAL PALSIED CHILDREN, AGES FOUR TO EIGHT	39
C SENTENCE ARTICULATORY STIMULI FOR CEREBRAL PALSIED CHILDREN, AGES FOUR TO EIGHT	40
D SUMMARY OF SUBJECTS' RAW SCORES ON TESTS OF FEEDING SKILLS (FST), WORD AND SENTENCE ARTICULATION, TOTAL SPEECH AND TOTAL NON-SPEECH DIO	41
E SUMMARY OF SUBJECTS' RAW SCORES ON SPEECH AND NON-SPEECH DIO TESTS	42

LIST OF TABLES

TABLE		PAGE
I	Pearson Product Moment Correlation Coefficients and Results of Fisher R Tests for FST, WAT, Speech DIO and Non-Speech DIO Tests	25
II	Mean Scores of Subjects by Age on the FST, WAT, Speech DIO and Non-Speech DIO Tests	27
III	Mean Scores of Subjects by Diagnostic Classification on the FST, WAT, Speech DIO and Non-Speech DIO Tests	28
IV	Mean Scores of Subjects by Degree of Mental Functioning on the FST, WAT, Speech DIO and Non-Speech DIO Tests	30

CHAPTER I

INTRODUCTION AND STATEMENT OF PURPOSE

Introduction

Irwin's study (1947) of normal articulatory acquisition in infants from birth to age 2.6 years indicated that bilabial sounds /p, b, m/ gradually accelerate in their frequency of occurrence. By 5 to 6 months /p, b, m/ have appeared and at 2.6 years they represent approximately 25 percent of all consonants produced. This is a slightly greater occurrence than in adulthood. At 2.6 years plosives are the most frequently occurring consonants and nasals are third most frequently occurring of all consonants produced.

In cerebral palsied children the order of consonant development is similar to normal children's development (Byrne, 1959). Bilabials occur most frequently for the cerebral palsied population and plosives are among the easiest consonants to produce. Consonants, however, appear later in the cerebral palsied child's speech development than in a normal child's development. Byrne's study of educable athetoid and spastic children between the ages of 2 and 7 years revealed 75 percent of her subjects accurately produced the sounds /w, b, j, m, d/. Byrne compared her data with Templin's (1959) data on articulatory acquisition in normal children. Templin defined acquisition of a sound by a certain age when 75 percent of her population at that age correctly articulated the sound. Templin's 3 year olds had acquired /w, b, j, m,

d/ and, in addition, 5 other sounds. Therefore, when compared to a normal population, Byrne's cerebral palsied population acquired fewer consonants. Additionally, Byrne's population included 2 to 7 year olds. When compared with Templin's 3 year old normal children, Byrne's cerebral palsied children acquired the sounds at a later age. Irwin's (1963) study supported the similarity to normal order of consonant development in cerebral palsied children. For cerebral palsied children, ages 6 to 16 years, the bilabials were easiest to produce. By manner of articulation, nasals were easiest in the initial and final positions of a word; plosives were easiest in medial position and second easiest in initial position.

To summarize, the bilabials such as /p, b, m/ are the most frequently occurring consonants for both normal children age 2.6 years and cerebral palsied children ages 2 to 7 years. In 6 to 16 year old cerebral palsied children, bilabials remain easiest to produce. Nasals occur with third most frequency of all consonants in normal children. For cerebral palsied children, the nasal consonant /m/ is one of the first 5 sounds to develop and nasals are the easiest consonants to produce in initial and final positions. By age 2.6 years plosives occur most frequently in the speech of normal children and the plosives /b, d/ are 2 of the first 5 sounds to develop in cerebral palsied children. There is, however, a delay in the development of all consonants, including bilabials, plosives and nasals, in cerebral palsied children.

Delay in development of speech sounds is due to many factors and among cerebral palsied children the impeding factor most often noted is dysarthria. The neuromuscular disturbance, as manifested in the

extremities, also may involve cerebral control of the muscles of the lips, tongue, larynx, diaphragm and thorax used in speech, as well as other associated speech musculature. The movements may have limited range, as in spasticity; they may be reduced in force or speed, which is true for most neuromuscular types of cerebral palsy; and there may be poor timing and direction of movement, as in athetosis (Darley and Aronson and Brown, 1969). Poor cerebral control leads to many types of speech problems, including articulatory errors. The child may make speech physiologically simpler; i.e., if he cannot raise the tongue tip for /n/, he may raise the tongue dorsum. Unvoiced plosives may be voiced (Hixon and Hardy, 1964), and furthermore, if he cannot get good lip closure for /p, b/, he may produce the sounds with labial-dental articulation.

Hixon and Hardy (1964) have studied the relationship between speech defectiveness and diadochokinesis in the cerebral palsied child. The results of their work indicated a significant negative relationship ($r = -.70$) exists between repetition rate for /mΛ, dΛ, gΛ/ and speech defectiveness, that is, the faster the diadochokinetic rate, the less often speech is judged defective in spontaneous conversation. They felt speech defectiveness could be predicted from the diadochokinetic rate of any of the 3 syllables. Their work partly supported the results of a study by Heltman and Peacher (1943); in the latter study the relationship between diadochokinetic rate and number of misarticulations was $r = -.76$. Heltman and Peacher discovered rates of lip and tongue movements with voice were significantly greater than rates of lip and tongue movements without voice. In both of the above-mentioned

studies, as compared to normal children, cerebral palsied children had significantly slower diadochokinetic rates and more misarticulations or speech defectiveness. In summary, Hixon and Hardy said one should instruct cerebral palsied children in speech movements rather than in tongue, lip and jaw exercises to strengthen oral muscles.

The motor foundation upon which speech is developed includes head and trunk control, coordinated respiration and phonation, normal development of feeding patterns, and babbling or automatic speech (Morris, 1970). Cerebral palsied children may have feeding problems such as limited cerebral control over muscle movements in sucking, swallowing, drinking and chewing. There may be a facilitory effect of teaching pre-speech feeding skills on later synergy of movement for speech (Bosley, 1965; Crickmay, 1966; Morris, 1970; and Mueller, n.d.). Conversely, are the number of misarticulations in cerebral palsied children reflected in poorer feeding skills? A feeding skills scale which one could devise would include specific tasks a child might use in feeding, such as maintaining a lip seal when cup drinking. The child would be rated according to the degree of ability on the tasks, such as "poor," "functional" or "good." One could determine the correlations between feeding skills and articulatory ability or between diadochokinetic rate and articulatory ability. If significant correlations were found to exist, a feeding skills scale or diadochokinetic test might be useful to predict synergistic movement for speech.

Statement of Purpose

Therefore, the purpose of this study was to determine whether or not the performance of feeding skill movements or the performance of diadochokinetic movements was significantly correlated to the synergy of movement for speech. The research was designed to investigate the value of specific feeding skills and diadochokinetic rate in cerebral palsied children as a requisite to speech development. The end purpose of the design was to determine whether or not articulatory proficiency in cerebral palsied children might be predicted from a feeding skills or diadochokinetic test.

These were the hypotheses tested:

1. In cerebral palsied children there would be a significant positive correlation between the raw score on a feeding skills test and the raw score on an articulation test of /p, b, m/.
2. In cerebral palsied children there would be a significant positive correlation between the diadochokinetic rate and the raw score on an articulation test of /p, b, m/.

Definitions

The following operational definitions are given:

Dysarthria

Dysarthria is characterized by slowness, weakness, limited range of motion and incoordination of the speech muscles because of a loss in motor control of the central or peripheral nervous system (Darley, and Aronson, and Brown, 1969).

Developmental Delay

Atypical developmental milestones for the chronological age of the child, in the areas of speech and language, motor skills, perceptual functioning, cognitive development, social behavior, self-help skills and personality (Gearheart, 1975). A developmentally delayed child may later be considered normal following future standardized intellectual testing and assessment of adaptive behavior.

CHAPTER II

REVIEW OF THE LITERATURE

Vegetative Processes and Speech

Cerebral palsy for the speech pathologist presents a constellation of communicative problems. Among the contributing factors may be abnormal sucking, swallowing and chewing. What are specific problems which might disrupt the communicative process? Palmer's (1952) study of 100 cerebral palsied children revealed 77 percent of children with moderate and severe speech handicaps had generally abnormal sucking, swallowing and chewing. Problems of swallowing only occurred in 6 percent of the cases and drooling in 7 percent. In 1955 Achilles did an analysis of specific disruptions to communication in cerebral palsied children. Generally abnormal functioning of sucking, swallowing and chewing occurred in 29 percent of cases. For example, jaw thrust indicating poor jaw control occurred in 3.3 percent of cases. Drooling occurred in 11.9 percent of the cases. Problems in swallowing only occurred in 2.6 percent of the cases. The 29 percent of cases generally abnormal included other abnormal processes of the oral muscles not specifically associated with sucking, swallowing and chewing. Achilles' (1956) study of speech disorders of cerebral palsied children compared athetoids and other types of cerebral palsied children. Abnormal functioning of sucking, swallowing and chewing occurred in 33 percent of athetoids and 22.9 percent of other types. Problems of swallowing

only occurred in 2.2 percent of athetoids and 3.3 percent of other types; and drooling occurred in 10 percent of athetoids and 14.8 percent of other types. Jaw thrust occurred in 4.4 percent of athetoids and 1.6 percent of other types. In sum, these studies were among the first analyses of specific disruptive mechanisms to communication in cerebral palsied children. They revealed abnormal sucking, swallowing, chewing patterns, drooling and poor jaw control were among the problems disrupting communication.

Looking at the normal developmental steps in feeding provides a basis through which to analyze problems that later may disrupt communication. The stages of normal feeding development include (Ingram, 1962; Caplan, 1973; Finnie, 1975; Morris, unpublished):

1. Sucking-swallowing. A newborn infant has a pattern of sucking several times and swallowing. With a stimulus, such as a nipple, there may first be an initial swallow followed by repetitive sucking. Between 6 to 12 weeks, the suck-swallow pattern is less prolonged.
2. Conscious swallowing. This occurs at nearly the same time solid foods may be introduced, at approximately 3 months. Because it cannot be sucked down, the solid requires a new response and the baby learns a new swallowing pattern.
3. Taking a liquid or solid food from a spoon. When the child, age 6 months, is presented with food on a spoon, he begins to take it off with the lips and transfer it for swallowing. The infantile pattern of swallowing is becoming modified; during the swallow, the tongue goes up behind the alveolar ridge and back, rather than on the alveolar ridge and forward.
4. Munching. During this stage, at 6 to 7 months, the child is approximating chewing. The biting reflex, inhibited at approximately 4 months, and the choking reflex, inhibited at approximately 7 to 11 months, coincide with better tongue and jaw control. The child dribbles and gags less.

5. Cup drinking. While in a sitting position, the child has jaw control to suck liquids into the mouth, a lip seal to control the liquid inside the mouth and tongue control for swallowing. The child has a sip-swallow pattern. Some dribbling and coughing may occur until he has developed better oral control. This stage may occur at approximately 7 to 8 months.
6. Chewing. With rotary tongue movement and lateralizing, rather than vertical, biting motions of the jaw developing, chewing progresses. Gradually more solid foods such as pieces of diced vegetables or toast can be handled. This occurs from 9 to 12 months.
7. Straw drinking. As this activity requires fine coordination of the lips, it is not usually attempted until the child is 3 to 4 years old.

The foundation for speech movement patterns seems to be established during the development of feeding skills. Finnie (1975) has succinctly stated:

. . . any abnormal feeding patterns that are allowed to develop, or to persist will certainly affect the child's attempts to babble and later to make articulate sounds.

By working with feeding skills before abnormal patterns are learned or after they have been learned, one may help the cerebral palsied child learn more normal movement patterns or prevent persistence of abnormal movement patterns of tongue, lips and jaw which he will use for speech.

Diadochokinesis

Among his evaluational techniques, Harold Westlake (1951) used an oral musculature test in which he had the child retract the lips from a rounded position while the teeth remained together to stabilize the lower jaw, open and close the lips with teeth together and open and close the mouth. The test was designed to:

1. describe the overall motor accuracy;
2. isolate foci of particular difficulty;
3. furnish a reference base for measuring improvement; and
4. encourage systematic therapy since it constitutes a map of an important aspect of the speech training (Westlake, 1951).

The test was used to plan therapy in lip, tongue and jaw exercises so the child could gain control over automatic movements. Westlake believed the kinesthetic-tactile feedback from practicing these non-speech movements would provide sensory-motor patterns useful for movements of speech.

In 1943 Heltman and Peacher did a study using 102 spastic children in which they tested articulation and rates of diadochokinesis. Diadochokinesis included repetitive movements of opening and closing the jaw, opening and closing the lips without voice and with voice (repetition of ba, ba, ba), and moving the tongue to the alveolar ridge and down without voice and with voice (repetition of la, la, la). The results indicated the diadochokinetic rates were significantly delayed in the spastics compared to the normals, and there was a high negative correlation ($r = -.76$) between the rate of diadochokinesis and speech defectiveness, that is, the more movements per second, the lower the error score on the articulation test. It was shown, additionally, that rates of movements of the lips and tongue with voice were significantly higher than those without voice. They concluded the diminished diadochokinetic rates bore a relationship to speech defectiveness, and,

further, exercises of the tongue, lips and jaws should be instructed, especially with voiced movements.

Irwin (1957) studied the relationship between correct articulations and selected non-speech movements adapted from Westlake's oral musculature test. The strength of the relationship was $r = .53$. He believed children with poor scores on the oral test might not necessarily have poor articulation, and those with good oral scores might not have good articulation.

Using diadochokinetic movements as independent variables and speech defectiveness as the dependent variable, Hixon and Hardy (1964) did a study of fifty children with spasticity and athetosis. Results indicated a greater mean number of speech movements performed in ten seconds, such as /dΛ, mΛ, gΛ/ than non-speech movements, such as repetitive placement of the tongue to the alveolar ridge. A multiple regression analysis performed showed 58 percent of the total speech defectiveness rating was due to variables introduced by the speech movements, whereas 6 percent was due to non-speech movements. Speech defectiveness did not correlate highly with non-speech movements, but did correlate highly with speech movements. If the two types of repetitive movements were related, speech defectiveness should have correlated highly with both. The results supported their theory of different neuromuscular patterns for the two types of movements. Furthermore, they felt speech movements:

1. Are more repetitive because the sense of audition is present; and
2. Speech movements are more automatic or less voluntary than non-speech movements. Non-speech

movements must be elicited through imitation,
which is very difficult for a dysarthric child.

Thus, they believed non-speech movements were inadequate for diagnosing oral paresis, and, further, one should instruct speech movements to establish appropriate sensory-motor patterns, rather than doing tongue, lip and jaw exercises suggested by Heltman and Peacher. In conclusion, Heltman and Peacher saw a significant relationship between non-speech movements and speech defectiveness while Hixon and Hardy did not.

According to the latter researchers, techniques of therapy should emphasize speech movements, rather than non-speech movements. Dysarthric children have difficulty doing imitative, meaningless movements of the oral musculature and doing drill on isolated phoneme positions. It is the pattern of movements and the transition from each pattern to the next, i.e., the synergy of movements, in which they should be instructed (Morris, n.d.).

CHAPTER III

METHODS AND PROCEDURES

Methods

General Plan

Twenty children with a medical diagnosis of cerebral palsy and a speech diagnosis of dysarthria comprised the subjects for the study. The subjects were chosen from two centers located in Portland, Oregon: the Child Development and Rehabilitation Center of the University of Oregon Health Sciences Center, and Holladay Center for Handicapped Children. All subjects were administered a feeding skills test, a diadochokinesis test and an articulation word and sentence test for the /p, b, m/ sounds. The examiner rated each child at the time of performance, using an operational rating scale for the feeding skills test, the number of speech diadochokinetic movements repeated in ten seconds and the number and type of misarticulation errors made on the articulation test.

Subjects

There were 20 subjects ranging in age from 4 to 8 years. The mean age of the subjects was 6.4 years. From the medical neuromuscular and topographic diagnoses given in the files it was determined there were 6 spastic quadriplegics, 4 spastic quadriplegics with athetosis, 4 spastic hemiplegics with athetosis, 1 left hemiplegic, 3 spastic

diplegics and 2 ataxia/choreoathetoids.

The following criteria were used to select subjects for the study:

1. The subject could understand the directions and cooperate in the experimental tasks.
2. The subject had to have hearing in 1 ear within 40 dB for the pure tone average of frequencies 500, 1000 and 2000 Hz. This was determined either by a record of an audiometric examination administered within 6 months of the study date or by a hearing screening test administered by the researcher utilizing a portable audiometer.
3. The speech diagnosis was dysarthria.

Measurement Instruments

Feeding Skills Test (FST). This is a descriptive list of movements the child may perform with his articulators when sucking, swallowing, chewing and drinking. The descriptive statements were compiled from the literature concerning good feeding patterns in cerebral palsied children by Mueller (n.d.), Finnie (1975), Crickmay (1966) and Sofka (n.d.).

A feeding skill was considered "poor" when a child did not keep the food or liquid in his mouth unaided. A feeding skill was judged "functional" when the child sucked, chewed, drank and swallowed but drooling occurred or food "leaked out" of the mouth. A feeding skill was considered "good" if, in addition to performing sucking, chewing, drinking and swallowing movements, the child did not drool while eating nor eject food from his mouth, that is, he maintained control over keeping the food or liquid in the mouth.

Gross scale values and descriptions were employed in judging feeding movements, partly because they were common terms used in the literature to describe these abilities and partly because of lack of sophisticated instrumentation. The following scale values were used: 2 = "good," 1 = "functional," 0 = "poor."

Prior to undertaking the study, an ASHA certified speech pathologist from Child Development and Rehabilitation Center instructed the researcher in rating pilot subjects. The clinician was experienced in instructing feeding skills to cerebral palsied children; she trained the researcher to judge feeding skills as "good," "functional," and "poor." Together the speech clinician and the researcher rated 20 percent of the subjects. On designation of a feeding skill, the speech clinician and the researcher reached 100 percent of agreement.

See Appendix A for a description of the FST.

Articulation Test. To test each subject's articulatory performance of /p, b, m/ 15 words and sentences for each sound tested were compiled by the following criteria:

1. Words had to be represented by simple line-drawings.
2. The words had to contain each phoneme in either initial, medial or final position in a word. Two syllable words were used to test medial consonants. All other words were single syllables with blends and sibilants excluded.
3. Vowels /ɛ, æ, ʌ, ɑ/ were used with single syllable words and immediately preceding /p, b, m/ in two syllable words.
4. Sentences had to contain words with /p, b, m/ in either the initial, medial or final position of a word.

5. Each sentence contained a word used previously in the word articulation assessment.

Operationally, it was determined that using low front and back vowels was easiest for the cerebral palsied children to produce and, therefore, it would provide the best articulatory environment in which to test /p, b, m/. The pictures representing the words were black and white simple line-drawings. For each phoneme there were 5 different pictures for the initial, 5 for the medial and 5 for the final positions of a word. There were 9 sentence presentations, one each for the initial, medial and final positions of /p, b, m/. For every word the researcher prepared a short sentence using that word. She picked the sentence containing the word the child had articulated correctly on the word test. In the first sentence for the phoneme the initial phoneme was rated, in the second sentence the medial phoneme, and in the last sentence the final phoneme. Sentences were said by the researcher no more than two times.

The child's misarticulations were recorded by type of error, i.e., omission, substitution or distortion for both word and sentence tests.

See Appendices B and C for the articulation test and for further information.

Diadochokinesis Test. In their study of articulatory motility in cerebral palsied children, Hixon and Hardy (1964) discovered rates of repetition for single consonant-vowel syllables were significantly related to judged speech defectiveness, i.e., the slower the rate of repetition of speech syllables, the greater the judged speech defec-

tiveness. Non-speech repetitive movements, such as opening and closing the jaw, were not related to speech defectiveness to the same degree as repetitive speech movements. Yet, both non-speech and speech movements were significantly affected by paralysis of the speech articulators.

To evaluate the motility of articulators in cerebral palsied speakers the researcher asked the subjects to do the following:

1. Open and close the lips while the mandible was free.
2. Open and close the lips while the mandible was stabilized by pressure under the chin to keep upper and lower teeth together.
3. Alternately purse and retract the lips when the mandible was stabilized by slight upward pressure under the chin.
4. Repeat separately /pΛ, bΛ, mΛ/.

The investigator counted the number of times the child repeated the task in ten seconds. The means of the subjects' diadochokinetic rates were computed separately for the speech-related DIO and the non-speech DIO because of Hixon and Hardy's (1964) contention that speech-related DIO would be a better predictor of the synergy of movement needed for speech than the non-speech DIO.

Procedures

Subjects were tested when they were most alert and before a major meal of the day, such as in the morning or after a rest period in the afternoon. When the subject arrived at the test setting, the researcher gave the following information:

I am a student working on a book about children like yourself. I am listening to the children talk and

watching them eat and drink. First, I will ask you to look at some pictures and tell me their names. Second, I will ask you to eat some food and drink some juice. Last, I will ask you to look at what I do with my mouth and then I will ask you to do it. Let's start.

Testing Articulation

Subsequent to giving the above information, the researcher instructed the child to look at the pictures and give their names. She showed each picture to the child. They were shown in the order of initial, medial and final positions of words, for /p, b, m/. When a child did not know the name of the picture or named it incorrectly, the researcher instructed the child in the following way: "Yes, but there is another name for this picture. Look at the picture again and listen to me. I will tell you the name. Then I would like you to tell me the name." When the word was repeated, the researcher provided only auditory cues, i.e., she hid her mouth from the child's sight.

When the subject had completed naming the pictures, the researcher asked the subject to do the following: "Now, I will read some sentences to you. When I am done reading each sentence, I would like you to say the whole thing, so please listen carefully." The researcher read the sentence. She encouraged the subject to complete it. When a child did not complete it, she repeated it a second time.

Testing Feeding Skills

For the FST, the researcher asked the subject to do the following tasks, one at a time:

- Eat the cracker.
- Eat the food on the spoon.
- Eat the applesauce on your lip.

Drink the water in the cup.
Hold the straw in your mouth.
Suck the juice with the straw.

The subject was fed in the usual feeding position as indicated by the parent or teacher. The researcher fed each child. Before presenting food to a subject, the researcher checked with the parent or teacher regarding the type of food the child could handle in his mouth. In presenting the food to be bitten off, the researcher put a small piece at the midline and slightly below and forward of the child's mouth.

Following presentation of the cracker, the researcher gave the child a small amount of soft, unmashed food on a shallow, rounded spoon. Mueller (1975) indicated one should present the spoon at the midline, pressing down on the tongue with the bowl of the spoon; pressing the tongue down with the bowl helps control tongue thrust. To determine the presence or absence of tongue thrust, the researcher did not press down on the tongue with the bowl of the spoon. Mueller (1975) said the child may need to learn to use his upper lip to remove food from the spoon; the food should not be scraped off on the teeth. To evaluate the child's ability to use his upper lip for food removal from the spoon, care was taken to avoid scraping food off on the teeth.

Third, the researcher placed a small amount of applesauce on the child's lower lip and instructed him to get the food off his lip.

In the drinking task, a plastic cup, cut out on top, was used. The researcher presented the cup at the midline, slightly below and forward from the child's mouth to prevent a head extension pattern. Mueller (1975) has suggested removal of the cup after each sip-swallow

may be too strong a stimulus, i.e., it may cause the child to lose head and jaw control. The investigator removed the cup after the child had taken a customary-sized drink, rather than after each swallow.

On the straw drinking task, standard plastic straws were used. On the end inserted into the mouth, at 1" below the tip, a line was drawn. When the child was asked to put the straw into his mouth, the researcher noted whether or not the 1" line remained visible. If the line was invisible, the possibility existed that the child was using his teeth to bite the straw, rather than using adequate lip pressure to keep it in his mouth. The examiner then gently repositioned it between the lips. She asked the child to drink the juice with the straw.

The researcher rated each drinking, chewing and swallowing skill immediately after the food or liquid was presented.

As part of the diadochokinesis test, the examiner explained she wanted to see how the subject could move his mouth and lips. Prior to each movement, she demonstrated the task; following this she said, "Do what I do," as she performed the movement simultaneously with the child. Exaggerated movements were discouraged. The researcher continued the movement until after the child had started it, but she continued it for no longer than ten seconds. Starting from when the child began the movement, the researcher counted the child's movements for ten seconds. A stopwatch was used.

Statistical Analyses of Data

Pearson Product Moment Correlation Coefficients were used to determine the correlation between the feeding skills test results and

the articulation test results, and, also, between the diadochokinesis test results and the articulation test results. The Fisher R test was used to determine the significance of the correlation coefficients.

In determining the significance of the differences between mean scores for all tests for males versus females and for spastic diplegics versus spastic quadriplegics, two-tailed t-tests were used.

CHAPTER IV

RESULTS AND DISCUSSION

Results

The purpose of this study was to determine whether or not the performance of feeding skill movements or the performance of diadochokinetic movements was significantly correlated to the synergy of movement for speech in cerebral palsied children. To determine ability in feeding skills a test, designated the Feeding Skills Test, or FST, was designed by which each subject's sucking, drinking and chewing ability was rated as either "poor," "functional," or "good." A diadochokinesis test (DIO) consisting of both non-speech movements, such as pursing and retracting the lips with mandible stabilized, and speech movements, such as repetition of /bΛ/, was given and the number of times the subject repeated a movement within ten seconds was counted. An articulation test consisting of words and sentences to test the sounds of /p, b, m/ was administered and indicated the degree of synergy of movement for speech. Twenty cerebral palsied children between the ages of 4 to 8 years whose speech diagnosis was dysarthria comprised the subjects for the study. The specific hypotheses tested were as follows:

1. In cerebral palsied children there would be a significant positive correlation between the raw score on a feeding skills test and the raw score on an articulation test of /p, b, m/.
2. In cerebral palsied children there would be a significant positive correlation between the

diadochokinetic rate and the raw score on an articulation test of /p, b, m/.

A Pearson Product Moment Correlation Coefficient between scores on the word and sentence test revealed $r = +.87$, indicating a high positive correlation between articulatory ability with words and with sentences. It was determined, therefore, to use the word articulation test (WAT) alone to determine further correlations between feeding skills, DIO and articulatory ability.

To determine if the synergy of movement used in feeding skills is a useful predictor of synergy of movement for speech, the Pearson Product Moment Correlation Coefficient (Pearson R) between the raw scores on the FST and the raw scores on the WAT was computed and it was found $r = +.75$. The Fisher R test was used to determine the level of significance of the correlation coefficient and it reveals the correlation is significant at the level of confidence, $\alpha = .01$ (Table I). Therefore, this is a highly significant relationship; hence, hypothesis number one is accepted.

Hypothesis number two was that the better the diadochokinetic rate the higher would be the raw score on the articulation test. The Pearson R was computed separately for the speech DIO and the non-speech DIO because it was noted in the literature that speech DIO would be a better predictor of the synergy of movement needed for speech than the non-speech DIO (Hixon and Hardy, 1964). The results indicated for speech DIO, $r = +.83$ and for non-speech DIO, $r = +.72$. The Fisher R test shows that the correlation coefficients are significant at the level of confidence, $\alpha = .01$ (Table I). Therefore, a highly signifi-

cant relationship exists between the ability to execute DIO of the oral muscles and articulatory ability, and hypothesis number two is accepted.

TABLE I
PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS
AND RESULTS OF FISHER R TESTS FOR FST, WAT,
SPEECH DIO AND NON-SPEECH DIO TESTS

Tests	Correlation Coefficients	Z-Score
FST and WAT	$r = +.75$	4.05*
Speech DIO and WAT	$r = +.83$	4.95*
Non-speech DIO and WAT	$r = +.72$	3.78*

*Significant at the level of
confidence, $\alpha = .01$.

Discussion

The statistical analysis of the data for hypothesis number one supports the development of feeding skills as the foundation for speech movement patterns. Subjects who scored higher than 50 percent on the FST scored 22 or more words out of 45 on the WAT. Without exception, those with fewer than 50 percent on the FST had less than 4 words on WAT. Perfect FST scores, however, did not result in perfect speech scores on WAT, nor did perfect speech scores necessarily forecast perfect feeding scores.

One possible explanation of the discrepancies in the subjects'

scores lies in the FST itself. It is an unstandardized measurement instrument which samples a wide range of feeding abilities. For example, it samples the ability to use rotary tongue movement which is not necessarily predictive of movement needed for articulation of the sounds /p, b, m/. That is, each specific feeding skill may not correlate as significantly with articulatory ability as the entire test correlates with the WAT.

Another explanation may lie in the diagnosis of each subject. Subjects, numbers 2, 6 and 20, who scored 38 percent or better on the FST and who articulated less than 7 percent of the words, were spastic quadriplegics. Subjects, numbers 12 and 14, who scored 69 percent on the WAT and 56 percent on the FST, were spastic-athetoid quadriplegics. Subjects 12 and 14's scores are consistent with the poor timing and direction of movement which is often a symptom in athetosis.

The judgments of specific feeding skills on the FST revealed the degree of dysarthria as did analysis by types of errors on the articulation test. For example, subject number 12 used distortions and this accounted for 12 out of 14 errors on the articulation test. In this subject occlusion was evaluated as normal. He made these distortions with labial-dental articulation so it appears that some sluggishness or incoordination of the lips was present. His functional ability to use his upper lip to remove food from a spoon, to use his lips to keep food from dribbling out of the mouth and other functional lip use was also indicative of the incoordination due to his dysarthria.

Neither a feeding skills assessment ($r = +.75$) nor a speech diadochokinesis test ($r = +.83$) could predict with complete accuracy each

sound the child might be able to say. A FST, however, would be highly useful as a clinical tool for predicting synergy of movement for connected speech because it is universally administrable. A speech-related oral DIO test would not be administrable to very young or severely involved children.

When the subjects were categorized into homogenous groups (sex, age, diagnosis and intelligence) to determine if a specific group achieved higher mean scores on the FST, WAT, speech and non-speech DIO tests, the data indicate that males and females do not differ in their abilities in a predictable manner across parameters. A two-tailed t-test revealed there is no significance in the differences at a level of confidence, $\alpha = .05$ for all test means. It also was found that there is not a consistent increase in abilities with increasing age across all tests (Table II). But non-speech DIO increased linearly

TABLE II
MEAN SCORES OF SUBJECTS BY AGE ON THE FST, WAT,
SPEECH DIO AND NON-SPEECH DIO TESTS

Age (Years)	Number Subjects	FST	WAT	Speech DIO	Non-Speech DIO
4	3	4	1.5	0	0
5*	1	16	43	37	7
6	10	11.8	27.8	45.5	15.6
7	6	7.8	13.7	24	25

*There was one subject in this category and the numbers represent the subject's raw score.

with age. One could speculate that the practicing of feeding movements would have an effect on the non-speech diadochokinetic movements and could well account for the linear increase with age. The wide range of intelligence and severity of the subjects are factors which interfere with the increase in the other abilities with increasing age.

There was a trend for subjects in different diagnostic categories to differ in their abilities (Table III). Subjects diagnosed as having spastic diplegia received the highest mean scores on all the tests

TABLE III

MEAN SCORES OF SUBJECTS BY DIAGNOSTIC CLASSIFICATION ON THE
FST, WAT, SPEECH DIO AND NON-SPEECH DIO TESTS

Diagnosis	Number Subjects	FST	WAT	Speech DIO	Non-Speech DIO
Spastic Quadriplegia	6	7.7	1.7	.2	.5
Spastic Quadriplegia/ Athetosis	4	8.5	29.5	25	8.8
Spastic Hemi- plegia/Athe- tosis*	5	9	16.8	36.5	8.5
Ataxia/Choreo- athetosis	2	13.5	36	49	14
Spastic Diplegia	3	14.3	42	66	29.3

*One of the subjects in this category was diagnosed as having left hemiparesis, post-trauma, without either spasticity or athetosis, and the mean scores of this group do not include this subject.

while those in the spastic quadriplegia group received the lowest mean scores for all tests. A two-tailed t-test indicated the differences between the two groups are significant at the level of confidence, $\alpha = .01$ for all tests. Topographically, that is by number and location of limbs involved, diplegia means all four extremities are involved, but legs are mainly affected and the arms only slightly (McDonald and Chance, 1964). Quadriplegia means all four extremities are equally impaired; thus this condition is usually the most physically handicapping. It would appear, therefore, that a significant factor in the feeding, speech and diadochokinetic abilities of spastic diplegic versus spastic quadriplegic subjects is the neuromuscular distinction between the classifications. That is, in spastic diplegia the upper trunk is less involved, allowing greater fine motor movements of the fingers, hands and arms. Consequently, hand to mouth function is more apt to occur, giving the oral musculature more experiences, in the same manner that a feeding program does.

Categorization of subjects by degree of mental deficiency, if any, obtained from the diagnosis, indicates subjects with normal intelligence have a higher mean score on all the tests as compared to those who have a diagnosis of mental retardation or developmental delay (Table IV). The subjects labeled mentally retarded received mean scores nearly two times lower on all tests, with the exception of the FST, than subjects without such diagnosis. The FST scores, too, were lower for mentally retarded and developmentally delayed subjects. Subjects who are developmentally delayed received the lowest mean scores on all the tests. It would appear, therefore, that the presence or

TABLE IV

MEAN SCORES OF SUBJECTS BY DEGREE OF MENTAL FUNCTIONING ON
THE FST, WAT, SPEECH DIO AND NON-SPEECH DIO TESTS

Mental Function	Number Subjects	FST	WAT	Speech DIO	Non-Speech DIO
Normal	7	11.9	35	60.1	23.1
Mentally Retarded	8	9.5	18	25.6	9.1
Developmentally Delayed	5	8.6	9.8	7.6	1.8

absence of mental retardation is an important factor in the feeding, speech and diadochokinetic abilities of these children.

The condition of mental retardation exists concurrently with deficits in adaptive behavior. During early childhood, adaptive behavior includes sensory-motor development (Gearheart, 1975). Sensory-motor maturation involves development of normal postural reflexes and normal postural tone (Morris, 1970). In cerebral palsy, the brain does not integrate muscle movements automatically for control of equilibrium (Bobath, 1971). Specific primitive reflexes of the brain remain and they prohibit normal postural reflexes and normal movement patterns which are necessary for head and trunk control. Consequently, the impaired head and trunk control may interfere with feeding, pre-speech and speech development. Additionally, due to his motor disability, the cerebral palsied child may interact less with the environment. Without the experience of handling many food textures and tastes in his mouth, including hands and toys, the child may not develop normal feeding

skills. With regard to social adjustment, the cerebral palsied child is often very dependent on others for providing many of his needs. A child who is not required by those caring for him to indicate his own decisions, whether by gesture or by vocalization, may be deprived of an opportunity to learn to communicate. By the nature of his condition, the cerebral palsied child may never achieve total independence. Thus, the effects of his severe motor disability may be impossible to separate from effects of his retarded intellectual development (McDonald and Chance, 1964).

In summary, the findings of this study support the predictive value of a FST ($r = +.75$) for determining synergy of movement for speech in cerebral palsied children. Further, they give validity to the development of a feeding skills program as a requisite to speech development. Results of the DIO tests also support Hixon and Hardy's (1964) findings that speech movements ($r = +.83$) are of more predictive value for determining articulatory ability than non-speech movements ($r = +.72$), because speech movements are more repetitive or more automatic, and more meaningful. Hixon and Hardy's contention that speech movements should be taught to cerebral palsied children, rather than meaningless oral muscle exercises, such as Westlake (1951) proposed, also is supported by the findings of this study.

CHAPTER V

SUMMARY AND IMPLICATIONS

Summary

The normal development of articulation is built upon the normal development of motor skills (Morris, 1970). Cerebral palsy is caused by brain damage and is characterized by neuromuscular incoordination. This interferes with normal development of motor skills. It also may interfere with normal development of speech if dysarthria is present. Because of these factors, the synergy of movement of the oral muscles used in feeding, in speech and in execution of diadochokinetic movements of the oral muscles is affected.

The purpose of the study was to determine whether or not the performance of feeding skill movements or the performance of diadochokinesis of the oral muscles was significantly related to the synergy of movement for speech. The end purpose of the design was to determine whether or not articulatory proficiency in cerebral palsied children might be predicted from a feeding skills or diadochokinetic test.

The specific hypotheses tested were as follows:

1. In cerebral palsied children there would be a significant positive correlation between the raw score on a feeding skills test and the raw score on an articulation test of /p, b, m/.
2. In cerebral palsied children there would be a significant positive correlation between the diadochokinetic rate and the raw score on an articulation test of /p, b, m/.

The subjects were twenty cerebral palsied children between the ages of 4 to 8 years whose speech diagnosis was dysarthria. The subjects were administered a feeding skills test, a word and sentence articulation test and a diadochokinetic test of the oral muscles.

The findings indicated that feeding skills are significantly related to ability to articulate words and sentences and further, speech-related diadochokinetic movements of the oral muscles are related to synergy of movement for speech at a highly significant level. When breaking down the data into homogenous groups for comparison of scores by sex, age, diagnosis and intelligence, males and females did not differ significantly in mean scores and also, age was not a consistent factor in abilities across all tests, but age was a factor in the increase of non-speech related diadochokinetic movements. Diagnosis, by topography, revealed higher mean scores on all tests at a significant level for spastic diplegics in comparison with spastic quadriplegics. A trend towards higher scores for all tests was noted among subjects with normal intelligence as contrasted with subjects who were mentally retarded or developmentally delayed.

Implications for Clinic and Future Research

Clinic

The conclusions of this study seem to indicate that the synergy of movement used in feeding skills is a foundation for the synergy of movement of speech. Therefore, this study supports Bosley's (1965), Morris' (1970), Crickmay's (1966) and Mueller's (n.d.) emphasis on teaching pre-speech feeding skills. We are interested, as speech

clinicians, in the vegetative processes, and in light of the high correlation between feeding skill test scores and articulation test scores, it would be worthwhile to develop a more refined feeding skills instrument. The speech clinician could use it as a first step in pre-speech therapy, for assessment and for determining skills which might be taught. This study also supports Hixon and Hardy's (1964) contention that techniques of therapy with the cerebral palsied should emphasize speech movements, rather than imitative, non-speech movements.

Research

A similar replication of this study could be done using subjects with a diagnosis of spastic diplegia whose scores were analyzed by the child's speech experiences, including therapy, and by degree of dysarthria. Additionally, it is suggested one obtain subjects with normal or near normal intelligence.

To create a diagnostic instrument for feeding skills which clinicians could use, it is suggested that sucking, swallowing, chewing and drinking processes be more completely analyzed and each of the component skills be included in a feeding skills assessment. Then an analysis of each item of a feeding skills assessment as it correlates with articulatory proficiency could be performed to increase the predictive usefulness of such a test for speech-related movements. Suzanne Morris, Ph.D., has been developing a pre-speech and feeding assessment rating scale which may be useful in this regard when it is published.

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APPENDIX A

FEEDING SKILLS TEST FOR CEREBRAL PALSIED CHILDREN, AGES FOUR TO EIGHT

Parameters of articulator use involved with feeding skills:

1. When eating, uses tongue and lip control to prevent food from dribbling out of the mouth.
2. When eating or drinking, has control of jaw movement.
3. When chewing, uses rotary tongue movement.
4. Uses upper lip to remove food from a spoon.
5. With upper lip, teeth or tongue, scrapes food from lower lip.
6. When drinking from a cup, sips and then swallows with closed lips.
7. Uses adequate lip pressure around a straw without using the teeth to hold the straw in place.
8. Sucks through a straw.

APPENDIX B

PICTORIAL ARTICULATORY STIMULI FOR CEREBRAL PALSIED CHILDREN, AGES FOUR TO EIGHT

	/m/	/b/	/p/
Initial	man mop mud mom muff	bed bum bat bun bath	pen pan pat pear pot
Medial	tummy lemon hammer momma comma	rabbit robin robber rubber hobby	puppy happy hopping pepper topping
Final	bum gum come mom jam	cab tub cub rub knob	cup cap mop up top

APPENDIX C

SENTENCE ARTICULATORY STIMULI FOR CEREBRAL PALSIED CHILDREN, AGES FOUR TO EIGHT

Sounds rated by researcher are underscored.

/m/

The man is big.
Mop the floor.
Mud is dirt.
Mom is here.
The muff has fur.

Rub her tummy.
A lemon is sour.
Hammer the nail.
Momma came.
Put the comma here.

The bum is old.
Gum is chewy.
Come home now.
Mom is here.
I like jam.

/b/

Up to bed.
The bum is old.
The bat hits.
A bun is hot.
The bath is full.

A rabbit hops.
The robin sings.
The robber steals.
A rubber is a boot.
My hobby is rocks.

The cab is yellow.
The tub has water.
Rub her tummy.
We rob a man.
The knob turns.

/p/

My pen writes.
A pan is heavy.
Pat the kitty.
A pear is fruit.
The pot has food.

A puppy is cute.
I am happy.
The bunny is hopping.
Pepper is black.
Put topping on pie.

My cup is full.
My cap is warm.
Mop the floor.
Up to bed.
A top is turning.

APPENDIX D

SUMMARY OF SUBJECTS' RAW SCORES ON TESTS OF FEEDING SKILLS (FST), WORD AND SENTENCE ARTICULATION, TOTAL SPEECH AND TOTAL NON-SPEECH DIO

Subject	FST	Words	Sen- tences	Speech DIO	Non- speech DIO
1. R.C.	14	40	9	70	22
2. N.C.	12	1	0	0	0
3. J.F.	16	6	0	1	2
4. H.W.	6	0	0	0	0
5. B.M.	16	43	9	37	7
6. J.S.	6	3	0	0	0
7. A.R.	3	0	0	0	1
8. M.W.	3	0	0	0	0
9. J.B.	0	0	0	0	0
10. C.J.	2	0	0	0	0
11. J.R.	13	41	8	35	5
12. J.K.	9	31	6	22	16
13. N.S.	12	22	3	67	9
14. J.B.	9	44	8	41	12
15. T.A.	16	45	8	79	25
16. T.H.	14	45	9	75	53
17. J.W.	16	45	9	121	56
18. S.K.	16	40	8	88	30
19. D.H.	13	32	3	28	6
20. A.K.	6	0	0	0	0

APPENDIX E

SUMMARY OF SUBJECTS' RAW SCORES ON SPEECH AND NON-SPEECH DIO TESTS

Subject	Open and Close Lips Mandible Free	Open and Close Lips Mandible Stable	Purse and Retract Lips	Repeat /p^/	Repeat /b^/	Repeat /m^/
1. R.C.	13	5	4	23	25	22
2. N.C.	0	0	0	0	0	0
3. J.F.	1	0	1	0	0	1
4. H.W.	0	0	0	0	0	0
5. B.M.	6	0	1	11	15	11
6. J.S.	0	0	0	0	0	0
7. A.R.	0	0	1	0	0	0
8. M.W.	0	0	0	0	0	0
9. J.B.	0	0	0	0	0	0
10. C.J.	0	0	0	0	0	0
11. J.R.	5	0	0	12	12	11
12. J.K.	8	5	3	8	7	7
13. N.S.	6	0	3	22	20	25
14. J.B.	8	0	4	18	14	9
15. T.A.	12	8	5	27	24	28
16. T.H.	27	19	7	20	30	25
17. J.W.	35	15	6	33	47	41
18. S.K.	11	12	7	24	37	27
19. D.H.	6	0	0	8	14	6
20. A.K.	0	0	0	0	0	0