# DIADOCHOKINESIS AND ARTICULATION IMPAIRMENT

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## ABSTRACT

The relationship between diadochokinetic rates and the degree of articulation impairment, measured as number of articulation errors on a test, was investigated. Six- and eight-year old children with articulation impairment demonstrated reduced diadochokinetic rates which appeared to improve with age. The larger the number of articulation errors, the slower the rates on both verbal and non-verbal tasks of diadochokinesis.

## INTRODUCTION

Many speech pathologists seem to feel that poor motor coordination is associated with an individual's failure to develop articulate speech. Studies have investigated the relationship between both gross and fine motor skills and articulatory defectiveness. Generally, investigations of gross motor skills have shown inconclusive and conflicting results. Mase (1946), and Carrell (1936) found no differences in motor abilities between articulatory defective and control groups. Other researchers (Albright, 1948; Clarke, 1969; Jenkins and Lohr, 1964; and Dickson, 1962) have found that children with normal speech are superior to those with speech defects on tests of gross physical abilities. Overall investigations of gross motor skills in normal and articulatory defective subjects seem to favour the normal group, but "sufficient evidence is lacking to support the hypothesis that articulatory defectiveness demonstrates a general retardation in motor skills" (Winitz, 1969; p. 155).

A considerable amount of research has been dedicated to the study of diadochokinesis. This may be defined as the maximum speed of movement with which a given reciprocating act (such as syllable repetition, tongue protrusion, or jaw movement) can be performed without confusion in the movement. Verbal diadochokinesis refers to the production of rapidly alternating sequences of syllables (Lundeen, 1950; Fletcher, 1972). Non-speech diadochokinesis includes movements of the tongue, jaw, lips, teeth, etc. repeated in a given period of time (Mase, 1946; Reid, 1947; Fairbanks and Spriestersbach, 1950). Typically, measurement of verbal diadochokinesis involves counting the number of syllables spoken in a five second period of time (Albright, 1946; Prins, 1962). Mechanical measures such as placing a stylus to the jaw (Seth, 1934), a bulb against the lips (Blackburn, 1931) or covering the subject's face with a mask (Strother and Kriegman, 1943) have been used. Although these methods were accurate, they introduced psychological and physiological abnormalities into the situation. Fletcher (1972) found that counting repetitions over a period of time produced as accurate estimates of diadochokinetic syllable rate as did mechanical measures.

A limited amount of research has dealt with diadochokinesis and its relationship to articulation. Mase (1946) found that normal children were significantly better at rapid

repetition of liprounding than articulatory defective children. Clarke (1969) reported that normal speakers showed superior performance on two tests of repeated tongue protrusion and teeth to lip movement. Clarke (1969) and Shelton et. al. (1966) found that diadochokinetic gesture sequences were performed inferiorly by children with delayed articulation. They also showed that with increasing numbers of articulation errors in four-, five-, and six-year olds, there was reduced ability to perform a complex tongue to alveolar ridge task. Among university students with superior and inferior articulation, Fairbanks and Spriestersbach (1950) found non-significant differences on tests of approximation of upper and lower lips, vertical movement of the mandible, contact between tongue and alveolar ridge, and tongue protrusion.

Studies of verbal diadochokinesis generally utilize nonsense syllables such as /p ʌ/, /t ʌ/, and /k ʌ/. Prins (1962) and Yoss (1972) examined the ability of normal and articulatorily impaired children to perform one, two and three syllable diadochokinetic tasks. Their findings indicated no significant differences between normals and children with delayed articulation in performance of single syllable diadochokinesis. However, the same children performed significantly poorer repeating two (/p ʌ t ʌ/) and three (/p ʌ t ʌ k ʌ/) syllable diadochokinetic tasks. Mase (1946) found that normal subjects repeated syllables significantly faster than articulatorily defective subjects. Similarly, Albright (1948) found a control group of children to show greater diadochokinetic rates on repetition of /la/, /t ʌ k ʌ/, /mu/ and a short poem than a group of articulatorily impaired subjects. Prins (1962) also investigated the relationship between diadochokinesis and type or degree of articulation impairment. He found that children with omission errors tended to be inferior to children who either lisped or had phonemic substitution.

Researchers have established normative data for diadochokinetic rates. Blomquist (1950) and Fletcher (1972) established rates for syllable repetition for children and Canter (1961) for adults. Normative data for various non-speech acts has also been established: Tongue protrusion and lateralization and jaw movement (Blackburn, 1931); eyebrow movement and teeth-clicking (Reid, 1947). These studies have indicated that as chronological age increases, diadochokinetic ability increases until about the age of eighteen.

In summary, studies have indicated that children and adults with defective articulation show difficulty in tests of non-verbal and verbal diadochokinesis. It was also suggested that there might be a relationship between the type (or degree) of articulation impairment and diadochokinetic rates.

The purpose of the present study is to investigate the relationship between degree of articulation impairment and the non-speech and verbal diadochokinetic rates on a population of articulatory defective subjects. It is hypothesized that the greater the degree of articulation impairment, the greater will be the difficulty experienced in tasks of diadochokinesis.

## METHOD

### Subjects

The subjects of the study were 9 six-year olds (5 males and 4 females with a mean age of 6 years, one month) and 9 eight-year olds (5 males and 4 females with a mean age of 8 years, three months). The children were attending a small town school. Each child was receiving articulation therapy. Two age groups were studied to see if the phenomenon is age dependent. Recent health and school reports indicated that all children had normal hearing and language skills, no structural anomalies, and were performing normally academically.

### Materials and Procedures

Children were tested individually in a large, quiet and well-lighted room. Testing averaged twenty-five minutes for each child.

Three tests were given in the following order to each child:

1. a standardized articulation test
2. an oral apraxia test
3. a diadochokinetic test

The **Fisher-Logemann Test of Articulation Competence** (1971), was used to measure the degree of articulation impairment. This test required the child to name pictures presented to him. For younger children, clues were given if they were unable to identify the pictures. All responses were recorded by the experimenter. Any sound which was incorrectly articulated in two or more of the two or three positions tested was labelled as an error. Degree of articulation impairment was decided by counting the number of sounds in error (Prins, 1962). Although there are some questions regarding the validity of this measure (Locke, 1968) it appeared the only practical one.

The **Isolated Non-Verbal Oral Motor Movements Task** (Yoss, 1972) was used to determine the presence of oral apraxia, i.e., the partial or complete inability to imitate oral non-speech movements on command. This test is an adaptation of a procedure used by De Renzi, Pieczuro, and Vignolo (1966) to test the presence of oral apraxia in adults. Some researchers (De Renzi, Pieczuro, and Vignolo, 1966; Rosenbek and Wertz, 1972) have found that oral apraxia is frequently associated with an articulation impairment. The thirteen test items included protrusion, elevation, lateralization, pointing, circular movements of the tongue and coordination of the breath stream. The child was required to imitate the non-speech movements of the experimenter.

Diadochokinetic rates were obtained on the following verbal and non-speech diadochokinetic tasks: /p ʌ/, /t ʌ/, /k ʌ/, /p ʌ t ʌ k ʌ/, tongue protrusion, and tongue lateralization. The selected syllables have traditionally been used to represent the three "primary" places of articulation and their combination (Lundeen, 1950; Canter, 1961; Prins, 1962; Fletcher, 1972). Use of fricative consonants in the diadochokinetic tasks was rejected, because preliminary investigation of the subject files revealed that the majority of errors involved production of fricative elements. The non-verbal diadochokinetic tasks were selected on the basis of their ease of visual observation.

The subject was seated and the experimenter demonstrated each diadochokinetic task to the child, after which he was given an opportunity to practice it. Finally, he was asked to repeat it as rapidly as possible until he was stopped, for a period of five seconds. Each task was sampled three times. The best performance was used in the study. All tests of

verbal diadochokinesis were tape-recorded to be tabulated at a later time. Tests of non-speech diadochokinesis were tabulated at the time of testing by the experimenter recording each repetition on paper.

### Reliability

The experimenter and a second judge, a graduating student and a faculty member in a graduate program in Speech Pathology, listened to the recordings of all eighteen subjects and tabulated the highest verbal diadochokinetic rates on each task. The listeners were to "mark down every CV-syllable containing an acceptable production of the specified consonant." Acceptable production was defined as "correct articulation of the stop-manner and the specified place of articulation." Voicing errors were allowed as these do not seem to influence the repetition rate (Sigurd, 1973). The Pearson Product Moment Correlation coefficients varied between .864 and .979 suggesting a high inter-judge reliability.

Agreement on the occurrence of articulation errors between the tester and the school speech therapist varied between 85 and 100%.

Because both the oral apraxia test and the non-speech diadochokinetic test involved direct visual imitation of the experimenter, no reliability measures were obtained as these would have required the presence of a second judge at the time of testing.

### Statistical Procedures

Means, ranges and standard deviations were computed for tests of articulation, oral apraxia, and diadochokinesis. The Pearson Product Moment Correlation Coefficient was used to determine the relationship between the various diadochokinetic rates and the number of articulation errors.

## RESULTS

### Articulation Testing

Mean number of speech sound errors for the six-year old group was 5.29 with a standard deviation of 3.41 and a range of 1 to 11 sound errors. Mean number of speech sound errors for the eight-year old group was 3.5 with a standard deviation of 1.71 and a range of 1 to 6 errors. This data is presented in Table I.

The five most frequently occurring sounds in error were: /s/, /ɣ/, /z/, /θ/ and /r/. The sounds present the same rank order of frequency of error for both groups with /s/ ranking highest. The six-year old group evidenced a total of 17 different phonemes in error compared to 7 in the eight-year old group.

### Diadochokinetic Testing

Means, standard deviations and ranges for diadochokinetic rates are presented in Table I. The repetition rates of the six-year old subjects for all verbal diadochokinetic tasks were slower than the rates reported by Fletcher (1972) for children of the same age. The differences were quite large for the repetition of /tʌ/ and /kʌ/. Among the eight-year olds the rates for /pʌ/ and /tʌ/ were slower than in Fletcher's data, but the rates for /kʌ/ and /pʌtʌkʌ/ were somewhat higher.

Repetition rates for six-year olds revealed a distinct pattern on the parameter of place of articulation. The six-year old subjects demonstrated a mean repetition rate decreasing

from labial /pʌ/, to alveolar /tʌ/, to velar /kʌ/. For the eight-year old group the mean rate was highest for /tʌ/ and lowest for /pʌ/.

The non-speech diadochokinetic abilities appeared less developed in the six-year old group. The mean rate of 9.14 for protrusion and of 8.72 for lateralization was considerably slower than the respective scores of 12.5 and 13.0 in the eight-year old group.

### Oral Apraxia Testing

All children performed well on the 13 item test. The mean score of the six-year old subjects was 11.71 with a standard deviation of .88 and a range of 11-13. The mean score of the eight-year old subjects was 12.83 with a standard deviation of .37 and a range of 12-13.

Because all subjects scored at perfect or near-perfect performance levels, correlation between this ability and degree of articulation impairment was not computed.

### Correlation of Diadochokinetic Rates and Degree of Articulation Impairment

High negative correlations were obtained between almost all measures of diadochokinesis and number of articulation errors. As can be seen in Table II the repetition of /pʌ/, /kʌ/ and /tʌ/ correlated most highly with degree of articulation impairment in the six-year old group. In the eight-year old group tongue protrusion and repetition of pʌ/ correlated most highly with degree of articulation impairment. For both groups, the repetition of /pʌtʌkʌ/ showed the lowest correlation for all diadochokinetic tasks measured. When the results of both groups were combined all the diadochokinetic measures showed significant ($p < .01$) negative correlations with the number of articulation errors. Overall, the diadochokinetic rates for the single syllables showed higher correlations than the combined syllables or the non-verbal movements.

## DISCUSSION

This study supported the hypothesis that the greater the degree of articulation impairment as measured by the number of articulation errors, the greater the difficulty on tasks of diadochokinesis. As the number of specific speech sound errors increased, slower diadochokinetic rates were obtained on both verbal and non-verbal tasks. The articulatorily impaired six-year olds repeated the diadochokinetic tasks slower than the mean rates established by Fletcher (1972) for normal speaking children. However, on two tasks (repetition of /kʌ/ and /pʌtʌkʌ/) the articulatorily impaired eight-year olds performed better than the norms. A practice effect may have improved the performance as these two tasks were the last ones.

Generally, the diadochokinetic rates for the single syllables /pʌ/, /tʌ/ and /kʌ/ showed high negative correlations with the established measure of articulation impairment, while the rates for the combined syllable /pʌ tʌ kʌ/ did not. This could indicate that the repetition of /pʌ tʌ kʌ/ is independent of articulation performance while the ability to repeat single syllables is related to the articulation skills. While this is possible, another explanation appears more plausible. The relatively narrow range of the values of /pʌtʌkʌ/ may have been responsible for the low correlation (Walker and Lev, 1969). The same phenomenon may also explain why the correlations are lower for the eight-year old group. In this group both the range of diadochokinetic rates and the number of articulation errors was much smaller. Thus the reduced variability may have lowered the correlations.

Overall, the ability to repeat bilabial and velar sounds, as opposed to alveolar sounds appears more highly correlated with the degree of articulation impairment. This finding appears somewhat questionable. Most frequently misarticulated sounds require tongue tip movement. Consequently one would expect the repetition of alveolar consonants to correlate more with the degree of articulation impairment. The various diadochokinetic tasks also appear highly interrelated. This area should further be researched. Preliminary analysis with the data indicated that intercorrelations between the repetitions of the various single syllables were more than .90 for the six-year old group and more than .60 for the eight-year-old group. The correlation between the two non-verbal diadochokinetic measures was more than .75 for both groups.

The present study was in agreement with available developmental data on diadochokinesis. Many researchers (Blomquist, 1950; Prins, 1962; and Fletcher, 1972) have shown that diadochokinetic rates increase with age. All scores for the six-year old group were lower than those of the eight-year old group on the six tests of diadochokinesis. The effect of place of articulation on repetition rates for the six-year old group revealed a pattern found in studies by Blomquist (1950) and Prins (1962), who indicated that labial and alveolar syllables were produced faster than velar syllables. Yoss (1972) suggested that the posterior portion of the tongue lacked the necessary mobility needed to make rapid movements. The same results were not found in the eight-year old group. In this group, the velar /k ʌ/ was produced faster than either /p ʌ/ or /t ʌ/. Since /k ʌ/ was the third diadochokinetic task preceded by /p ʌ/ and /t ʌ/, it is suggested that a practice effect may have increased the repetition rate of this syllable.

Tests of oral apraxia involving imitation of thirteen non-speech oral gestures, appeared to show no relation with the number of articulation errors. All children in both age groups scored at perfect or near-perfect levels on the oral apraxia test. Apparently the oral apraxia test was not sensitive enough to the apraxic components or apraxia was not involved.

The children in this study demonstrated functional articulation disorders without any obvious organic cause. However, all the children evidenced impaired diadochokinetic ability when compared to normative data of children of the same age. Previous studies have indicated that many children labelled as having "functional" articulation delay not only show reduced non-speech and verbal diadochokinetic ability but also reduced ability in oral form recognition, two-point discrimination and oral vibrotactile sensation (Bishop and Ringel, 1973; Ringel, 1967; Fucci, 1972). Thus some children with "functional" articulation problems may actually have mild organic defects which result in the subtle motor disabilities seen as slow diadochokinesis in the present study. The fact that the bulk of the errors involved fricatives (37/47 among 6 year olds and 25/28 among 8 year olds) also seems to support this hypothesis. One could assume that the production of fricatives and other continuant consonants comprising of close approximation of two articulators requires a higher degree of motor control than making the same articulators come into complete contact with each other as in stops and nasal consonants. Consequently a child with mild motor deficits would have more difficulty acquiring the more "complex" sounds than one whose problem is solely that of faulty learning.

It is suggested that a clinician selecting a caseload of children with articulation disorders should be most concerned with those children demonstrating not only the articulation impairment but also minor sensory or physiological impairment such as the inability to perform oral diadochokinetic tasks with adequate speed. The results of the present investigation seem to point to the possibility that diadochokinetic tasks could be used at

an early stage to predict those children who do not "grow out" of their problems. However, more research with a large number of subjects is needed to study the validity of this assumption and to establish guidelines for the use of diadochokinetic tests for predictive purposes. The aspects needing specific attention are the intercorrelation of various diadochokinetic tasks, the relationship of age and diadochokinetic performance and the relationship between diadochokinetic rates and type of errors.

In summary, this study indicated that six- and eight-year old children with articulation impairment demonstrated reduced diadochokinetic rates. The larger the number of articulation errors, the greater was the difficulty experienced on both verbal and non-verbal speech tasks of diadochokinesis. The finding of previous studies that several articulation impaired children perform at normal levels on some tests of oral motor functioning was also supported by the study. All children with articulation impairment performed at perfect or near-perfect levels in the imitation of single non-speech oral motor gestures as assessed by an oral apraxia test.

**TABLE 1. Results of Articulation and Diadochokinetic Testing**

**6 YEAR OLDS**

| | Mean | Range | S.D. | Fletcher's (1972) Norms * |
|---|---|---|---|---|
| Articulation Test | 5.29 | 1-11 | 3.41 | |
| Diadochokinetic Test (rep./5 secs) | | | | |
| p ʌ | 20.29 | 15-24 | 3.10 | 20.83 |
| t ʌ | 18.00 | 13-23 | 3.25 | 20.40 |
| k ʌ | 16.43 | 11-22 | 3.50 | 18.18 |
| p ʌ t ʌ k ʌ | 4.57 | 4-6 | .73 | 4.85 |
| Protrusion | 9.14 | 6-14 | 3.14 | |
| Lateralization | 8.71 | 5-14 | 2.96 | |

**8 YEAR OLDS**

| | | | | |
|---|---|---|---|---|
| Articulation Test | 3.5 | 1-6 | 1.71 | |
| Diadochokinetic Test (rep./5 secs) | | | | |
| p ʌ | 21.00 | 18-29 | 2.83 | 23.80 |
| t | 22.33 | 20-30 | 2.29 | 22.72 |
| k ʌ | 21.67 | 19-28 | 2.14 | 20.83 |
| p ʌ t ʌ k ʌ | 7.00 | 5-10 | 1.29 | 6.02 |
| Protrusion | 12.50 | 8-17 | 2.75 | |
| Lateralization | 13.00 | 11-18 | 2.52 | |

*These values were converted from the originals to correspond to the repetitions/5 seconds.

**TABLE 2. Correlations Between Number of Articulation Errors and Diadochokinetic Rates**

| | 6 years old | 8 years old | combined |
|---|---|---|---|
| p ʌ | -.979** | -.800** | -.868** |
| t ʌ | -.919** | -.715* | -.829** |
| k ʌ | -.948** | -.662* | -.833** |
| p ʌ t ʌ k ʌ | -.711* | -.505 | -.569** |
| protrusion | -.767** | -.843** | -.781** |
| lateralization | -.864** | -.605* | -.765** |

* $p < .05$

** $p < .01$

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