The Relationship Between Articulation Disorders and Motor Coordination in Children

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This study was designed to examine the relationship between articulation disorders, soft neurological signs, and motor abilities. Fifteen children with articulation problems, as measured by the Templin-Darley Articulation Screening Test and a connected speech sample, were compared with a normal control group (matched for sex and age) on the Quick Neurological Screening Test, the Imitation of Postures Test (from the Southern California Sensory Integration Tests), and the 1984 version of the Stott Test of Motor Impairment that has been revised by Henderson. A significant difference was found between the groups on the Motor Impairment Test and the Quick Neurological Screening Test, suggesting that as a group, children with articulation deficits are not dyspraxic. This study supports other research findings stating a relationship between articulation problems and motor impairment, but it also indicates that this motor impairment is not necessarily dyspraxia.

Many occupational therapists are involved in remediating problems in motor coordination and dyspraxia in children (Ayres, 1972; Cermak, Coster, & Drake, 1980; Conrad, Cermak, & Drake, 1983). A high incidence of articulation problems has consistently been noted in these children (Abbie, Douglas, & Ross, 1978; Ayres, 1972; Gubbay, 1975). Conversely, speech therapists working with children who have articulation problems have noted that these children have more motor problems than do their peers (Bilto, 1941; Jenkins & Lohr, 1964). This apparent relationship between deficits in articulation and deficits in motor coordination has been examined by a number of investigators (Bernthal & Bankson, 1981) and some studies have indeed found a relationship between severe articulation problems (referred to as developmental apraxia of speech) and problems in motor coordination (sometimes referred to as motor dypraxia) (Bilto, 1941; Jenkins & Lohr, 1964; Prins, 1962). Unfortunately, other studies have indicated that there is no relationship (Aram & Horwitz, 1983; Reid, 1947). In addition, children with motor dyspraxia as well as children with developmental apraxia of speech have been shown to have a higher incidence of soft neurological signs (Kornse, Manni, & Rubenstein, 1981; Rosenbek & Wertz, 1972; Yoss & Darley, 1974), even though one study did not concur with this outcome (Williams, Ingham, & Rosenthal, 1981). Since children are typically identified and treated earlier for speech deficits than they are for motor coordination deficits (Gubbay, 1979; Williams, Ingham, & Rosenthal, 1981), the relationship between these problems ought to be of major concern to occupational therapists because more than 1.3 million children have functional articulation problems (Yoss & Darley, 1974) and are unable to correctly pronounce sounds although they do not display paralysis, weakness, or deformities (Reid, 1947). If a relationship between articulation deficits and problems in motor coordination exists, many of the children being seen for articulation problems should also be screened for motor problems and considered for occupational therapy services.

Various theories have been proposed to explain functional articulation problems in children. At one time articulation problems in children were thought to be similar to the expressive aphasias seen in adults with lesions to Broca's area (Rosenbek & Wertz, 1972). However, it has been shown that articulation problems in children are not the result of specific lesions of the left hemisphere (Kornse, Manni, & Rubenstein, 1981; Rosenbek & Wertz, 1972). It appears that the praxis centers for speech movement may be diffuse in the child's brain, whereas the control of speech is localized in the adult. Thus, the
understanding of adult brain lesions has not provided answers to apraxia in children (Rosenbek & Wertz, 1972).

Motor dyspraxia also has an unknown etiology. Gubser (1975, 1979) has hypothesized a multifactorial etiology to explain motor dyspraxia, which may include perinatal influences and alterations of cerebral organization. Ayres (1972, 1980a) believes that motor dyspraxia is the result of a disorder of sensory integration. Both motor dyspraxia and developmental apraxia of speech seem to be sensitive to interferences from as yet unidentified sources (Jenkins & Lohr, 1964).

This study is designed to further examine the relationship between articulation deficits, soft neurological signs, impairments in motor coordination, and motor dyspraxia. It is hypothesized that children with articulation problems will score more poorly than children without articulation problems on the Quick Neurological Screening Test (Mutti, Sterling, & Spalding, 1978), and on tests of motor coordination and planning, specifically the Test of Motor Impairment (Stott, Moyes, & Henderson, 1984), and the Imitation of Postures test (Ayres, 1980b).

Method

Subjects

The subjects were 30 children from a middle- to upper-middle-income suburban public school in Massachusetts. They ranged in age from 5 to 8 years. Fifteen subjects had functional articulation problems, and 15 subjects (the control group) did not have functional articulation problems.

All subjects in the articulation disorder group were identified by the speech and language pathologist in their school as having articulation problems. In addition, they scored below the -1 standard deviation score on the Templin-Darley Articulation Screening Test (Templin & Darley, 1964) and/or demonstrated 10% or more misarticulated words in a speech sample of 50 connected words. The mean standard score on the Templin-Darley was -1.86 (SD = 1.98), and the mean word error score on the connected speech sample was 24.80% (SD = 19.25%). All children in the articulation group had normal receptive language skills (standard scores equal to or greater than 85) as assessed by the revised Peabody picture vocabulary test (Dunn & Dunn, 1981). The mean score on the Peabody was 114 (SD = 12.7).

The control group was matched with the articulation disorder group by sex and age (within 6 months). The mean age (and standard deviation) for the control and articulation disorder groups was 82.6 months (11.7 months), and 82.7 months (11.7 months), respectively. There were 9 boys and 6 girls in each group. All subjects were free from obvious physical limitations such as deformities, paralysis, and weakness. No child in either group was diagnosed as learning disabled.

Instrumentation

Templin-Darley Articulation Test. The 50-item screening subtest of the Templin-Darley Articulation Test was used to assess the general accuracy of the subjects' articulation. The stimuli are line drawings, and subjects are asked to identify items in the drawing. The subjects' total number of correctly identified items was compared with the mean number of items produced by children of the same age in the standardization sample. A standard deviation score was calculated for each subject.

Connected Speech Sample. Conversational speech was elicited to assess articulation with standard questions asked of the child about his or her address, classroom, and family. The child also named some numbers and colors. The conversational speech was tape-recorded, with the first 50 words being evaluated for articulation disorders. The percentage of incorrect words in the sample was calculated for each subject.

Peabody Picture Vocabulary Test—Revised Form M. This test assesses receptive vocabulary using single words. A raw score is converted to a language quotient related to the age of the subject.

Quick Neurological Screening Test. This is a 15-item screening test, which relates neurological integration to learning. The test aids in the identification of children with learning disorders. Scores were totaled for each subject in accordance with the instructions in the test manual. In addition, scores were categorized as normal, suspicious, or impaired. A score of 25 or less is considered normal; scores between 25 and 50 are considered suspicious, and scores above 50 indicate that a subject is impaired. Prior to categorization, scores were recalculated to take the subjects' age into account.

Test of Motor Impairment—Revised 1984. This test is based on the Oseretsky Tests of Motor Proficiency (Doll, 1946). It is a screening test designed to detect impairment of motor function. Eight items for each age level are presented. These items include ball skills (catching and throwing), unimanual and bimanual dexterity, and static and dynamic balance. Each item is scored with zero points for passing, one point for borderline performance and two points for a performance that has been determined to represent failure. Thus the range of scores is 0–16. Scores are categorized as impaired (4 + points) or nonimpaired (0–3.5 points) motor performance.
**Imitation of Postures Test.** This test is one of the tests of the Southern California Sensory Integration Tests (Ayres, 1980b). It requires the child to assume a series of positions and/or postures demonstrated by the examiner, a process that requires motor planning or programming a skilled or nonhabitual motor act (Ayres, 1980b, p. 5). The test is used to assess motor dyspraxia. Scoring is based on completion or partial completion of the posture, or the inability to assume the posture, and the time it takes to assume the posture. Raw scores are converted to standard scores according to the age of the subject.

**Procedures.** Subjects were tested on the Templin-Darley Articulation Screening Test and a sample of connected speech. If the subject's standard deviation scores were less than −1.0 on the Templin-Darley and/or they made 10% or more errors on the words in the connected speech sample, they were placed in the articulation disorder group. Then all subjects with articulation problems were tested on the revised Pea-body picture vocabulary test and included in the study if they had a language quotient of 85 or greater.

All subjects were tested on the Quick Neurological Screening Test, the Test of Motor Impairment, and the Imitation of Postures test in the order listed. The standardized procedures described in the respective test manuals were followed.

**Results**

The mean and standard deviation for each of the groups on the Quick Neurological Screening Test, the Imitation of Postures test, and the Test of Motor Impairment are shown on Table 1. Between-group analyses were performed on the raw score of the Quick Neurological Screening Test to determine if the articulation disorder group presented more soft neurological signs than the control group. Results indicated a significantly greater number of soft neurological signs in the articulation disorder group \[ F(1,28) = 10.24, p < .01 \].

In addition, scores on the Quick Neurological Screening Test were categorized as normal or suspicious of having a deficit by taking into account the child's age and adjusting the raw score points accordingly. When the age at which 50% of the normative sample passed a specific item was greater than a child's age, the score from this item was not included in the raw score points to determine the category. For example, children under 6 years of age are not expected to pass the palm form recognition test or the sound patterns test; hence points from these two items were not included when the raw scores were categorized as normal or suspicious. In using this method, all subjects in the control group were in the normal category, 10 of the 15 subjects in the articulation disorder group were in the normal category; 5 were in the suspicious group. Using these data, the Fisher Exact Probability Test was calculated with \[ p = .02 \], showing a significant difference between the groups on the Quick Neurological Screening Test categories \( p < .05 \).

Between-group analyses were performed on the Imitation of Postures test scores. The between-group difference was not significant \[ F(1,28) < 1 \].

Between-group analyses were also performed on the number of errors on the Test of Motor Impairment. The articulation disorder group made significantly more errors than the control group \[ F(1,28) = 6.48, p < .05 \]. In addition, scores on the Test of Motor Impairment were categorized as normal or impaired. One subject of the 15 in the normal control group scored in the impaired category on the Test of Motor Impairment and 6 of the 15 subjects in the articulation disorder group scored in the impaired category. The Fisher Exact Probability Test was calculated with \( p = .04 \).

Correlation coefficients were computed between certain tests for the articulation disorder group. A Pearson correlation coefficient was calculated for the connected speech and Templin-Darley scores. The correlation \( r = −0.41 \) approached, but did not reach, significance \( p < .10 \). Similarly, a Pearson correlation coefficient was computed between the Test of Motor Impairment points and the Imitation of Postures test standard score. The correlation was not significant \( r = −0.14 \).

The Interrater analysis was performed comparing two speech therapists on three samples of connected speech. They ranked the three samples in the same order of severity, with differences between two of the samples being 4%, and a difference of 14% (64% and 50%) on one sample.

**Discussion**

The articulation disorder subjects displayed significantly more soft neurological signs when assessed on the Quick Neurological Screening Test than did their normal peers. This is true despite the fact that the Quick Neurological Screening Test is designed to identify children at risk for learning disabilities and none of the subjects were identified as having learning disabilities. Perhaps the younger, 5- and 6-year-old children in this sample had not yet been identi-

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**Table 1**

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<th>Mean and Standard Deviation of Articulation Disorder and Normal Control Subjects on Three Tests</th>
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<td>Group</td>
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<td>Articulation disorder</td>
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<td>Normal control</td>
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Note: QNST = Quick Neurological Screening Test (Mutt, Sterling, & Spalding, 1978); TMI = Test of Motor Impairment (Stott, Moyes & Henderson, 1984); IP = Imitation of Postures test (Ayres, 1980b).
ified. While the number of raw score points alone (not adjusted for age) would have identified 30% of the normal group as being in the suspicious range, and 80% of the children in the articulation disorder group as being in the suspicious or deficit range, the use of raw score points to categorize children as at risk for learning disabilities at the younger ages is hazardous. Although the test purports to be appropriate for children 5 years old and older and uses the same cut-off scores, an examination of the percentages of children passing each item at the younger ages indicated that at the 5-year-old level (5.0), 9 out of 15 items on the Quick Neurological Screening Test are passed by less than 50% of children at this age. A similar but less marked problem exists for 6-year-olds.

When scores were recalculated taking into account the age at which a child passed each item, five of the articulation disorder subjects were still identified as being in the suspicious range. If the presence of an articulation disorder coupled with soft neurological signs can be considered to represent developmental apraxia of speech as is suggested by some researchers (Kornse, Manni, & Rubenstein, 1981; Rosenbek & Weitz, 1972; Yoss & Darley, 1974), then five of the children in the articulation disorder group may be identified as having developmental apraxia of speech. It is interesting to speculate that those subjects with developmental apraxia of speech are more likely to have developmental motor dyspraxia than children with articulation problems without soft neurological signs. Unfortunately, the number of subjects in the current study was not large enough to examine this relationship.

The difference between the articulation disorder group and the control group on the Test of Motor Impairment supports previous research, which indicates that children with articulation problems do less well on motor coordination tests than their peers (Biltz, 1941; Jenkins & Lohr, 1964; Prins, 1962). However, two other studies did not support this type of relationship (Aram & Horwitz, 1983; Reid, 1947). One reason for these different findings may be the type of test used. Studies have used different methods of assessing articulation as well as different methods of assessing motor coordination, thus limiting the accuracy that can be achieved by comparing studies. The finding in this study that, in the articulation group, there was no significant correlation between scores on the Imitation of Postures test and the Test of Motor Impairment supports the suggestion that the different motor tests used in the various studies may be measuring different things. The Test of Motor Impairment is a general test of motor coordination while the Imitation of Postures test more specifically assesses one type of motor planning ability. The children with articulation problems in this study were not dyspraxic as a group, but they were less well coordinated in general motor abilities than were their peers. The fact that this sample did not include children with identified learning disorders may also have influenced the results. The majority of children with developmental dyspraxia appear also to be learning disabled (Abbie, Douglas, & Ross, 1978; Gubyan, 1975, 1979). Perhaps selection of an articulation disorder sample with identified learning-disabled subjects would have presented different results.

An alternative explanation for the finding that children with articulation problems were not dyspraxic deals with the test used. Levine (1985) has suggested that articulation deficits are more clearly related to fine motor planning than gross motor planning. While the Imitation of Postures test is considered the best single indicator of dyspraxia on the Southern California Sensory Integration Tests, it was designed to be used in conjunction with an entire test group (Ayres, 1980b). Moreover, it assesses only one aspect of praxis. Ayres (1985) has suggested that, because of an underlying general cognitive or conceptual basis, motor planning may be more clearly related to receptive language than to expressive language. The new Sensory Integration and Praxis Tests (Ayres, 1985) include six different tests measuring elements of motor planning, including constructional praxis, praxis to verbal command, graphic praxis, sequencing praxis, and oral praxis, as well as the ability to imitate postures. The use of a variety of tests of praxis will provide more detailed information on the relationship between dyspraxia and articulation problems. Recently, in a sample of 182 children with known or suspected sensory integrative dysfunction, Ayres and Mailoux (1985) found a moderate correlation (r = .42) between the Imitation of Postures test and the Oral Praxis test, the new Sensory Integration and Praxis test that most closely relates to oral dyspraxia (Ayres, 1985). However, the association between the Oral Praxis test and a test of manual motor sequencing, the Sequencing Praxis test, was even higher (r = .56), suggesting a general sequencing function common to both manual and oral tasks (Ayres, 1985; Ayres & Mailoux, 1985). The Oral Praxis test was also somewhat related to bilateral motor execution (Ayres & Mailoux, 1985).

The relationship between the measures of articulation was examined in the articulation group. No significant correlation was found between scores on the Templin-Darley and the connected speech samples. Several subjects who did not score impaired on one of these tests did score impaired on the other, and vice versa. Three subjects did not score impaired on the Templin-Darley although their connected speech scores demonstrated an error rate ranging from 10% to 18%. The one subject who did not score in the impaired range on the connected speech sample had a standard deviation score of -3.9 on the Templin-Darley. There are several reasons why the two articulation tests did not highly correlate with
each other. Some children can control their articulation problem and correctly articulate single words in a screening test such as the Templin-Darley although they cannot control their articulation in connected speech (Bernthal & Bankson, 1981). The subject who scored well on the connected speech sample and did poorly on the Templin-Darley did so because, in the connected speech sample, she did not use many words containing sounds she commonly misarticulated. One limitation of the connected speech sample is the inability of the tape recorder to accurately record misarticulated, high-frequency syllable sounds, such as the s sound, which is a frequently misarticulated phoneme (Bernthal & Bankson, 1981).

The results of this study have several implications for occupational therapists. First, the relationship between articulation problems and motor coordination suggests that occupational therapy screening for motor coordination disorders should be considered in children with articulation problems. Second, occupational therapy using sensory integration procedures has been found to improve language in children with sensory integration problems (Clark & Steingold, 1982). While articulation is a speech disorder rather than a language disorder, it may be that if the articulation problems are found to be related to a motor planning disorder (with a somatosensory conceptual base) when comprehensive manifestations of motor planning are assessed, then sensory integration procedures may influence both motor dyspraxia and developmental apraxia of speech. Clark and Steingold (1982) have eloquently elaborated this rationale. While controlled trials are necessary to validate this approach to treatment, it is interesting to note that some speech therapy treatment manuals for articulation disorders include gross and fine motor activities (Bilto, 1941).

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