LITERATURE REVIEW

MOTOR COORDINATION AND VERBAL SKILLS:

DOES PRACTICE WITH GROSS AND FINE MOTOR SKILL TASKS AFFECT SPEECH ARTICULATION?

By

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For

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PSYC 4105

Previous research has identified a positive correlation between fine motor skills of the hands and verbal abilities including comprehension and articulation. The present study examined the effect of practicing tasks to improve motor coordination on speech articulation. Sixteen children in junior and senior kindergarten were pre-tested on measures of manual dexterity and articulation. On the basis of their scores, children were assigned to 1 of 4 groups: gross motor activities, fine motor activities, verbal activities, or regular classroom activities. The children practiced their activities for 20 minutes each day for one week, after which they were tested again on manual dexterity and articulation. The results were analyzed for improvements within the groups and for differences in improvements between the groups. Results are discussed in relation to previous findings.

Motor Coordination and Verbal Skills:

Does practice with gross and fine motor skill tasks affect speech articulation?

The purpose of this study is to examine further the relationship between motor skills and verbal abilities, specifically, by looking at the effect of enhancing motor coordination on speech articulation. In their first two years of life, children typically make considerable progress in language and motor development. Initially able to produce only reflexive cries and nonverbal sounds, during this period most children acquire a substantial vocabulary and learn to form simple multiword sentences. From a very limited repertoire of motor reflexes at birth, normal infants progress to being able to walk, negotiate stairs, and even to run fairly well by the age of two. In general, the processes of early speech and motor development are seen as occurring in a synchronous fashion. Their acquisition follows an orderly progression, with advances in speech and motor skills interrelated to considerable extent, in that progress in spoken language frequently occurs after a spurt in motor development (Bonvillian, Orlansky, and Novack, 1983).

Gross motor and upper extremity motor functioning are positively correlated with cognitive and verbal skills in young children (Annett, 1970; Bishop & Williams, 1992; Smirni & Zappala, 1989; Williams, Bishop, & Cooper, 1991), but the question remains: how does this relationship work? Are they related simply as a matter of brain maturity or do they influence each other as well? Former research has concentrated on discovering the relationships between motor functioning and speech and language skills. Although some researchers (Annett,

1970; Smirni & Zappala, 1989) suggest that improved manual skills, especially left hand functioning, are significant for the growth of verbal ability, the question of whether or not simple exercises designed to improve one set of skills could improve the other set has not yet been studied. For example, will enhancing motor performance affect verbal skills? Or, will practicing verbal skills affect motor performances?

Ramsey (1984) observed 5-month-old infants in an attempt to predict and observe synchronies in development. He found that unimanual right handedness emerged during the same week that duplicated syllable babbling began. He stated that the clear temporal correspondence between the emergence of hand preference and babbling suggest a reorganization in asymmetrical control of manual and vocal functions at this point in development.

Annett (1970) examined the growth of manual skill for each hand separately over a wide age range (from 3.5 years of age to 15 years of age) to establish norms for speed of movement which can be used for the assessment of manual disability. A test of vocabulary was used to give an indication of the intelligence distribution of the sample. Two hundred and nineteen children aged from 3.5 years to 15 years were tested individually with a peg-moving task, a vocabulary test, and 7 hand preference tasks. When the subjects were classified as right-, mixed, or left-handed on the basis of preferences, mixed-handers tended to be more widely distributed in vocabulary score, being more numerous than right-handers at the bottom and at the top of the scale. The vocabulary distribution of

the left-handers was displaced toward the upper ability range. When the subjects were grouped according to relative manual speed rather than preferences, the vocabulary means of left- and mixed handers were higher than those of right-handers. Subjects with very low vocabulary scores tended to be slow with both hands, but particularly the left. Annett concluded that skill in the left hand is especially significant for the growth of verbal ability.

Smirni and Zappala (1989) felt that the degree and type of manual preference might influence cognitive performance. The aim of their study was to determine the correlation between verbal and visuospatial performance for direction and extent of manual specialization and fine motor ability of both hands. Forty-seven children between the ages of 4 years, 6 months and 6 years, 4 months were given a test battery that included a manual dexterity task (grooved pegboard); an auditory comprehension task (token test); a verbal fluency test (set test); a constructional praxis test (Block design); and a visual perception test (form discrimination). No significant correlation was found between direction and extent of manual specialization and verbal and visuospatial skills. However, manual ability was significantly correlated with performance on both the set test (comprehension) and the Block design. The authors state that increased motor abilities, including speed and coordination, of both hands is important as the dexterity of the non-preferred hand is highly correlated with cerebral maturation to the same extent as the preferred hand.

Carroll, Fuller, and Lindley (1989) suggest that educators should consider visual-motor training for children experiencing articulation disorders. They assessed the differences between children with diagnosed functional articulation disorders and a control group on visual-motor ability. The Sounds-in-Words subtest of the Goldman-Fristoe Test of Articulation was used to determine the presence or absence of an articulation disorder. The Minnesota Percepto-Diagnostic Test - Revised was used as a measure of visual-motor accuracy. Their result show that the articulation- disordered groups performed significantly more poorly than did the control group. A significant correlation was found between the MPD-R errors and articulation errors on the Sounds-in-Words subtest; as visual-motor performance (rotation of figures) deteriorated, articulation errors increased.

When comparing vocal and manual control in children with normal speech/language, children with articulation disorders, and children who stutter Bishop, Williams, and Cooper (1991) found that overall reaction time decreased with age and both speech-disordered groups were slower than controls. Vocal reaction times were longer than manual times and reaction time increased with increased task complexity. A significant two-way interaction between age and task indicated that the greatest differences in vocal and manual performance occurred at the young ages for all groups. Variability of performance decreased as age increased; stutterers had significantly more variable reaction times than non-stutterers; and performances on vocal tasks were more variable than those on manual tasks. The results of this study appear to support the idea that both the

young stuttering and articulation-disordered populations have a constitutional predisposition to slower sensory-motor performance common to speech-motor and manual-motor systems.

A second study by Williams and Bishop (1992) examined the speed and consistency of manual movements of young stutterers, articulation-disordered children, and children with normal speech. This study was concerned with the notion that a part of the difficulty underlying selected speech disorders in children is a widespread slowness and inconsistency of processes in producing and carrying out motor responses. The average movement time results show significant main effects of group, age, and task complexity. Overall, there was a significant increase in the speed of manual movements with age. Movement times slowed with increased task complexity for all ages and groups. Stutterers and articulation-disordered children were significantly slower than children with normal speech. Variability of movement time increased as a function of task complexity for both the normal and the articulation-disordered children. Stutterers' movement times were as variable on the simple task as they were on the more complex task. Motor-control processes of speech-disordered and normal children appear to be similar in that the proportion of total response time allotted to planning versus executing manual movements was dependent on task complexity. These data suggest that execution of manual motor responses of speech-disordered children are generally less efficient (e.g. slower and more variable) than children with normal speech development.

In an attempt to predict fine motor skills of children having language and speech disorders Sommers (1988) tested 37 children using a battery of expressive and receptive language test, a measure of fine motor performance, a dichotic listening test, and individual intelligence tests. IQs and mental ages were not related to fine motor skills. The strongest relationship was found between auditory comprehension and fine motor skills. Significant but weaker links to motor skills were found on each spoken language test. Fine motor skill indices could be predicted by expressive and receptive language test scores when combined with chronological age and the dichotic right-ear test score.

The process of crawling provides a state of eye-hand coordination, vestibular processing, improvement of balance and equilibrium, spatial awareness, tactile input, kinesthetic awareness, and social maturation (McEwan, Dihoff, & Brosvic, 1991). McEwan et al. (1991) examined the hypothesis that children with early crawling experience would show normative performance on selected sub-tests of the Miller Assessment for Preschoolers (MAP), while the performance of children lacking such experience would be lower. A parental questionnaire concerning motor skill, especially creeping and crawling, produced a sample of 10 crawlers and 10 non-crawlers, who were then matched on the basis of sex and age. Five sub-tests were selected from the MAP to provide insight into the children's development of body schema, visual-spatial abilities, and upper extremity motor planning skill. For 4 of the sub-tests, no significant differences were found between the two groups, although the non-crawlers median performance was at

least one decile below that of the crawlers. The average score for the crawlers on the fifth sub-test (Imitation-of-Posture) was significantly higher than that of the non-crawlers, as was the average score for all five sub-tests. The authors suggest that children deficient in motor planning abilities and proprioceptive functioning should benefit from increased floor and mat activities requiring high tactile, proprioceptive, and kinesthetic input.

A positive correlation between crawling and manual skills suggested by McEwan, et al. (1991) and a similar correlation between manual dexterity and verbal skills suggested by Smirni and Zappala (1989) and others (Sommers, 1988; Carroll, Fuller, & Lindley, 1989; Bishop, Williams, & Cooper, 1991; Williams & Bishop, 1992) suggests that improvements in either physical or verbal performances should effect similar improvements in the other. As the overall maturation of the speech centers in the brain are behind that of the motoric centers at birth, and the development of the speech centers proceeds at a slower pace (Bonvillian, Orlansky, & Novack, 1983), I hypothesized that practice movements designed to advance motor coordination could improve verbal abilities as well. The present experiment deals with the following questions: Will practice with gross motor movements improve fine motor skills and verbal abilities?; Will practice with fine motor movements improve verbal abilities?; and Will these treatments improve verbal abilities more than practicing verbal skills will?

Annotated Bibliography

Annett, M. (1970) The growth of manual preference and speed. *British Journal of Psychology, 61*, 545-558.

The primary purpose of this study was to examine the growth of manual skill for each hand separately over a wide age range and to establish norms for speed of movement which can be used for the assessment of manual disability. 219 children aged from 3.5 years to 15 years were tested individually with a peg-moving task, a vocabulary test (the Peabody Picture Vocabulary Test), and 7 hand preference tasks. The proportions of right-, mixed-, and left-handers among younger and older children were remarkably similar. Differences between the hands in manual speed do not increase with age. In fact, the means and standard deviations for age-groups show a systematic trend toward greater speed and smaller variation with growth. There was a linear relationship between degree of hand preference (right, mixed-right, mixed-left, and left) and degrees of relative manual skill. When the subjects were classified as right-, mixed, or left-handed on the basis of preferences, mixed handers tended to be more widely distributed in vocabulary score, being more numerous than right-handers at the bottom and at the top of the scale. The vocabulary distribution of the left-handers was displaced toward the upper ability range. When the subjects were grouped according to relative manual speed rather than preferences, the vocabulary means of left- and

mixed handers were higher than those of right-handers. Subjects of very low vocabulary score tended to be slow with both hands, but particularly the left. The results of this study indicate that skill in the left hand is especially significant for the growth of verbal ability.

Bishop, J. H.; Williams, H. G.; & Cooper, W. A. (1991) Age and task complexity variables in motor performance of children with articulation-disordered, stuttering, and normal speech. *Journal of Fluency Disorders, 16*, 219-228.

The purpose of this study was twofold 1) to compare vocal and manual control in young stutterers, articulation-disordered children, and children with normal speech/language, and 2) to examine the effects of age and task complexity on vocal and manual motor control in different speech-disordered groups. The subjects were 72 caucasian boys between the ages of 3 years and 10 years, 11 months. Three manual tasks and three vocal tasks of increasing complexity were performed by all children. The order of task complexity was randomized for each subject. All vocal tasks were presented together, as were all manual tasks. Overall reaction time decreased with age and both speech-disordered groups were slower than controls. Vocal reaction times were longer than manual times and reaction time increased with increased task complexity. A significant two-way interaction between age and task indicated that the greatest differences in vocal and manual performance occurred at the young ages for all groups. An analysis of the results of the standard deviations of reaction times indicate that main effects of age, group, and task were significant. Variability of performance decreased as age increased; stutterers had significantly more variable reaction times than non-stutterers; and performances on vocal tasks were more variable than those on manual tasks. The results of this study appear to support the idea that both the young stuttering and articulation-disordered populations have a constitutional

predisposition to slower sensory-motor performance common to speech-motor and manual-motor systems.

Bonvillian, J. D.; Orlansky, M. D.; Novack, L. L. (1983) Developmental milestones: sign language acquisition and motor development. *Child Development, 54*, 1435-45.

The visual cortex matures prior to the auditory cortex, facilitating the onset of a visual language system before an aural-oral system. This study examines the early sign language acquisition of eleven young children aged 4 mo. to 3 yr. as well as the relative proportion of iconic signs (resemble the objects or actions for which they stand) in their vocabulary. The experimenters visited the children in their homes for one hour every 5-6 weeks for a period of 16 months. During each visit they made a written record of the children's motor skill and their expressive and receptive sign language vocabulary, as well as a videotape of their sign productions. The subjects attained motor milestones within the expected age ranges reported in normative studies. However, they attained in sigh language the corresponding spoken language milestones several months in advance: for example, the mean age at which they produced their first recognizable sign was 8.5 months. They had a vocabulary of 10 different signs at a mean age of 12 months, and by 18 months the subjects had a mean vocabulary of 48.7 signs. The mean age at which the subjects first began to combine signs was 17 months. The proportion of iconic signs in the subjects' vocabulary was 33.2%. 35.4 % of the signs were metonymic (use a relatively small aspect or feature of the referent). The rest, 31.4% had arbitrary meanings. Thus, a full two thirds of their early signs did not have readily transparent meanings. The subjects accelerated

vocabulary development cannot be attributed soley on more advanced motor skills as there was no clear-cut relationship between early vocabulary growth and the ages at which subjects passed the different motor milestones.

Carrol, J. L.; Fuller, G. B.; & Lindley, K. E. (1989) Visual-motor ability of children with articulation disorders. *Perceptual and Motor Skills, 69*, 32-34.

This study assessed the differences between children with diagnosed functional articulation disorders and a control group on visual-motor ability. The articulation-disordered group, composed of 34 children aged 3.5 years to 15 years old enrolled in speech therapy, was matched with the control group according to age, sex, teacher, and grade. The Sounds-in-Words subtest of the Goldman-Fristoe Test of Articulation was used to determine the presence or absence of an articulation disorder. The Minnesota Percepto-Diagnostic Test - Revised was used as a measure of visual-motor accuracy. A t-test on MPD-R rotation errors between the two groups showed that the articulation- disordered groups performed significantly more poorly than did the control group. A significant correlation was found between the MPD-R rotation T scores and articulation errors on the Sounds-in-Words subtest; as visual-motor performance (rotation of figures) deteriorated, articulation errors increased.

McEwan, M. H.; Dihoff, R. E.; Brosvic, G. M. (1991) Early infant crawling experience is reflected in later motor skill development. *Perceptual and Motor Skills, 72*, 75-79.

The process of crawling provides a state of eye-hand coordination, vestibular processing, improvement of balance and equilibrium, spatial awareness, tactile input, kinesthetic awareness, and social maturation. This study examined the hypothesis that children with early crawling experience would show normative performance on selected subtests of the Miller Assessment for Preschoolers (MAP), while the performance of children lacking such experience would be lower. A parental questionnaire concerning motor skill, especially creeping and crawling, produced a sample of 10 crawlers and 10 non-crawlers, who were then matched on the basis of sex and age. Five subtests were selected from the MAP to provide insight into the children's development of body schema, visual-spatial abilities, and upper extremity motor planning skill. For 4 of the subtests, no significant differences were found between the two groups, although the non-crawlers median performance was at least one decile below that of the crawlers. The average score for the crawlers on the fifth subtest (Imitation-of-Posture) was significantly higher than that of the non-crawlers, as was the average score for all five subtests. The authors suggest that children deficient in motor planning abilities and proprioceptive functioning should benifit from increased floor and mat activities requiring high tactile, proprioceptive, and kinesthetic input.

Ramsey, D. S. (1984) Onset of duplicated syllable babbling and unimanual handedness in infancy: evidence for developmental change in hemispheric specialization? *Developmental Psychology, 20*, 64-71.

This study used a longitudinal design to test for a developmental relation between unimanual handedness and duplicated syllable babbling. Thirty infants were tested for unimanual handedness at weekly intervals from 5 mo. for about 14 weeks. Each session was videotaped for later scoring. During each visit, mothers reported whether their infants started or continued to babble that week. Unimanual right handedness emerged on the same session that duplicated syllable babbling started. It was not present 3 and 4 weeks after the onset of duplicated syllable babbling, but reemerged on the fifth session. Ramsey offers two possible explanations for his results. First, increased left hand activity might reflect release of inhibition by the left hemisphere, and the reemergence of unimanual handedness might indicate a new level of motoric dominance by left-brain structures over both right and left handed activities, for example, bilateral hand movements like clapping and patticake. The other possibility is that this discontinuity reflects a disruption in activities mediated by the dominant hemisphere caused by the emergence of new skill mediate by the non-dominant hemisphere, for example, right-hemisphere specialization for certain perceptual and emotional abilities.

Smirni, P. & Zappala, G. (1989) Manual behavior, lateralization of manual skill and cognitive performance of preschool children. *Perceptual and Motor Skills, 68*, 267-72.

Degree and type of manual preference might influence cognitive performance. The aim of this study was to show the presumed correlation between verbal and visuospatial performance for direction and extent of manual specialization and fine motor ability of both hands. The subjects were 47 children from 4 yr. 6 mo. of age to 6 yr. 4 mo. The test battery included a manual dexterity task (grooved pegboard); an auditory comprehension task (token test); a verbal fluency test (set test); a constructional praxis test (Block design); and a visual perception test (form discrimination). No significant correlation was found between direction and extent of manual specialization and verbal and visuospatial skills. However, manual ability was significantly correlated with performance on both the set test (comprehension) and the Block design.

Sommers, R. K. (1988) Prediction of fine motor skills of children having language and speech disorders. *Perceptual and Motor Skills, 67*, 63-72.

This study investigated the following questions: 1) What single relationships exist between language and speech scores, chronological age, and right-ear dichotic scores and an index of fine motor skills?; 2) To what extent will these relationships contribute substantially to prediction of fine motor skill performance?; and 3) Will subjects show normal right-ear dichotic processing? Thirty-seven children, ages 5 to 9 years were studied using a battery of expressive and receptive language test, a measure of fine motor performance, a dichotic listening test, and individual intelligence tests. IQs and mental ages were not related to fine motor skills. The strongest relationship was found between auditory comprehension and fine motor skills. Significant but weaker links to motor skills were found on each spoken language test. Fine motor skill indices could be predicted by expressive and receptive language test scores when combined with chronological age and the dichotic right-ear test score.

Williams, H. G. & Bishop, J. H. (1992) Speed and consistency of manual movements of stutterers, articulation-disordered children and children with normal speech. *Journal of Fluency Disorders, 17*, 191-203.

This study was concerned with the notion that a part of the difficulty underlying selected speech disorders in children is a widespread slowness and inconsistency of processes in producing and carrying out motor responses. The subjects were 54 caucasian boys between the ages of 5 years and 10 years, 11 months. Two manual tasks of increasing complexity were performed by all the children. The order of task complexity was randomized for each child. The average movement time results show significant main effects of group, age, and task complexity. Overall, there was a significant increase in the speed of manual movements with age. Movement times slowed with increased task complexity for all ages and groups. Stutterers and articulation-disordered children were significantly slower than children with normal speech. Variability of movement time increased as a function of task complexity for both the normal and the articulation-disordered children. Stutterers' movement times were as variable on the simple task as they were on the more complex task. Motor-control processes of speech-disordered and normal children appear to be similar in that the proportion of total response time allotted to planning versus executing manual movements was dependent on task complexity. These data suggest that execution of manual motor responses of speech-disordered children are generally less

efficient (e.g. slower and more variable) than children with normal speech development.

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MOTOR COORDINATION AND VERBAL ABILITIES:

DOES PRACTICE WITH GROSS AND FINE MOTOR SKILL TASKS AFFECT SPEECH ARTICULATION?

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Previous research has identified a positive correlation between fine motor skills of the hands and verbal abilities including comprehension and articulation. The present study examined the effect of practicing tasks to improve motor coordination on speech articulation. Sixteen children in junior and senior kindergarten were pre-tested on measures of manual dexterity and articulation. On the basis of their scores, children were assigned to 1 of 4 groups: gross motor activities, fine motor activities, verbal activities, or regular classroom activities. The children practiced their activities for 20 minutes each day for one week, after which they were tested again on manual dexterity and articulation. The results were analyzed for improvements within the groups and for differences in improvements between the groups. Results are discussed in relation to previous findings.

Motor Coordination and Verbal Skills:

Does practice with gross and fine motor skill tasks affect speech articulation?

In their first two years of life, children typically make considerable progress in language and motor development. Initially able to produce only reflexive cries and vegetative sounds, during this period most children acquire a substantial vocabulary and learn to form simple multiword sentences. And from a very limited repertoire of motor reflexes at birth, normal infants progress to being able to walk, negotiate stairs, and even to run fairly well by the age of two years.

In general, the processes of early speech and motor development are seen as occurring in a synchronous fashion (Bonvillian, Orlansky, & Novack, 1983). Their acquisition follows an orderly progression, with advances in speech and motor skills interrelated to a considerable extent. Progress in spoken language frequently occurs after a spurt in motor development (Bonvillian, Orlansky, &Novack, 1983; Ramsey, 1984). Research has shown that gross motor and upper extremity motor functioning is positively correlated with cognitive and verbal skills in young children (Annett, 1970; Bishop & Williams, 1992; Smirni & Zappala, 1989; Williams, Bishop, & Cooper, 1991), but the question remains: how does the relationship work? Are they related simply as a matter of brain maturation of do they influence each other as well? Other research has concentrated on discovering the relationships between motor functioning and speech and language skills. Although some researchers (Annett, 1970; Smirni & Zappala, 1989) have suggested that improved manual skills, especially left hand functioning, is

significant for the growth of verbal ability, it has not yet been studied whether or not a simple exercises designed to improve one set of skills could improve the other. For example, will enhancing motor performance affect verbal skills? Or, will practicing verbal skills affect motor performances?

Studies examining the relationship between motor skills and verbal abilities report only correlational data. For example Ramsey (1984) observed five-month-old infants and found that unimanual right-handedness emerged during the same week that duplicated syllable babbling began. Other researchers have found that manual ability of both hands is significantly correlated with vocabulary performance (Annett, 1970; Smirni & Zappala, 1989). Carroll, Fuller , and Lindley (1989) reported that children with articulation difficulties have poorer visual-motor performance than children without articulation difficulties. Studies comparing the motor performance of children with articulation-disordered, stuttering, and normal speech suggest that execution of manual motor responses of speech-disordered children are generally less efficient (e.g. slower and more variable) than children with normal speech development (Bishop, Williams, & Cooper, 1991; Williams & Bishop, 1992). Expressive and receptive language test scores have been found to be moderately highly correlated with fine motor skills, and that these scores, in concert with chronological age and a dichotic right-ear test score, can predict fine motor-skill indices substantially (Sommers, 1988).

The purpose of this study was to examine further the relationship between motor abilities and verbal skills. As the overall maturation of the speech centers in

the brain are behind that of the motoric centers at birth, and the development of the speech centers proceeds at a slower pace (Bonvillian, Orlansky, & Novack, 1983), I hypothesized that practice movements designed to advance motor coordination would improve verbal abilities as well. Also, McEwan, Dihoff, and Brosvic (1991) found evidence of a significant relationship between crawling in infancy and upper-extremity motor planning skills. Therefore the following questions were investigated: (a) Will practice with gross motor movements improve fine motor skills and verbal abilities?; (b) Will practice with fine motor movements improve verbal abilities?; and (c) Will these treatments improve verbal abilities more than verbal interaction will?

Method

Participants

Seven children in junior kindergarten (3 girls, 4 boys) and nine children in senior kindergarten (4 girls, 5 boys) at St. Mark's Roman Catholic school in Sault Ste Marie were examined. The children ranged in age from 4 years, 4 months to 5 years, 10 months. Parents of these children completed a consent form which included a background questionnaire concerning motor skills, especially crawling, and language skills to provide additional information on the children's previous motor and verbal development. Each child was assigned to one of four groups based on their preliminary test scores.

Tests

Manual dexterity task: Pegboard The board was 2 cm thick, 45.7 cm long by 23.3 cm wide, with 30 holes 2.8 cm in diameter placed 2 cm apart in 5 rows of six. The pegs were 2.5 cm in diameter and 5 cm long. The children were asked to place as many pegs in the holes as they could in 30 seconds. The task was repeated alternately, twice for each hand (a total of 1 minute for each). Manual dexterity was calculated as the total number of pegs placed with both hands.

Articulation task: The Sounds-in-Words subtest of the Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1972) The children were required to produce single word responses of potentially troublesome words. The test scores the number of errors made. To get a measure of articulation ability the number of errors made was subtracted from the total number of errors possible.

Verbal comprehension task: Token test The children were presented with 15 cards, each showing two drawings. They were asked to point to the correct item when questioned about size, shape, or colour.

Procedure

The children were tested two or three at a time with the test battery in a familiar room equipped with child-sized furniture at the school in which the child was enrolled. After testing they were assigned to one of four groups. The groups were: the gross motor movement group (Group 1), the fine motor movement group (Group 2), the verbal activity group (Group 3), or the no treatment group (Group 4). Groups 1, 2, and 3 were taken to the school gymnasium. Group 1 was given animal movements (crawling, slithering, and jumping); ball movements

(throwing, catching, kicking, and rolling); and played follow-the-leader (walking the balance beam, running, forward and backward rolls) in order to enhance gross motor coordination. Group 2 was given a bead roller-coaster, laces to strings through beads, as well as picture puzzles to sew together in order to enhance manual dexterity. Group 3 was read a story and asked questions about the story in order to strengthen verbal comprehension and communication. Group 4 followed the regular classroom schedule with the teacher (either free play, show and tell, or snack). Each treatment session lasted for 20 minutes each day between 10:30 am and 11:15 am each day. After a week of practice, each child was again tested with the manual dexterity task and the articulation task. The verbal comprehension task was eliminated from the test battery as most of the participants made no errors and fewer than 20% made more than one error.

Results

Mean scores are reported in Table 1. No significant correlations were found between crawling and manual dexterity (0.098 and 0.153). Positive correlations were found between manual dexterity and articulation ability (0.340 and 0.292). An analysis of variance was done using Groups (4) as a between subjects factor and Time (2) as a within subjects factor. Overall there was an increase in articulation ability from the first test session to the second test session ($F1, 30 = 2.31, p = 0.139$), but no significant increase in manual dexterity between the two test sessions ($F1, 30 = 0.94, p = 0.340$). Also, no significant differences were found between the groups on increases in articulation ability ($F3, 12 = 0.22$,

$p = 0.879$) or on increases in manual dexterity ($F3, 12 = 0.53, p = 0.670$). There were no interactions.

MEASURE		GROSS MOTOR	FINE MOTOR	VERBAL	CONTROL
Articulation Ability (1)	M	65.75	65	66.25	66.75
	SD	6.75	5.29	7.04	6.08
Articulation Ability (2)	M	68	68.75	68.25	69.25
	SD	6.38	2.99	4.65	2.06
Manual Dexterity (1)	M	47.25	48.75	50	47.75
	SD	5.68	6.45	10.55	5.56
Manual Dexterity (2)	M	51.25	52.5	53.25	46.75
	SD	8.06	7.94	11.5	4.11

Table 1: Mean Articulation and Manual Dexterity Scores

Discussion

Present data show much weaker correlations than those found in previous research. Very small increases in articulation ability and manual dexterity were found. No significant differences were found between the groups on increases in articulation ability or manual dexterity. The weak correlations and non-significant results could be explained by the small number of participants in the present study (16) when compared to the number of children studied in previous research (from a low of 20 to a high of 219). As the Sounds-in-Words Subtest of the Goldman-Fristoe Test of Articulation has a test-retest validity of 95%, the overall increase in articulation ability scores can be assumed to be due to an actual increase in ability.

That all groups increased about the same amount suggests that there was an effect of time, but no effect of treatment.

Several difficulties were encountered during the course of this experiment. First, as a result of the lack of parental participation on the consent form and questionnaire, the sample size was reduced from 37 to 17. One child's results were excluded because he was absent on the final day of testing. Another difficulty was the short amount of time between testing sessions. This was due to the March break, P.D. days, and class trips out of the school. A final difficulty was that the practice sessions were not at the same time every day. Although we were given permission to use the school gymnasium each day from 10:30 am to 10:50 am, we often had to wait for another class to finish with the gym or we were interrupted by another class wanting to use the gym.

Although the results of the treatment sessions were not significant this does not suggest that enhancing motor coordination has no effect on articulation. McEwan et al. indicate that children deficient in motor-planning abilities should benefit from floor and mat activities. Others suggest visual-motor training for children experiencing articulation difficulties (Carrol, Fuller, & Lindley, 1989). Further study is needed with larger sample sizes and a longer treatment period.

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