
Effectiveness of School-Based Occupational Therapy Intervention on Handwriting

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KEY WORDS

- handwriting legibility and speed
- manipulation
- visual motor

OBJECTIVE. This study investigated the effects of school-based occupational therapy services on students' handwriting.

METHOD. Students 7 to 10 years of age with poor handwriting legibility who received direct occupational therapy services ($n = 29$) were compared with students who did not receive services ($n = 9$) on handwriting legibility and speed and associated performance components. Visual-motor, visual-perception, in-hand manipulation, and handwriting legibility and speed were measured at the beginning and end of the academic year. The intervention group received a mean of 16.4 sessions and 528 min of direct occupational therapy services during the school year. According to the therapists, visual-motor skills and handwriting practice were emphasized most in intervention.

RESULTS. Students in the intervention group showed significant increases in in-hand manipulation and position in space scores. They also improved more in handwriting legibility scores than the students in the comparison group. Fifteen students in the intervention group demonstrated greater than 90% legibility at the end of the school year. On average, legibility increased by 14.2% in the students who received services and by 5.8% in the students who did not receive services. Speed increased slightly more in the students who did not receive services.

CONCLUSION. Students who received occupational therapy services demonstrated improved letter legibility, but speed and numeral legibility did not demonstrate positive intervention effects.

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In a recent survey of 167 occupational therapists who work in Ohio schools, 98% reported that they receive referrals for students with handwriting problems (Tait, 1998). These results are similar to those reported by Chandler (1994), who analyzed surveys returned from more than 900 school-based therapists across the United States and found that the most common reason for referral to occupational therapy was handwriting problems. Because of the increased prevalence of computer word processing, some persons regard handwriting as a lost art; however, written expression remains an important part of elementary school curricula (Amundson, 2001). Handwriting constitutes the primary way that elementary school students demonstrate their knowledge in all academic areas.

When handwriting is poor (i.e., illegible), a teacher may interpret the student's written responses as incorrect or as an indication of noncompliance (i.e., the student is not making an effort to be neat). Students who have difficulty with handwriting must concentrate on correctly forming letters and may attend less to the subject matter or to the instructor. The student may turn in shortened written responses because the motor effort is fatiguing. Academic failure can result from any of these problems associated with poor handwriting (Tseng & Cermak, 1993).

Variables Associated With Handwriting

The performance components that relate to handwriting skill have been well researched. One consistent finding is the importance of visual-motor integration to handwriting legibility (Cornhill & Case-Smith, 1996; Tseng & Murray, 1994). Tseng and Murray (1994) reported that the 143 children in their sample with poor (i.e., illegible) handwriting had low scores on perceptual-motor measures. In addition, the children scored lower on fine motor measures than children with good handwriting. Cornhill and Case-Smith (1996) found similar results: Both visual-motor and in-hand manipulation skills correlated highly with handwriting skill in second-grade students. Weil and Amundson's (1994) study of kindergarten students demonstrated strong relationships between visual-motor skills and handwriting. Berninger and Rutberg (1992) examined additional variables and found that a fine motor task (sequentially touching the thumb to the tip of each finger) had the strongest correlation with handwriting.

Intervention for Handwriting Problems

The occupational therapy literature is replete with theories, principles, and strategies to promote handwriting and manipulation in school-age children (Amundson, 2001; Benbow, Hanft, & Marsh, 1992; Chu, 1997). Benbow (1990, 1995) proposed a biomechanical or "kinesthetic" approach to handwriting remediation. She hypothesized that handwriting is primarily a kinesthetic skill that improves when the hand is biomechanically, motorically, and perceptually prepared to hold utensils and create written forms. Benbow (1990) developed a curriculum that teaches children the basic movements of letter formation by practicing letters grouped according to shape. Visual and kinesthetic cues are used to reinforce the child's perceptions of those movements. Olsen (1999) also has written a handwriting curriculum that uses a developmental approach, grouping the letters by difficulty and teaching a handwriting style that uses simple, vertical lines.

Other authors (e.g., Amundson, 2001; Chu, 1997) have recommended using a combination of approaches based on the students' individual problems. Sensory integrative interventions often emphasize tactile and vestibular input and are believed to help children increase their ability to attend and focus. These approaches also seem to benefit students with poor motor planning (Cermak, 1991). Emphasis on the neuromotor and biomechanical aspects of handwriting can benefit children with low muscle tone, postural instability, and weakness (Amundson, 2001). If handwriting interventions have limited effects on improving legibility, then compen-

satory methods may be of greater benefit to students and a more effective use of public school resources.

In recent years, students with illegible handwriting can perform a majority of their written work on a computer or word processor. Work sheets can be scanned into the computer and completed with a keyboard. Light-weight word processors can be transported and set up easily in the classroom, removing many of the barriers to using a computer for classroom written work.

Although theories and strategies to remediate handwriting problems have proliferated in recent years, empirically based evidence documenting handwriting intervention effectiveness is minimal. Published studies on handwriting efficacy use single-subject design (Lockhart & Law, 1994) or do not directly measure handwriting as the dependent variable (Oliver, 1990). Efficacy studies of school-based occupational therapy have focused on the development of hand skills (Case-Smith et al., 1998; Davies & Gavin, 1994) rather than on handwriting performance. Student outcomes in handwriting when occupational therapy services are provided need further study.

Research Questions

The purpose of this study was to examine the effects of school-based occupational therapy on children's handwriting and associated school functions. The following research questions guided the investigation:

1. Compared with a control group of students with poor handwriting who do not receive occupational therapy, will students with poor handwriting who receive occupational therapy services make greater improvements in visual-motor skill, visual-perception skill, dexterity, in-hand manipulation skills, legibility, and handwriting speed?
2. Will students with poor handwriting who receive occupational therapy services demonstrate statistically significant improvement over the course of the school year in school functions associated with visual-motor and manipulative skills?

Method

Sample

The students were recruited by occupational therapists from five school districts in central Ohio and southern Illinois. To identify students for the comparison group, teachers were asked to identify those with poor handwriting. Poor handwriting was defined as problems in letter formation, alignment, consistency of size, and spacing. Previous studies have successfully used teacher identifica-

tion of handwriting problems to form good and poor handwriting groups (Cornhill & Case-Smith, 1996; Tseng & Murray, 1994). Each identified student's file was reviewed to determine whether the presence of medical or education problems would exclude his or her participation in the study. Parents signed informed consent forms and were asked to identify significant medical history and prescribed medications.

Forty-four second-, third-, and fourth-grade students (31 with occupational therapy intervention, 13 without) were recruited and consented to participate in the study. None had diagnosed medical conditions or vision or hearing problems. In addition to parent consent, the inclusion criteria for the intervention sample were: (a) received special education and occupational therapy services, (b) had poor handwriting as judged by their teachers and had handwriting goals on their individualized education programs (IEPs), and (c) demonstrated cognitive function within normal limits as documented in the school files. The students in the comparison group had poor handwriting as judged by their teachers but did not receive occupational therapy services. Students in the comparison group also demonstrated cognitive function within normal limits as documented in their school files or as reported by the teacher. Visual-motor, fine motor, and handwriting performance of the comparison group was anticipated to be slightly higher than that for the group receiving occupational therapy services.

Instruments

The assessments administered follow a model of evaluation used in previous research (Case-Smith et al., 1998). In this model, three levels of performance are evaluated: (a) performance components with hypothesized association to a targeted skill, (b) the targeted skill (handwriting), and (c) related school functions.

Performance components. Three subtests of the Developmental Test of Visual Perception (DTVP; Hammill, Pearson, & Voress, 1993) were administered to measure position in space, figure ground perception, and copying. The subtests were selected because the skills that they measure have purported relationships to handwriting. In the position in space subtest, the student is asked to match a figure to one from a series of similar figures, only one of which is identical. In the figure ground subtest, the student is asked to find figures that are hidden in a complex, confusing background. The copying subtest measures visual-motor integration as children are first shown a simple figure and asked to draw it on a piece of paper. The test figures become increasingly complex with subsequent figures. Norms for the DVPT were developed using a sample of 1,972 children 4 to 10 years of age. During test develop-

ment, a series of reliability and validity studies was completed. Test-retest reliability for the DTVP ($n = 88$) ranged from $r = .71$ to $r = .86$ and was $r = .96$ for the total score. Interrater reliability ($n = 88$) was $r = .98$ for the total test (Hammill et al., 1993).

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP; Bruininks, 1978) tests motor functioning of children from 4.5 to 14.5 years of age. Two of the subtests for fine motor skill were administered in this study and selected because they appear to relate to handwriting and manipulation. The visual-motor control subtest measures the ability to coordinate precise hand and visual movements. The upper-limb speed and dexterity subtest measures hand and finger dexterity and speed of arm and hand movement. The BOTMP was standardized with a sample of 765 children (about 70 in each age group) (Bruininks, 1978). Reliability and validity studies are reported in the test manual; the fine motor composite test—retest reliability was moderate to high ($r = .77$ and $.88$), and interrater reliability was excellent ($r = .98$ and $.90$). Standard scores for the visual-motor control and upper-limb speed and dexterity subtests were used in this study.

In-hand manipulation components—translation and rotation—were measured using the materials of the nine-hole peg test. Speed and accuracy were measured using the administration and scoring procedures reported in earlier studies (Case-Smith, 1995, 1996). With the student seated at a small table, the peg-board was positioned at midline, and the child was instructed to use one hand only. In the rotation test, the participant prehended a 1-in. peg from the peg-board, rotated it 180° in his or her fingertips, and returned it to its peghole. The task consisted of each hand individually rotating five pegs. The task was repeated once with each hand, producing two time scores. The number of drops and times the peg was stabilized on another surface were recorded. Using the means of these scores, a composite score based on the time (in sec) and the number of drops and stabilizations was computed. In the translation test, the student individually prehended two, three, four, and then five pegs, moving them into the palm and then back into the fingertips to return to the peg-board. The seconds required to complete each trial were recorded, and a mean for the four trials was computed. In addition, the number of drops and stabilizations for each trial was recorded, and a mean of the four trials was computed. A composite score for the mean time and mean number of drops and stabilizations was used in the data analysis.

Targeted skill—handwriting speed and legibility. Handwriting speed and legibility were measured with the Evaluation Tool of Children's Handwriting (ETCH; Amundson, 1995). The manuscript version of the test was

administered to students who had not completed cursive instruction in their classrooms (all second-grade and most third-grade students), and the cursive version was used with those who had (some third-grade and all fourth-grade students). Of the students who received occupational therapy services, 23 were tested with the manuscript version and 6 with the cursive. Of the comparison group, 6 were tested with the manuscript version and 3 with the cursive. All subtests of the ETCH were administered: lowercase and uppercase letters, numerals, near-point and far-point copying of letters and words, dictation, and composition. Handwriting speed was recorded according to the ETCH standard instructions, and a mean speed score was computed. A total legibility score (mean percentage of all legible letters) was computed. All tests were scored by the author, and half were double scored by another occupational therapist. All scoring discrepancies were discussed until consensus regarding the most accurate score was reached.

Fair to good reliability has been demonstrated for the ETCH. Diekema, Deitz, and Amundson (1998) examined the interrater reliability of three raters who scored booklets for 59 children. Interrater reliability for total letters and numbers ranged from ICC = .82 to ICC = .84. For total letter legibility, test-retest reliability was $r = .77$, and for total numeral legibility, it was $r = .63$ (Diekema et al., 1998).

Related school functions—School Function Assessment (SFA). Two sections of the SFA (Coster, Deeney, Haltiwanger, & Haley, 1998) were completed by the students' occupational therapists and teachers for the intervention group. The purpose of the SFA is to evaluate a student's participation in school-related activities. This instrument was selected to include an ecologic view of the student's role and ability to function at school in tasks that require manipulation skills.

After test construction, the SFA was field tested on 266 students. After a revision, it was standardized with a sample of 363 students with disabilities from 40 states plus Puerto Rico. The internal consistency of the separate scales is strong (Cronbach's alpha = .92–.98). Test-retest reliability ($n = 29$) ranged from $r = .80$ to $r = .98$. The activity performance sections completed were those that appeared to relate to manipulation and handwriting skills—Using Materials and Written Work. The SFA criterion scores estimate the student's ability relative to the difficulty of the items.

Procedure

The author and four occupational therapists completed the testing. The 12 occupational therapists who provided the intervention participated in two training sessions on administering and scoring the tests and on recording the intervention data. The author tested 36 of 44 students. The

standardized instructions and procedures were used, without exception.

The students were evaluated during the school day in a testing room or conference room outside their classrooms. The observational tests were completed in single one-on-one sessions (approximately 1 hr). For the students receiving services, their teachers and occupational therapists collaborated to complete the SFA subsections. All measures were completed at the beginning (September–October) and end (April–May) of the 1998–1999 and the 1999–2000 school years.

Intervention

Intervention was provided by 12 occupational therapists in the five districts. Mean number of years of therapists' experience was 15.4, and mean number of years in the school system was 13.2. All students in the intervention group received direct, regular (defined as approximately 30 min/week on the IEP) occupational therapy services in their schools. Each therapist kept a record of each session with the student. This record included the duration (in min), format (group vs. individual), and provision of consultation and parent contact (within the week of the intervention session). The types of activities provided and goals addressed also were recorded, using a check-off format. The frequency of sessions, goals, activities, and service delivery models were summed for the 7-month intervention period. A mean time for each session and a summed time for all sessions were computed. Follow-up interviews of the therapists regarding their interventions were completed after the posttests were scored to assist in interpreting the results.

Data Analysis

For the standardized tests (DTVP, BOTMP, SFA), scaled or criterion scores were used in the analysis. The ETCH yields percentages of legible letters and numbers and speed in letters and numbers per minute. Using the Statistical Package for the Social Sciences version 10 (SPSS, 2001), frequencies, means, and standard deviations were computed and examined for all tests. To determine the level of change made by the students in the intervention group, t tests and effect sizes comparing pretest and posttest scores were computed (Cohen, 1988). To compare the occupational therapy and comparison groups, two-way analyses of variance (ANOVAs) using time as a repeated factor and group as a between factor were completed. These analyses compared the differences between the pretests and posttests, the differences between the two groups, and the interaction between pretest and posttest scores and group membership.

Results

Of the original sample of 44 children, 38 (29 in the intervention group, 9 in the comparison group) completed beginning- and end-of-year testing. Two students in the intervention group were eliminated because they developed major neurological problems. In addition, 4 students in the comparison group did not complete end-of-year testing: 1 was expelled from school; 2 were referred for occupational therapy services; and 1 was not available for end-of-year testing (see Table 1).

Occupational Therapy Intervention

For 25 students, information regarding the occupational therapy intervention sessions over the course of the academic year was recorded through a standardized form. (Data on intervention for 4 students were lost.) The mean duration of the sessions was 32.2 min ($SD = 5.61$, range = 25–49 min). The mean number of sessions was 16.4 ($SD = 3.56$, range = 10–25) or slightly more than twice per month. The average total time for direct occupational therapy services delivered to each student was 528 min ($SD = 155.3$, range = 312–836) or almost 9 hr. This number estimates time spent in one-on-one (95%) or small group (5%) activities with the student and does not reflect time in meetings with teachers or parents to discuss a student's program.

Approximately 29% of the total 16.4 sessions of direct, hands-on services included consultation with other professionals, and 14% included contact with parents or home programs. For 23 of the 25 students with recorded intervention data, specific consultation with teachers was reported.

Handwriting practice or activities designed specifically

to improve handwriting were implemented in 77% of the sessions. In both their intervention records and their interviews, the therapists reported using eclectic approaches, combining ideas from the various published curricula and programs. They reported emphasizing the particular skill areas that seemed to constrain or limit the student's progress in handwriting; that is, each therapist individualized the intervention emphasis according to the student's needs.

Comparison of Performance Components

Pretest and posttest comparisons were made for the in-hand manipulation test, the DTVP, and the BOTMP. Means for scaled or timed scores of these tests are presented by group in Table 2. To estimate effect sizes for change over the course of the academic year, standard scaled scores were analyzed using paired t tests (see Table 3). The students made significant changes in in-hand manipulation, visual-motor control, and position in space perception.

The two-way ANOVA revealed that the students in the intervention group improved more in in-hand manipulation and visual-motor control than those in the comparison group (see Table 4). Progress in the other performance components was no greater for the participants who received occupational therapy services than for those who did not receive services. (Interaction effects for time and group were not significant.)

Pretest and Posttest Comparisons of Handwriting and School Functions

Students' beginning- and end-of-the-year scores on the ETCH and SFA were compared using paired t tests. Means and standard deviations are presented in Table 5, and statistical comparisons are presented in Table 6.

The two-way ANOVA (see Table 4) indicated that the intervention group improved more than the comparison group in total percentage of legible letters ($p = .054$). Although not significant, handwriting speed increased slightly in the students who received occupational therapy but increased more in the students who did not receive occupational therapy.

Discussion

Description of Sample and Intervention

This sample of children with poor handwriting primarily had diagnosed learning disabilities and seemed to exemplify students who often receive occupational therapy services with emphasis on handwriting (Sandler et al., 1992; Weintraub & Graham, 2000). The boy-to-girl ratio reflects the gender prevalence in handwriting concerns observed by other researchers and reported in the literature (Sandler et

Table 1. Sample Description

Characteristic	Intervention Group ^a	Comparison Group ^b
Mean age (years)	8.6	9.08
Grade level		
Second	13	2
Third	11	3
Fourth	5	4
Hand dominance		
Right	20	5
Left	9	4
Gender		
Male	24	4
Female	5	5
Ethnicity		
Caucasian	28	8
African-American	1	1
Educational diagnosis		
Learning disabilities	15	4
Developmental disabilities	11	
Emotion-behavior	3	5
None	0	
Other related services		
Physical therapy	1	0
Speech therapy	6	0

^a $n = 29$. ^b $n = 9$.

Table 2. Means and Standard Deviations for the Visual-Motor, Manipulation, and Visual-Perceptual Measures

Performance Component	Intervention Group		Comparison Group	
	Pretest <i>M (SD)</i>	Posttest <i>M (SD)</i>	Pretest <i>M (SD)</i>	Posttest <i>M (SD)</i>
BOTMP visual-motor control ^a	9.14 (5.4)	11.25 (6.3)	15.44 (4.8)	16.78 (5.5)
BOTMP speed and dexterity ^a	11.15 (5.8)	11.16 (5.5)	12.89 (5.7)	10.89 (5.4)
DTVP position in space ^a	6.78 (2.9)	7.93 (3.3)	7.88 (2.9)	8.50 (1.9)
DTVP figure ground ^a	8.30 (3.2)	8.85 (2.7)	10.5 (2.8)	9.62 (3.0)
DTVP copying ^a	8.21 (2.2)	8.44 (2.4)	9.00 (2.4)	10.22 (2.4)
In-hand manipulation (total sec + drops)	25.65 (6.8)	19.9 (3.4)	20.12 (3.9)	16.49 (3.1)

Note. BOTMP = Bruininks Oseretsky Test of Motor Proficiency; DTVP = Developmental Test of Visual Perception.

^aStandard (scaled) reported.

al., 1992; Tseng & Murray, 1994). Ethnic representation was limited but reflected the region of the study.

In the group receiving occupational therapy, handwriting activities were implemented in 77% of the sessions, and visual-motor activities were implemented in 72% of the sessions, suggesting that the therapists scaffolded handwriting skills on underlying visual-motor skills (Chu, 1997). Although visual-motor skill activities were used with almost every student, as reported in the therapists' interviews, sensory integration approaches were used primarily when children demonstrated specific problems in sensory integration or motor planning (in one third of the sessions).

The therapists reported using specific handwriting activities to remediate individual student problems; for example, they used vibration or resisted writing to increase proprioceptive input and writing on the chalk board or a vertical surface to improve arm strength and stability. Behavioral and motor learning techniques, such as shaping, stimulus fading, modeling, verbalized description of letter formation, and self-monitoring, also were reported. Developmental and behavioral approaches were aimed at specific letter formation, alignment, sizing, or spacing issues.

The intervention appeared representative of school-based intervention in that a variety of techniques and activities were used (Case-Smith, 1996; Chu, 1997; Malloy-Miller, Polatajko, Anstett, 1995). Frequent communication with teachers suggests that the therapists worked to establish carryover of their program and to integrate recommended activities into classroom activities. Each therapist described her communication with teachers as a critical element of the intervention.

Progress in Performance Components

By using norm-referenced scaled scores, the before and after BOTMP and DTVP measures were adjusted for the student's maturation. Therefore, stable rather than increased scores were expected over the course of the year, and any improvement in scores should be considered an effect of intervention or of variables other than maturation. With this in mind, the students in the intervention group made significant improvements in BOTMP visual-motor control and in DTVP position in space. They also made significant gains in in-hand manipulation, although the raw time scores used were not adjusted for maturation. The students in the intervention group improved more in in-hand manipulation than those in the comparison group. In a previous study, preschool children who received occupational therapy services also improved more in in-hand manipulation and position in space when compared with a group of children who did not receive services (Case-Smith et al., 1998), suggesting that these skills may consistently increase with occupational therapy intervention. Most of the therapists reported that manipulation of small objects was regularly practiced in their intervention sessions. Through its association with dynamic grasping patterns and the isolated finger movements used to form small letters, in-hand manipulation is believed to contribute to handwriting legibility (Cornhill & Case-Smith, 1996). The children gained more than 5 sec in their composite time scores, which suggests improved efficiency in isolated finger movements and may be a clinically significant increase in skill.

The students who received occupational therapy made gains similar to the comparison group in the other visual-

Table 3. Comparisons of Pretest and Posttest Scores of Students Receiving Occupational Therapy Services (Paired *t* Test Results)

Measure	<i>n</i>	Correlation (<i>p</i>)	<i>t</i>	<i>p</i>	Effect Size
In-hand manipulation	29	.285 (.141)	3.78*	.001	1.51
BOTMP visual-motor control	28	.618 (.000)	-2.1*	.039	0.58
BOTMP speed and dexterity	28	.477 (.014)	0.40	.690	0.11
DTVP position in space	27	.692 (.000)	-2.44*	.022	0.67
DTVP figure ground	27	.119 (.555)	-0.73	.473	0.20
DTVP copying	29	.592 (.001)	-0.62	.541	0.16

Note. BOTMP = Bruininks Oseretsky Test of Motor Proficiency; DTVP = Developmental Test of Visual Perception.

Table 4. Main, Time, and Interaction Effects for Pretest and Posttest Scores of Students Receiving Occupational Therapy Services Compared With Students Not Receiving Services (Two-Way ANOVA Results)

Measure	Main Effects for Time		Main Effects for Group		Interaction Effects for Group and Time	
	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>
In-hand manipulation	12.66	.001	0.37	.548	7.84	.008
BOTMP						
Visual-motor control	2.67	.111	0.14	.715	9.55	.004
Speed and dexterity	0.56	.460	1.43	.240	0.07	.795
DTPV						
Position in space	2.72	.108	0.24	.630	0.55	.462
Figure ground	0.04	.852	0.71	.407	3.17	.084
Copying	7.36	.099	3.31	.264	2.69	.110
ETCH						
Letter legibility	22.45	< .001	4.04	.052	3.77	.054
Handwriting speed	5.71	.024	0.31	.583	0.04	.838

Note. ANOVA = analysis of variance; BOTMP = Bruininks Oseretsky Test of Motor Proficiency; DTPV = Developmental Test of Visual Perception; ETCH = Evaluation Tool of Children's Handwriting.

motor and visual-perceptual subtests. Students with delays often lose ground over time when standard scores are used or when compared with higher-level students. With this expectation, the students' maintained or improved performance on visual-motor, visual-perceptual, and manipulation tests is a positive finding.

Progress in Handwriting and Related School Functions

The students in the intervention group made significant gains in handwriting legibility and significantly more progress in total letter legibility than those in the comparison group. All 29 students in the intervention group initially had less than 85% legible letters (pretest mean = 75.8% legibility). At the end of the school year, 15 had more than 90% legible letters, and only 5 continued to have less than 85% legibility. For the 15 with more than 90% legibility, functional handwriting was achieved; for those with less than 85% legibility, computer word processing may be the best emphasis of intervention for written expression goals. Although not all students receiving services achieved optimal progress, on average they improved

14.2% total legibility (effect size = 1.99), whereas students not receiving services remained unchanged over the course of the year. Improvements may reflect the occupational therapists' emphasis on handwriting. The therapists in this study reported that they were the primary professionals specifically addressing the students' IEP goals in handwriting; however, they also reported high levels of collaboration with teachers. Data were not collected regarding teachers' supportive activities of students' handwriting; therefore, the frequency of carryover and teachers' emphasis on handwriting are unknown variables.

Handwriting speed in the students in the intervention group increased from 32 to 37 letters per minute. This change was not significant (effect size was moderate), and speed increases were smaller for the students receiving occupational therapy services than for the students not receiving services. A number of students in the intervention group completed the handwriting items as if they had been instructed to concentrate and write carefully. These students seemed to recognize that if they wrote slowly and carefully, the product was more legible.

Table 5. Means and Standard Deviations for ETCH Legibility and Speed and SFA Using Materials and Written Work

Measure	Intervention Group		Comparison Group	
	Pretest <i>M (SD)</i>	Posttest <i>M (SD)</i>	Pretest <i>M (SD)</i>	Posttest <i>M (SD)</i>
ETCH (% legible)				
Alphabet (lowercase)	74.9 (13.9)	88.6 (7.5)	84.4 (11.1)	92.6 (6.1)
Alphabet (uppercase)	65.6 (19.8)	87.7 (11.2)	70.8 (19.4)	82.4 (17.4)
Near-point copy	89.4 (8.1)	91.9 (8.0)	90.5 (8.3)	96.5 (4.4)
Far-point copy	82.2 (10.2)	89.8 (7.2)	90.4 (8.6)	93.6 (7.3)
Dictation	81.2 (11.9)	90.4 (9.7)	84.5 (10.3)	93.6 (7.2)
Composite	77.2 (16.3)	91.2 (7.7)	89.6 (6.1)	94.5 (6.4)
Total letters	75.8 (13.1)	90.0 (5.4)	85.8 (7.8)	91.6 (8.2)
Total numbers	86.0 (11.9)	91.8 (10.2)	93.6 (8.8)	93.8 (3.9)
ETCH speed: letters/min (composite)	32.1 (18.4)	37.0 (14.5)	29.4 (9.4)	37.3 (12.0)
SFA				
Using materials	83.3 (16.0)	86.0 (13.7)	—	—
Written work	66.6 (13.1)	78.6 (15.3)	—	—

Note. ETCH = Evaluation Tool of Children's Handwriting; SFA = School Function Assessment.

Table 6. Comparisons of ETCH and SFA Pretest and Posttest Scores for Students Receiving Occupational Therapy Services (Repeated-Measures *t*-Test Results)

Measure	<i>t</i>	<i>p</i>	Effect Size
ETCH			
Alphabet (lowercase)	-5.9	.00	1.74
Alphabet (uppercase)	-6.3	.00	1.79
Near-point copy	-1.6	.12	0.42
Far-point copy	-4.4	.00	1.25
Dictation	-4.6	.00	1.23
Composition	-4.1	.00	1.16
Total letter legibility	-6.4	.00	1.99
Total number legibility	-2.7	.01	0.73
Total speed	-1.59	.13	0.50
SFA			
Using materials	-1.30	.22	0.38
Written work	-4.34	.00	1.29

Note. *n* = 29. ETCH = Evaluation Tool of Children's Handwriting; SFA = School Function Assessment.

Although they mentioned specific activities to improve letter formation, alignment, and spacing, therapists did not report an emphasis on handwriting speed. They did report that practice helped the students become more automatic in writing. If students' writing became more automatic, it was not reflected in the speed score. Other studies have found that children in these age ranges, 7 to 10 years, write between 35 and 73 letters per minute (Ziviani & Watson-Will, 1998), suggesting that the students in the present study remained relatively slow in handwriting. In summary, increased handwriting speed was not an effect of intervention. Because speed did not relate to legibility, students who demonstrated good legibility at the end of the year may or may not have been among the fast handwriters.

The SFA indicated whether the students functioned better in school activities that involved written communication and manipulating materials. Criterion scores on the SFA written work scale increased by 12 points, and the effect size of this increase was substantial ($d = 1.29$). The students did not improve in using materials.

Limitations

Sample size and use of one geographic region limit the generalizability of this study. Use of a descriptive outcomes design also limits the interpretation of why the intervention was effective. Although detailed data were collected regarding the occupational therapy intervention, information about the child's academic program and other services was not collected. Preevaluations and postevaluations were completed by myself or the collaborating therapists who were not blind to the group status of the student. The imbalance of group sizes creates problems in statistical comparisons, although the statistical analyses (*t* tests) were adjusted for unequal sample sizes.

Conclusion

Students who received occupational therapy services improved in overall letter legibility but did not improve in numeral legibility or handwriting speed. The students increased an average of 14% in letter legibility, and 15 of 29 students who had poor legibility at the beginning of the year (< 85% total letter legibility) demonstrated good legibility at the end of the school year (> 90% total letter legibility). The performance components associated with handwriting slightly increased when norm-referenced scores were used. Occupational therapy intervention included teacher consultation and eclectic approaches that were individualized to the problems that seemed to constrain the student's handwriting performance. With these positive results, clinical trials of specific handwriting interventions is a next step in clarifying which approaches result in optimal outcomes. ▲

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References

- Amundson, S. J. (1995). *Evaluation Tool of Children's Handwriting: ETCH examiner's manual*. Homer, AK: OT Kids.
- Amundson, S. J. (2001). Prewriting and handwriting. In J. Case-Smith (Ed.), *Occupational therapy for children* (4th ed., pp. 545-570). St. Louis, MO: Mosby.
- Benbow, M. (1990). *Loops and other groups*. Tucson, AZ: Therapy Skills Builders.
- Benbow, M. (1995). Principles and practices of teaching handwriting. In A. Henderson & C. Pehoski (Eds.), *Hand function in the child: Foundations for remediation* (pp. 255-281). St. Louis, MO: Mosby.
- Benbow, M., Hanft, B., & Marsh, D. (1992). Handwriting in the classroom: Improving written communication. In C. B. Royeen (Ed.), *AOTA Self-Study Series: Classroom applications for school based practice* (pp. 1-32). Rockville, MD: American Occupational Therapy Association.
- Berninger, V. W., & Rutberg, J. (1992). Relationship of finger function to beginning writing: Application to diagnosis of writing disability. *Developmental Medicine and Child Neurology*, 34, 198-215.
- Bruininks, R. H. (1978). *Bruininks-Oseretsky Test of Motor Proficiency*. Circle Pines, MN: American Guidance Services.
- Case-Smith, J. (1995). The relationships among sensorimotor

- components, fine motor skill, and functional performance in preschool children. *American Journal of Occupational Therapy*, 49, 645–652.
- Case-Smith, J. (1996). Fine motor outcomes in preschool children who receive occupational therapy services. *American Journal of Occupational Therapy*, 50, 52–61.
- Case-Smith, J., Heaphy, T., Marr, D., Galvin, B., Koch, V., Ellis, M. G., & Perez, I. (1998). Fine motor and functional performance outcomes in preschool children. *American Journal of Occupational Therapy*, 52, 788–796.
- Cermak, S. (1991). Somatodyspraxia. In A. Fisher, E. Murray, & A. Bundy (Eds.), *Sensory integration: Theory and practice* (pp. 138–170). Philadelphia: F. A. Davis.
- Chandler, B. (1994, December 15). The power of information: School based practice survey results, *OT Week*, 18, 24.
- Chu, S. (1997). Occupational therapy for children with handwriting difficulties: A framework for evaluation and treatment. *British Journal of Occupational Therapy*, 60, 514–520.
- Cohen, J. (1988). *Statistical power analysis for behavioral science* (2nd ed.). Hillsdale, NJ: Erlbaum.
- Cornhill, H., & Case-Smith, J. (1996). Factors that relate to good and poor handwriting. *American Journal of Occupational Therapy*, 50, 732–739.
- Coster, W., Deeney, T., Haltiwanger, J., & Haley, S. (1998). *School Function Assessment: User's manual*. San Antonio, TX: Psychological Corporation.
- Davies, P. L., & Gavin, W. J. (1994). Comparison of individual and group/consultation treatment methods for preschool children with developmental delays. *American Journal of Occupational Therapy*, 48, 155–161.
- Diekema, S. M., Deitz, J., & Amundson, S. J. (1998). Test–retest reliability of the Evaluation Tool of Children's Handwriting–Manuscript. *American Journal of Occupational Therapy*, 52, 248–254.
- Hammill, D. D., Pearson, N. A., & Voress, J. K. (1993). *Developmental Test of Visual Perception* (2nd ed.). Austin, TX: PRO-ED.
- Lockhart, J., & Law, J. (1994). The effectiveness of a multisensory writing programme for improving cursive writing ability in children with sensorimotor difficulties. *Canadian Journal of Occupational Therapy*, 61, 206–210.
- Malloy-Miller, T., Polatajko, H., & Anstett, B. (1995). Handwriting error patterns of children with mild motor difficulties. *Canadian Journal of Occupational Therapy*, 62, 258–267.
- Oliver, C. E. (1990). A sensorimotor program for improving writing readiness skills in elementary-age children. *American Journal of Occupational Therapy*, 44, 111–116.
- Olsen, J. Z. (1999). *Handwriting without tears* (5th ed.). Potomac, MD: Author.
- Sandler, A., Watson, T. E., Rooto, M., Levine, M. D., Colement, W. L., & Hooper, S. R. (1992). Neurodevelopmental study of writing disorders in middle childhood. *Developmental and Behavioral Pediatrics*, 13, 17–23.
- SPSS, Inc. (2001). SPSS for Windows, version 10 [Software]. Chicago: Author.
- Tait, I. (1998). *Survey of school based therapists on evaluation and reference*. Unpublished master's thesis, The Ohio State University, Columbus.
- Tseng, M. H., & Cermak, S. A. (1993). The influence of ergonomic factors and perceptual-motor abilities on handwriting performance. *American Journal of Occupational Therapy*, 47, 919–926.
- Tseng, M. H., & Murray, E. A. (1994). Differences in perceptual-motor measures in children with good and poor handwriting. *Occupational Therapy Journal of Research*, 14, 38–52.
- Weil, M., & Amundson, S. J. C. (1994). Relationship between visuomotor and handwriting skills of children in kindergarten. *American Journal of Occupational Therapy*, 48, 982–988.
- Weintraub, N., & Graham, S. (2000). The contribution of orthographic, fine motor, and visual-motor processes to the prediction of handwriting status. *Occupational Therapy Journal of Research*, 20, 121–140.
- Ziviani, J., & Watson-Will, A. (1998). Writing speed and legibility of 7–14 year old school students using modern cursive script. *Australian Occupational Therapy Journal*, 45, 59–64.