Effect of an Occupational Intervention on Printing in Children With Economic Disadvantages

Cindee Q. Peterson, David L. Nelson

Objective. The purpose of this study was to evaluate whether an occupational therapy intervention improved an academic outcome (D’Nealian printing) in a school setting. The study specifically examined improvement in printing skills in economically disadvantaged first graders who were at risk academically and socially. The intervention was based on an occupational framework including biomechanical, sensorimotor, and teaching–learning strategies.

Method. The final sample consisted of 59 first-grade children from a low socioeconomic urban elementary school-based health center who were randomly assigned to an occupational therapy intervention or a control condition. In addition to regular academic instruction, the intervention group received 10 weeks of training twice a week for 30-minute sessions. The control group received only regular academic instruction. Subjects were pretested and posttested on the Minnesota Handwriting Test, which assesses legibility, space, line, size, and form (the main variables in this study) as well as speed.

Results. Multivariate analysis of variance confirmed that the gain scores in the occupational therapy intervention group were significantly greater than those in the control group. The Hotelling-Lawley Trace value was 0.606, with $F(5, 53) = 6.43, p < .0001$. The estimated effect size (η²) was .378, with an observed power of .994. Largest gains for the intervention group were in the areas of space, line, and size.

Conclusion. The intervention group demonstrated a significant increase in scores on the posttest of the Minnesota Handwriting Test when compared to the scores of the control group. Occupational intervention was effective in improving the academic outcome of printing in children who are economically disadvantaged.

The socioeconomic status of children is linked to their health and development (U.S. Department of Health and Human Services, 2000). Poor school performance, behaviorally and academically, can be attributed to the social and economic circumstances in which children and their families live (Wagner & Gomby, 1996). Currently, however, children from economically disadvantaged backgrounds rarely receive occupational therapy services. Only children who qualify for special education services through the 1997 Amendment to the Individuals With Disabilities Education Act are eligible for occupational therapy services in schools. In effect, this law excludes from occupational therapy many children who are academically at-risk because of environmental, cultural, or economic disadvantages and who enter the elementary school system unprepared for academic pursuits.

School-based health centers are federally funded, geographically dispersed, experimental programs designed to integrate health services and educational services for children from economically disadvantaged settings, including homeless children (National Assembly on School-Based Health Care, 2000). Health professionals, social service professionals, and education professionals work together in school-based health centers to help prepare the child for success in the classroom.

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The current study was made possible after administrators at a school-based health center invited the department of occupational therapy at the local university to explore a role for occupational therapy as part of the children's health supervision team.

Handwriting (specifically D'Nealian printing in the current study) is a developmentally significant skill that occupational therapists frequently address in special education schools (Benbow, Hanft, & Marsh, 1992). In this paper, printing is considered a subset of handwriting, which also encompasses cursive writing. D'Nealian printing is routinely taught in many school systems, including the school-based health center serving as the site for the current study. Programs for teaching printing as a subset of handwriting vary because of controversies regarding which form of printing (slanted, as in D'Nealian, or traditional manuscript alphabet) helps students make the transition to cursive writing (Armitage & Ratzlaff, 1985; Brown, 1984; Duvall, 1985; Graham, 1994; Viadero, 1993).

According to Graham (1994), an estimated 44% of urban students have difficulty with handwriting; however, teachers in kindergarten through sixth grades spend only an average of 30 to 60 minutes per week teaching handwriting. Other authors have stated that children in elementary school spend 30% to 60% of their day involved in fine motor activities, with writing tasks predominating over other forms of manipulation (McHale & Cermak, 1992). Direct relationships between handwriting and socioeconomic status exist (Lee-Corbin & Evans, 1996); poor families may not emphasize reading and letter formation because of the stressors of poverty (Lindmark, 1996). Illegible handwriting has been found to have a secondary effect on school achievement and self-esteem in children (Malloy-Miller, Polatajko, & Anstett, 1995). When teachers evaluate two or more versions of a paper that differ only in legibility, neater papers are assigned higher grades than papers with poor penmanship (Chase, 1986; Sweedler-Brown, 1992). Children who make excessive printing errors are at increased risk of failure in the first and second grades (Simner, 1982).

Handwriting research has focused primarily on the developmental trends in letter formation, legibility, tool use, speed, and pencil grasp (Burton & Dancisak, 2000; Dennis & Swinth, 2001; Graham, Berninger, Weintraub, & Schafer, 1998; Graham, Weintraub, & Berninger, 1998; Schnick, 1991; Simner, 1984; Šovík & Arntzen, 1991; Tseng & Chow, 2000; Ziviani & Elkins, 1986). Correlational studies in handwriting research have studied relationships among kinesthetic perception, eye-hand coordination, visual perception, in-hand manipulation, cognitive processing, and printing performance (Cornhill & Case-Smith, 1996; Tseng & Murray, 1994; Weil & Cunningham-Amundson, 1994; Weintraub & Graham, 2000). Handwriting research has identified what factors are correlated with poor handwriting, but little research has tested the efficacy of handwriting interventions in controlled experiments. As Weil and Cunningham-Amundson stated, “Common handwriting instructional and remedial practices have been seated more in tradition than empirical research” (1992, p. 58).

An exception to the general lack of controlled intervention studies is an experiment by Berninger, Abbott, and Vaughan (1997), who tested 144 first-grade students at risk for handwriting problems. The students were randomly assigned to one of six instructional treatment conditions, and were treated in groups of three, twice a week for 20-minute sessions, until they had completed 24 lessons. Results indicated that combining visual cues (numbered arrows as guides for letter formation) with memory retrieval was the most effective intervention for improving handwriting.

The current study involved an integration of multiple theoretical perspectives to handwriting intervention. Biomechanical, sensorimotor, and teaching–learning principles were applied, all from an occupational perspective. This use of multiple theoretical perspectives is typical of occupational therapy intervention in handwriting, according to a survey of Canadian therapists and a review of literature conducted by Feder, Majnemer, and Synnes (2000). In the occupational perspective (Nelson, 1996, 1997), the essential role of the occupational therapist is to collaboratively synthesize occupational forms that are meaningful and purposeful to the individual, so that the individual is able to engage in adaptive occupational performances. Regardless of whether the individual is conceptualized from a biomechanical, sensorimotor, or teaching–learning perspective, the occupational therapist works with the individual to set up a situation (occupational form) leading to active, voluntary engagement (occupational performance). For children, meaningful and purposeful occupational forms tend to involve play, with ample opportunity to impact materials and with multiple variations on themes and imagery. Therefore, playful occupational forms were incorporated throughout the intervention sessions.

According to Levine (1993), handwriting involves much more than biomechanical functions. However, Levine also stated that higher-order functions such as attention, memory, sequencing, and language needed to produce fluent writing can be severely disrupted by biomechanical factors. Paper position, writing surfaces, grip, and posture should be emphasized using a biomechanical approach to promote a functional pencil grasp. Posture, strength, and
coordinated at the scapula, shoulder joint, elbow, wrist, and hand joints also are necessary in the process of moving thoughts to paper (Benbow, 1995; Levine, 1993). Biomechanical interventions for strength and mobility utilize occupational forms incorporating resistance, weight bearing, and coordination.

In the sensorimotor approach, interventions oriented to the child’s sensory systems are used to stimulate or inhibit motor responses (Ayres, 1972; Bobath, 1978; Rood, 1962). Variations in sensory experiences provide a child with enhanced sensory feedback to improve motor skills for daily occupations such as printing. Occupational forms stimulate touch, vestibular sensation, and proprioception, which serve as bases for effective vision, hearing, and, ultimately, learning. In the current experiment, a focus was put on the development of motor planning abilities because of their importance in the many sequences of movement necessary in handwriting.

The teaching-learning model, called an acquisitional model by Mosey (1981), is derived from theories of learning. This model suggests that printing can be improved through practice, repetition, feedback, and reinforcement (Cunningham-Amundson, 1992; Kaminsky & Powers, 1981). Strategies for learning letter formation include modeling, tracing, copying, dictating, composing, self-monitoring, and peer recording. Letter size, form, spacing, and horizontal alignment are practiced. Rules for printing such as “grammar of action” (Goodnow & Levine, 1973) or “simultaneous production” indicating where to start and end a letter (Levine, 1993) are relevant to the teaching-learning approach. Grading the occupational form for success is critical because repeated failure can lead to “a generalized academic disenchantment” (Levine, Oberklaid, & Meltzer, 1981).

The purpose of this study was to determine if the occupational therapy intervention group increased scores on the posttest of the Minnesota Handwriting Test (MHT) (Reisman, 1999) when compared to the control group in terms of printing quality. Secondary research questions involved a) the possible effects of the intervention on specific qualities of handwriting (legibility, space, line, size, and form) and on speed; and b) the relationships between MHT performance and age, gender, race, and number of school absences.

Method

Design

This study used a pretest, posttest experimental design where subjects were randomly assigned to intervention or control conditions. The dependent variables were generated by the MHT (Reisman, 1999), which was first evaluated for test-retest and interrater reliability.

Sample

The original sample consisted of 62 first-grade children. Three subjects relocated before the study was completed, resulting in a final sample size of 59. Included were 30 Caucasian students, 25 African-American students, and 4 Hispanic students. Completing the study were 31 girls and 28 boys. Mean age was 7.1 years (SD = 0.4). Inclusion criteria for participants in the study were: (a) enrollment in one of three first-grade classrooms in a school served by a federally funded school-based health center for economically disadvantaged children; (b) informed consent; and (c) maintenance in the school until the end of the study and attendance for at least 10 of 20 planned group sessions. The mean absences from the 20 planned sessions over the course of the study was 2.2 (SD = 1.7). The research plan called for exclusion from the study for any student missing more than 10 sessions; no child was excluded due to absenteeism. Eighty percent of students attending this school were considered homeless according to federal guidelines, and two residential centers for victims of abuse were within the school boundaries for attendance. The school neighborhood continues to have the highest crime rate, the highest assault rate, and the highest domestic violence rate in the city, which has a population of approximately 100,000. The school turnover rate each academic year is approximately 40 percent, and the school has the highest percentage of students on free or reduced lunch of all 18 elementary schools in the district.

Instrument

The MHT (Reisman, 1993) was used in the current study to measure outcome. The MHT measures five indicators of handwriting quality (legibility, space, line, size, and form) in addition to speed. The speed score was not considered a primary dependent variable in this study because speed is difficult to interpret in terms of function. A high speed score might be the result of impulsivity or the result of efficiency. Graham, Weintraub, and Berninger (1998) discussed data indicating that prompts to write quickly sometimes led to declines in legibility. Often when children were asked to write neatly, the speed of printing decreased.

Test sheets for the MHT are available in both standard manuscript and D’Nealian script style to fit the instructional style of each classroom. Students copy words from a preprinted example onto marked lines below the example. The words on the example (“the quick brown fox jumped over the lazy dogs”) include all letters of the alphabet. These words are presented in a mixed order to adjust for the speed...
and memory advantages that better readers may have; the mixed order requires all students to refer to the example word by word. The handwriting sample is scored based on specific directions for each category (legibility, form, space, line, size, and form) and speed. Each category is scored based on error rate with a maximum potential score of 34. Rate or speed is scored by counting the number of letters completed in 2.5 minutes.

Vincent, Wilde, Peterson, and Nelson (1998) conducted test-retest reliability and interrater reliability studies in the class of first-graders preceding those enrolled in the current study at the school-based health center. In a test-retest reliability study with 56 subjects, intraclass correlation coefficients (ICCs) ranged from .60 to .89 on legibility, spacing, alignment, size, form, and speed. A random effects model for a single rater (Shrout & Fleiss, 1979) was used. Criteria for interpretation of these ICCs (Eliaziw, Young, Woodbury, & Fryday-Field, 1994; Landis & Koch, 1977) indicate levels of agreement ranging from high moderate to almost perfect. An interrater reliability study was also conducted on the scoring of the MHT. Fourteen occupational therapy students received training to administer and score the MHT, but three did not attain acceptable levels of interrater agreement on test samples. The remaining eleven raters were tested on 20 examples randomly drawn from those used in the test-retest reliability study. ICCs for the five main variables used in this study ranged from .73 to .99 (from good to almost perfect). The ICC for speed was .65.

Procedure

The project was approved by a university's Human Subjects Institutional Review Board. The children were randomly assigned to either an experimental (handwriting intervention) or control (no handwriting intervention) condition. Randomization procedures ensured that each child was assigned in an unbiased way. Each child was assigned a number from 1 to 62; number slips were drawn from an opaque container and alternately assigned to group 1 or group 2. Assignment of groups to the intervention or control condition was also random.

The 30 children randomly assigned to the intervention group were scheduled to receive 20 sessions of occupational therapy. Barring absences, each child was to be seen on Monday and Wednesday afternoons from 2:00 to 2:30 or from 2:30 to 3:00 for 10 weeks. The interventions were conducted in the school's gym, cafeteria, library, and boys' and girls' club. The 14 occupational therapy students mentioned above were trained by the principal investigator to serve as interventionists. Prior to initiation of the study, each of the interventionists participated in 8 hours of classroom training emphasizing principles and techniques of intervention. In the actual study, the principal investigator designed writing intervention plans specifying the objectives for each session and the occupational forms to be employed. Interventionists were trained to modify the plan according to the actual situation, and these modifications were recorded together with the interventionists' observations of the child's occupational performance.

In the pretesting and posttesting of the actual study, the children were removed from the classroom for administration of the MHT. The principal investigator administered the MHT to control group subjects, and 14 occupational therapy students administered the MHT to the intervention group subjects. Each test handwriting sample was then coded to ensure blind scoring and was randomly assigned for scoring to the 11 occupational therapy students who had achieved good interrater reliability. Each scored a mean of 10.7 handwriting samples.

Each child in the intervention group followed an individualized daily plan that was reflective of a general plan applied to all participants (e.g., certain equipment and space were made available for the day). For example, if a child was having special difficulty with letter retrieval from memory, extra time was devoted to occupational forms that challenge memory. Usually the first five minutes of each session plan called for sensorimotor “heavy work” to be done in groups of five children. Games synthesized to provide running, jumping, kicking, pulling, pushing, crawling, and rolling characterized much of “heavy work.” For the next 20 minutes, each child was engaged on a one-to-one or two-children-to-one basis in occupational forms designed to promote motor planning, motor memory, self-monitoring (e.g., “is my paper in the right place?”), and learning of specific strategies for improving letter size, line use, and spacing. Games and outsized materials, including vertical and slanted writing surfaces, were emphasized. Letters were practiced while using multiple sensory modalities (e.g., writing through shaving cream), and pencil grasp was explored in playful ways. The final 5 minutes of each session was typically spent in actual practice of D’Nealian handwriting. Even here, playful imagery was used to enhance memory (e.g., references made to “monkey tails,” “tummies,” “fishhooks,” and “snake tails”). Vertical and slanted writing surfaces were used in addition to horizontal surfaces. Classroom teachers were not informed about the content of the interventions until debriefings were held after the conclusion of the study.

Plan for Data Analysis

A multivariate analysis of variance (MANOVA) on the difference scores (gain scores) generated by the five variables of interest (legibility, space, line, size, and form) was planned.
to compare the gains made by the intervention group with those of the control group. Alpha was set at .05. This was the main statistical test planned for the entire experiment and provided a single overall strategy to determine whether the intervention was effective. After the multivariate test, secondary univariate analyses of variance of heuristic value were planned to look at individual elements of handwriting. Stevens (1986, p. 122) recommended that multivariate analysis be followed by post hoc univariate tests at a reduced alpha level, especially when the number of dependent variables is seven or less. Therefore, for these comparisons, alpha was set at .01 in order to provide a conservative set of tests. Data collected also provided opportunities for ex post facto analyses of the relationships between age, gender, race, and number of school absences on the one hand and performance on the MHT on the other hand.

Results

Preliminary Analyses

There were no significant differences between the two randomly assigned groups in terms of age, gender, race, or absences from the 20 planned group sessions. Also, there was no significant difference between the two groups in terms of pretest scores on any of the handwriting variables. As expected, all five scores of printing quality for both groups on the pretest were below the norm for first graders, as reported by Reisman (1999, p. 85); however, speed scores approximated the norm.

Main Hypothesis

In the test of the main hypothesis (see Table 1), MANOVA showed that the gain scores for handwriting in the occupational therapy intervention group were significantly greater than those in the control group. The Hotelling-Lawley Trace value was 0.606, with $F(5, 53) = 6.43, p < .0001$. The estimated effect size ($\eta^2$) was .378, with an observed power of .994. This is a very large effect, indicating a substantial difference between the occupational therapy intervention group and the control group (Cohen, 1988). Paired $t$ tests demonstrated no significant changes, either positively or negatively, for the control group from pretest to posttest.

Secondary Analyses

Univariate tests of the differences between the intervention and control conditions are presented in Table 2. Space, line, and size differences were statistically significant at the planned .01 level. The other two main variables did not reach the conservative .01 alpha level. The $\eta$'s in Table 2 indicate effect sizes, as defined by Cohen (1988). Cohen defined a small effect size as .20; a medium effect size as .50; and a large effect size as .80. The effect sizes for the five main dependent variables were in the medium and large ranges. Speed was not significantly different between groups.

Post hoc $t$ tests showed that gender and race were not significantly related to handwriting either in terms of the pretest or in terms of improvement of printing (gain scores). A Pearson correlation showed an inverse relationship between improvement of printing and number of absences [$r(58) = - .27, p = .04.$]. Relationships between improvement and age were not significant, but on the pretest age correlated significantly with legibility [$r(58) = .37, p < .01$], space [$r(58) = .39, p < .01$], and form [$r(58) = .37, p < .01$].

Discussion

The purpose of the study was to determine if an occupational therapy intervention improved scores in handwriting as measured by five factors of the Minnesota Handwriting Test. The main research question was answered with a single, planned statistical test (MANOVA), and the result was unambiguous. As hypothesized, the intervention group

<p>| Table 1. Descriptive Results of the Study for the Intervention ($n = 30$) and Control ($n = 29$) Groups |
|-----------------------------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th></th>
<th>Pretest $M$ $SD$</th>
<th>Posttest $M$ $SD$</th>
<th>Difference $M$ $SD$</th>
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<td>32.4 2.7</td>
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<td>0.37 4.7</td>
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<td></td>
<td></td>
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<td>29.1 4.8</td>
<td>3.23 4.2</td>
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<td>28.7 5.2</td>
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<td>-5.13 9.8</td>
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<tr>
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<td>23.9 7.4</td>
<td>-1.44 9.9</td>
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</table>

* Not a primary dependent variable in the study.
demonstrated a substantially greater increase in scores on the posttest of the MHT when compared to the increase in scores of the control group. The effect size was very large in confirmation of the hypothesis that occupational therapy made a difference. In support of the results, several research design strengths should be noted. The subjects were randomly assigned to the intervention and control groups; test-retest and interrater reliability studies were conducted on the instrument used for measuring the dependent variables (MHT); and the scorers of the outcome instrument were blind as to experimental condition.

**Space, Line, and Size**

Univariate tests of variance on space, line, and size reached statistical significance at the .01 level. Space, line, and size are three of the five categories most often identified in the literature as contributing to printing quality (Alston, 1983; Kaminsky & Powers, 1981). The strong individual scores for improvement in space, line, and size may be attributed to the emphasis that the intervention placed on scanning for improvement in space, line, and size. The objectivity of the measures for space, line, and size also support the significant improvement in individual scores on these variables. Planning the use of space on a page, letter spacing, and monitoring letter size require visual–spatial skills. Space, line, and size are simultaneous production skills (Levine, 1993) that involve an awareness of spatial arrangement on the writing surface.

**Legibility and Form**

Univariate tests of variance on legibility and form did not reach the conservative .01 alpha level for significance (see Table 2). However, the effect sizes were in the medium range, and this indicates that it would be incorrect to conclude that the intervention had no effect on these variables. Only future study with a larger sample or a less conservative alpha level could determine whether or not this intervention enhances printing legibility or form.

In the literature, legibility is defined as a letter that is recognizable out of context and contains all letterform strokes with no reversals (Alston, 1983; Reisman, 1993). Scoring of legibility requires judgment on the MHT because letter recognition is somewhat variable among raters. Test-retest reliability for legibility was second-to-lowest among the five main variables, and any problem of reliability tends to decrease the chances of finding differences between groups.

Letter form is most closely related to writing rules that specify how to start, execute, and end a letter (Levine, 1993). Simner (1982) identified how form errors in hand printing correlate with academic performance measures in kindergarten and first-grade reading, phonics, language, and math. Simner attributed form errors to poor memory of shapes of letters and numbers, short attention span, and difficulty in planning the sequence of strokes needed to form letters. In the intervention, asking the children to talk through the formation of a letter using playful imagery and D’Nealian language emphasized verbal self-direction. Perhaps if more time had been spent per session on these techniques, letter form would have improved enough to be statistically significant. Test-retest reliability for form was lowest of the five main variables.

**Speed**

The speed score was never considered a primary dependent variable in this study because of the difficulty in determining the relationship between fast or slow letter formation and printing quality. Graham, Weintraub, and Berninger (1998) found that handwriting speed develops gradually and becomes faster at each progressive grade level. They also found that legibility declines when children are asked to write quickly. However, it should be pointed out that children who write slowly and neatly may not get their assignments done in a timely way. Studies examining the correlation between handwriting speed and legibility have yielded contradictory findings (Hamstra-Beltz & Blote, 1990; Phelps, Stempel, & Speck, 1985; Sasson, Nimmo-Smith, & Wang, 1986; Ziviani & Elkins, 1984). In the current study, speed was not emphasized, and there were no significant differences on this variable between groups. The authors suggest that an emphasis on quality of handwriting should precede attempts to increase speed of production.

**Limitations**

Children in the intervention group received more attention than those in the control group because they were removed from the classroom for 30 minutes twice a week. A third condition to the study would have strengthened the results if the third group had received an equal amount of attention without a handwriting intervention. Another limitation is that the administrators of the MHT were not blind to experimental condition. This may be a relatively benign limitation because the MHT involves a brief standard protocol that is read to the subject and that allows for little or no opportunity to influence the performance of the subject.

A limitation common to most efficacy research in the human services is that the intervention consisted of multiple factors. Whether a single intervention or a combination of intervention strategies was the cause of improvement is not known. It is possible that the strategies of adding cues...
and practicing memory retrieval accounted for the outcomes, as in the study by Berninger et al. (1997). On the other hand, subjective observations made over the course of the study suggested the importance of addressing biomechanical factors, such as weak intrinsic muscles of the hand, and sensorimotor factors, such as motor planning. As Feder et al. (2000) found in their survey of Canadian occupational therapists and in their review of literature, most occupational therapists addressing problems of handwriting use multiple theoretical perspectives and eschew an exclusive commitment to a teaching–learning model restricted to repetitive practice. Individualization of intervention also added to the complexity of the intervention. Thousands of events occurred between the children and those interacting with them. A rigid program conducted mechanically in a laboratory might decrease the complexity of the interaction, but such a program would not be a true efficacy study in the context of a complicated world. In this study, as in all real-world efficacy studies, the independent variable was somewhat open-ended; however, there was a definite program based on theoretical principles that were consistently implemented and that formed the context for the multiple interactions between the children and interventionists. Importantly, this study demonstrated that a practical program in a complex school setting can have a significant effect on a variable of importance in the development of children. An experimental design with randomization and a control group ensures the best possible protection for internal validity even though the intervention condition is necessarily somewhat open-ended.

**Future Research**

Berninger et al. (1997) critiqued prior literature for using insensitive and subjective measures of handwriting quality (e.g., use of educators or therapists who subjectively evaluated handwriting samples based on untested criteria). The authors recommend the MHT as an objective, sensitive measure for use in future research as well as in clinical practice.

Employing sensitive and objective measures, future research should contrast the relative effects of biomechanical, sensorimotor, and teaching–learning strategies in enhancing handwriting. This would help determine which of these different approaches are responsible for the positive outcomes found in the current study. However, there is also a need for additional studies that involve multiple, interacting strategies, as in the current study and as in current occupational therapy practice. It is possible that the combination of strategies is more effective than any of the strategies used in isolation; furthermore, the use of multiple strategies reflects the real world of occupational therapy practice.

Studies should also address the effectiveness of playful occupational forms in comparison to rote training; use of a one-on-one style of intervention compared to an in-classroom intervention; and relative efficacy of different intensities and durations of intervention. Studies on these topics will enhance theoretical understanding while examining the efficiency of different ways to deliver interventions.

The current study found that an occupational intervention could enhance a variable of importance (printing) in children with socioeconomic disadvantages. Future studies might also address the effectiveness of occupational therapy in helping these children and their families in other academically oriented and nonacademically oriented ways.

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**References**


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