
Occupational Therapy Effects on Visual-Motor Skills in Preschool Children

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KEY WORDS

- developmental delays
- prewriting skills
- treatment effectiveness

OBJECTIVE. The purpose of this study was to evaluate the assumption that preschool children who receive occupational therapy will demonstrate significant improvement in their visual-motor skills as measured on the Developmental Test of Visual-Motor Integration (VMI) and the two supplemental Visual Perception and Motor Coordination tests.

METHOD. Preschool children with developmental delays ($n = 12$) received occupational therapy a minimum of one individual 30-minute session, and one group 30-minute session per week for 1 school year. Their performance was compared to that of two control groups; preschool students without disabilities who received occupational therapy ($n = 16$) for one 30-minute group session per week and students without disabilities ($n = 15$) who received no occupational therapy. The VMI and two supplemental tests were administered three times to each student, at the beginning, middle, and end of school year.

RESULTS. Planned comparison tests showed that students with developmental delays demonstrated statistically significant improvement in visual-motor skills and developed skills at a rate faster than expected when compared to typically developing peers on the VMI. The effect size for preschool students without disabilities who received occupational therapy exceeded the effect size for the VMI and Visual Perception supplemental test for the preschool students without disabilities who received no therapy, although, the difference in the post-test performance of these two groups was not statistically significant.

DISCUSSION. The results of this study demonstrate that intervention, including occupational therapy, can effectively improve visual-motor skills in preschool-aged children.

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Evidenced based practice is becoming increasingly important to occupational therapy and other health professions in this current climate of health reform (Law & Baum, 1998; Tickle-Degnen, 1999). Given this climate it has become of paramount importance for practicing occupational therapists to conduct effectiveness studies in the field. This present study examines the effectiveness of occupational therapy on enhancing the visual-motor skills in preschool children.

Visual-motor skills have been defined as “the ability to integrate the visual image of letters or shapes with the appropriate motor response” (Schneck, 1996, p. 370). While visual-motor skills may be seen as isolated motor responses, these skills have been demonstrated as being highly associated with other functional activities such as handwriting. For example, scores from tests of visual-motor skills and fine motor accuracy have been shown to correlate positively with handwriting ability scores (e.g., Cornhill & Case-Smith, 1996; Tseng & Murray, 1994). Thus, visual-motor skills can be thought of as being multifaceted and influenced by a number of factors (e.g., pencil grip, fine motor skills, eye-hand coordination, kinesthesia, motor planning, and visual-perceptual skills) as described by Schneck (1996).

While each of these factors may have an impact on the visual-motor skills necessary to succeed in preacademic and academic settings, the research on the effects

of each of these factors individually on visual-motor ability is inconclusive (e.g., Levine, Oberklaid, & Meltzer, 1981; Schneck, 1991; Ziviani & Elkins, 1986). However, if visual-motor skills are a product of the interaction of multiple factors, then it would be reasonable to assume that only multifaceted intervention would produce results with positive outcomes in visual-motor skills.

A few studies investigating the impact of intervention on visual-motor skills have been reported for both preschool-aged and school-aged children. In one of the studies, Kannegieter (1970) provided “normal” preschool children with a “perceptual-cognitive-learning program” and evaluated the impact of 3 months of training on their ability to replicate geometric drawings at 3 time periods—once prior to treatment (pre-test), immediately following the treatment period (post-test), and 4 weeks following treatment completion (follow-up test). Fifty-eight preschool participants were randomly assigned to an experimental group (perceptual-cognitive training) and a control group (no perceptual-cognitive training). Both groups performed equally well on the visual-motor post-test immediately following intervention. However, the experimental group performed significantly better than the control group on the follow-up test 4 weeks later. Kannegieter suggested that the time between the post-test and follow-up test allowed generalization to occur in the treatment group. Given the short duration of intervention (less than 3 months) and that significant differences between the treatment group and the no treatment group that occurred at follow up, one might speculate that a longer intervention period may result in even greater improvement.

In a study with a longer intervention period, Parush and Markowitz (1997) compared the effects of two types of therapy, gross motor (large space treatment), and fine motor (restricted place treatment) on 53 preschool children with perceptual motor dysfunction. For both groups, treatment was provided for 7 months at an intensity of 1.5 hours per week in a group setting of 4–6 children. Participants in both the treatment groups showed significant improvements in perceptual motor functioning. There were no significant differences between the two therapy groups.

In an earlier study of school-age students, Oliver (1990) combined occupational therapy treatment with a supplementary program implemented by parents and staff, in which both interventions emphasized sensorimotor activities. Outcome measures were related to writing readiness. Three groups of elementary students were included in the study: (a) students without disabilities, (b) students who demonstrated a verbal IQ at least 15 points above performance IQ, and (c) students who were placed in special education classes. All groups received direct treatment one time

per week for 30 minutes and also participated in the supplementary program three times per week. The duration of treatment for students in all three groups was 5–8 months. Students with discrepancies between verbal and performance IQ made the most gain in visual-motor skills, as measured by the Developmental Test of Visual Motor Integration (VMI; Beery, 1982), followed by the students in special education. Students without disabilities made gains, however, the gains were not as marked as the other two groups. Unfortunately, tests for neither statistical significance nor effect sizes were reported in this study.

The results of Parush and Markowitz (1997) and Oliver (1990) suggest that intervention can improve visual-motor skills for school-aged students with cognitive deficits and preschool children with perceptual motor deficits. However, the results of these studies are confounded by maturation effects; that is, the observed changes may be due to the fact that the children gained skills due to maturation alone during the period between assessments.

Rationale for the Study

The relationship between visual-motor skill performance and academic success is unmistakable. With pencil and paper activities being one of the primary focuses of instruction in early education, the role that visual-motor skills can have on preacademic and academic success (i.e., copying shapes and handwriting) is self-evident. In addition, a number of investigations support the notion that good visual-motor skill development is a precursor to performing well in kindergarten and early primary grades (Beery, 1967; Solan & Mozlin, 1986; Weil & Amundson, 1994).

The VMI (Beery, 1967, 1982, 1989, 1997), a standardized test, is an assessment tool that has been used in a number of these studies, as well as the studies that have evaluated the effectiveness of intervention on visual-motor skills discussed previously. Duffey, Ritter, and Fedner (1976) found that the VMI and the Goodenough-Harris Draw a Man test (Vane, 1967) were predictors of future academic success. Weil and Amundson (1994) found that children who were able to copy the first nine designs on the VMI performed better on letter copying activities than those children who copied less than nine forms. In addition, Klein (1978) demonstrated that the VMI was a consistent predictor of academic performance through second grade, as well as a “reliable instrument to be used with a young preschool population” (p. 461). Maeland (1992) compared clumsy, dysgraphic, and “normal” children and concluded that “handwriting was significantly related to visuomotor integration, visual form perception, and tracing in the total group” (p. 1207). Together the results of these studies

demonstrate that the score on the VMI is a good predictor of academic performance. The use of the VMI in occupational therapy intervention effectiveness studies is justified. However, the use of the VMI as an outcome measure should be consistent with the intervention approach being assessed. For example, the VMI may be considered as an appropriate outcome measure if the acquisitional frame of reference (Royeen & Duncan, 1999) is guiding the intervention in a preschool setting where imitating and copying represent some of the skills that the children are learning.

Purpose of This Study

The purpose of this study was to evaluate the assumption that occupational therapy provided to preschool children with developmental delays and preschool children without disabilities will significantly improve their visual-motor skills. The following research questions guided the study:

1. Do preschool children with developmental delays demonstrate significant improvements in visual-motor skills as shown by the ability to copy a greater number of forms on the VMI following occupational therapy for 1 school year when compared to their performance on the VMI prior to therapy?
2. Will preschool children with developmental delays exhibit a rate of gain consistent with typical peers by obtaining a standard score following occupational therapy for 1 school year that is equal to or greater than the standard score obtained prior to therapy?

Method

Design

A quasi-experimental, two-factor mixed design was used. The three groups of preschool children differing in disability level and the amount of therapy received across 8 months represented the first factor—a between factor. The three repeated measurements of the participants' visual motor skills that were assessed, pre-, mid-, and post-therapy, constituted the second factor—a within factor. The research questions were evaluated statistically using a series of planned comparisons (a priori *t* tests) between the groups' visual motor skills pre- and post-therapy.

Participants

The participants, preschool children with developmental delays and preschool children without disabilities, were selected via a convenience sample. All students were enrolled in a 1/2-day preschool program. The group of preschool children with developmental delays (G1: $n = 12$ including 8 males) were selected based on the following criteria: (a) served

by the same county Board of Cooperative Educational Services (BOCES; 50-mile radius); (b) were 3–6 years of age ($M = 53.34$ months, $SD = 10.04$); (c) had a parental consent to participate in the study; (d) demonstrated normal hearing and visual acuity as measured by the preschool screening and preschool files; and (e) qualified for occupational therapy services (all demonstrated delays in fine motor and visual-motor skills) and received services as directed by their Individualized Educational Plan (IEP). None of the children in this study had specific medical diagnoses (e.g., Down syndrome or cerebral palsy). Students with severe physical limitations (i.e., could not use their arms functionally) or those with profound retardation (in accordance with psychological testing) were excluded from the study.

Preschool children without disabilities were selected according to the following criteria: (a) all were residents within one rural western New York school district included in the above mentioned BOCES with varied socioeconomic backgrounds; (b) all candidates had a parental consent to participate in the study; (c) children were 3–6 years of age; and (d) children were free from disability as indicated from a regularly conducted screening using the Screening Test for Educational Prerequisite Skills (Smith, 1990). At the beginning of the school year an informational meeting with all parents of these preschool children was held to explain the purpose of the study and that their child may or may not receive occupational therapy. Parents made an informed consent knowing their child would be randomly assigned to either the treatment or no treatment (control) group. For the purpose of deriving two research control groups, random sampling was used to place these preschool children into the treatment group (G2: $n = 16$ including 5 males; $M = 52.63$ months, $SD = 4.10$) and control group (G3: $n = 15$ including 8 males; $M = 53.40$ months, $SD = 2.88$). Members of these two groups were equally distributed between the two preschool classrooms housed in one school.

Instrumentation

The VMI (Beery, 1997), a standardized test, served as the principal assessment instrument. The VMI has 24 geometric forms that are developmentally sequenced and measures visual-motor skills by examining the child's drawings that attempt to replicate the geometric stimulus. Rating criteria are provided for accurate scoring of the drawings. The highest possible raw score is 50. The mean standard score is 100 with a standard deviation of 15. Reliability and validity for the VMI have been reported across age groups (De Mers, Wright, & Dappen, 1981; Klein, 1978). Rykman and Rentfrow (1971) report the split-half reliability of the VMI in 2nd, 4th, and 6th grade to be $r = 0.74$. Test-retest reliability was established between two independent scorers

within a 1-week time interval and were .62 and .84 for each scorer, respectively (Rykman & Rentfrow).

The most recent version of the VMI (Beery, 1997) includes two supplemental tests (i.e., Visual Perception and Motor Coordination) in addition to the principal visual-motor test. These supplemental tests were added to assist in separating out the components of visual perception and motor coordination from the primary visual-motor test that assesses both components as an integral skill (Beery, 1997). The total possible raw score that can be achieved on each of the supplemental tests is 27. Each supplemental test also has a standard score mean of 100 with a standard deviation of 15.

Procedures

Assessment. All students were given the VMI individually 3 times during the school year—in September, December, and at the end of May. All testing was administered by a registered occupational therapist (the first author) in accordance to the guidelines in the VMI manual. The VMI tests were scored by two occupational therapy graduate students who were trained in scoring the VMI and blind to both the purpose of the study and the group membership of the participants. Twenty-five percent of the tests were scored by an additional registered occupational therapist blind to the groupings to establish interrater reliability. A high correlation coefficient ($r = 0.97$) was found when the scoring outcomes of the graduate students were compared to the scoring outcomes of the registered occupational therapist indicating a strong interrater reliability in this study.

The VMI is one of several assessments that can be used by occupational therapists to evaluate preacademic skills in preschool children. Children included in this study received other evaluations and observations to plan the individualized interventions according to guidelines outlined in the Individuals With Disabilities Education Act (IDEA, 1999) and recommendations in relationship to occupational performance (for extended discussion see Coster, 1998). The VMI was used as an outcome measure in this research because all of the children with developmental delays in this study displayed visual-motor deficits.

Occupational Therapy Intervention. The acquisitional and developmental frames of reference guided the occupational therapy intervention. Within the acquisitional frame of reference, the therapist shapes behaviors that contribute to skill acquisition, the goal of intervention (Royeen & Duncan, 1999). The developmental frame of reference emphasizes the continuous modification and emergence of skills with age (Law, Missiuna, Pollock, & Stewart, 2001). In keeping with the developmental frame of reference, all activities were designed based on the children's chronological and developmental ages.

Children in group one (G1) received direct occupational therapy consisting of at least one 30-minute individual and one 30-minute group session per week. Individual therapy sessions for children with developmental delays addressed all areas of need as defined on their IEPs except for visual-motor skills. Needs in the visual-motor domain were addressed in the group therapy sessions only. Therapy commenced following pre-test administration of the VMI (3rd week of September) and lasted through the end of May.

Children in group two (G2) received direct occupational therapy services consisting of one 30-minute group session per week. The group therapy sessions for G2 consisted of the same visual-motor activities as G1 group sessions. Thus, the two treatment groups (G1 and G2) received the same amount and type of therapy in the visual-motor domain although the children in G2 did not have developmental delays.

The following types of activities were included in the group therapy: (a) fine motor activities, such as arts and crafts, finger plays, and small manipulatives; (b) gross motor activities, such as obstacle course, music, dancing; and (c) visual-motor and visual perception activities, such as drawing, cutting, and assembly. These activities required visual-motor skills and were carefully designed so as not to teach to the outcome measure (i.e., VMI) by using alternative geometric lines and shapes for drawing activities.

Children in group 3 (G3) served as the control group. These children did not have developmental delays and did not receive occupational therapy. Given that children in G2 and G3 were in the same preschool room, all group therapy was provided in a room outside the preschool classroom in order to ensure that children in the no treatment control group did not participate. All intervention was conducted by an occupational therapist (i.e., the first author).

Data Analysis

Since the research questions were posed as a series of planned comparisons between groups, analysis of variance (ANOVA) procedures employing a 3 X 3 mixed design were conducted using SPSS for Windows (Version 10.0, 2001) in order to obtain an unbiased error term for the a priori Tukey t tests (Kirk, 1995, pp. 118–119). The three treatment groups (G1, G2, and G3) represented the between factor and the three assessment periods (the September, the December, and the June assessments) constituted the within factor. These ANOVAs were conducted using both the raw scores and the standard scores of the VMI, the Visual Perception, and Motor Coordination tests. The data met the assumptions for analysis of variance; that is, the data were found to be normally distributed and homogeneous (Bartlett's Box's M ranged from $F = 0.50$,

$p = .92$ to $F = 1.68$, $p = .07$; Green, Salkind, & Akey, 2000, pp. 200–203). In order to preserve the experimentwise error rate of $\alpha = .05$ for the study, the testwise rate for each ANOVA was set to $\alpha = .008$ using a technique similar to the Dunn/Bonferroni procedure (i.e., dividing the experimentwise α level by the number of analyses [.05/6] [Kirk, 1995, p. 120]). The results of these ANOVAs are presented in Table 1.

Since the multiple a priori Tukey t -test procedures (Kirk, 1995) that were used to evaluate the planned comparisons were conducted based on these ANOVAs, no further adjustment of the α level was needed (Sheskin, 1997, p. 341). To allow direct comparisons of the gains across tests and groups, effect sizes were computed for the obtained t scores and were adjusted for correlation between the pre- and post-test (Cohen, 1988, pp. 538–539). A pooled estimated sigma obtained from the mean squared error term of the analysis of variance and an r value pooled across groups were used to calculate the effect size. Any effect size greater than 0.80 is considered large and meaningful (Cohen).

Results

Planned comparisons of the post-therapy (3rd administra-

Table 1. Results of the Six 3 X 3 Mixed Analysis of Variance Designs Conducted to Derive Unbiased Error Terms for Both the Raw Scores and the Standard Scores of the VMI Total, the Visual Perception, and the Motor Coordination Measures

Scale and Measure	Source	Mean Squares	df	F	Significance of p
Raw Scores					
VMI Total					
	Groups	58.408	2, 40	11.242	<.0005
	Time	74.567	2, 80	40.361	<.0005
	Time*Group	1.717	4, 80	.929	.451
Visual Perception					
	Groups	74.700	2, 40	11.600	<.0005
	Time	151.418	2, 80	19.605	<.0005
	Time*Group	.836	4, 80	.108	.979
Motor Coordination					
	Groups	76.009	2, 40	11.332	<.0005
	Time	67.501	2, 80	13.942	<.0005
	Time*Group	4.334	4, 80	.895	.471
Standard Scores					
VMI Total					
	Groups	1521.069	2, 39	10.676	<.0005
	Time	129.550	2, 78	1.990	.144
	Time*Group	96.492	4, 78	1.482	.216
Visual Perception					
	Groups	2312.590	2, 40	10.188	<.0005
	Time	438.167	2, 80	1.975	.145
	Time*Group	112.164	4, 80	.506	.732
Motor Coordination					
	Groups	1318.207	2, 40	9.010	.001
	Time	370.918	2, 76	2.175	.121
	Time*Group	126.501	4, 76	.742	.567

* Denotes $p < .005$ (i.e., that the obtained t value is statistically significant)

Note. VMI = Developmental Test of Visual Motor Integration

tion) mean raw scores on the VMI ($M = 7.75$) to the pretherapy (1st administration) mean raw scores ($M = 4.83$) revealed that preschoolers with developmental delays (G1) demonstrated statistically significant improvement in VMI scores, $t(80) = 5.71$, $p < .0005$. Significant gains in performance were also found in the Visual Perception supplemental test, $t(80) = 3.98$, $p < .0005$. However, the gains observed on the Motor Coordination supplemental test were not significant, $t(80) = 2.21$, when evaluated against the adjusted α level of .008. Children without disabilities (G2 and G3) also had statistically significant gains on the VMI and the Visual Perception supplemental test though smaller effect sizes than the children with developmental delays (G1). On the Motor Coordination supplemental test children without disabilities demonstrated statistically significant larger gains than those exhibited by the children with developmental delays (see Table 2).

To further evaluate the effects of therapy on children with developmental delays (G1), comparisons between their performance and the performance of children without disabilities who did not receive therapy (G3) were made. As expected, at the first administration prior to therapy, significant differences existed between these two groups on the raw scores of the VMI total, Visual Perception, and Motor Coordination measures ($t_{2,80} = 4.14$, $p < .0005$; $t_{2,80} = 3.20$, $p < .005$; $t_{2,80} = 3.15$, $p < .005$, respectively). Significant differences between the two groups continued to exist on all three measures after therapy as well ($t_{2,80} = 3.73$, $p < .0005$; $t_{2,80} = 2.60$, $p < .005$; $t_{2,80} = 3.34$, $p < .005$, respectively).

Table 2. Mean Performance (Standard Deviations) as Measured by the Raw Scores on the VMI, the Visual Perception Supplemental Test, and the Motor Coordination Supplemental Test for Each Group Before and After Therapy. Differences Between Group Means Pre- and Post-Therapy (i.e., Gain) Were Evaluated Using One-Tailed, a priori t tests where the $df = 80$

Scale and Group	Mean Pre-Therapy	Mean Post-Therapy	Gain	Tukey t value	Effect Size
VMI Total					
G1 $n = 12$	4.83 (3.04)	7.75 (2.63)	2.92	5.71**	3.31
G2 $n = 16$	7.81 (1.87)	10.31 (2.15)	2.50	4.98**	2.84
G3 $n = 15$	8.73 (2.55)	11.27 (3.33)	2.54	4.96**	2.88
Visual Perception					
G1 $n = 12$	5.67 (3.08)	9.83 (2.59)	4.16	3.98**	1.54
G2 $n = 16$	9.94 (3.68)	13.81 (2.97)	3.87	3.70**	1.44
G3 $n = 15$	10.40 (4.12)	13.67 (3.77)	3.27	3.13*	1.21
Motor Coordination					
G1 $n = 12$	5.17 (3.83)	7.00 (3.79)	1.83	2.21	.95
G2 $n = 16$	7.75 (2.93)	10.94 (2.95)	3.19	3.85**	1.66
G3 $n = 15$	9.20 (3.00)	11.27 (2.40)	2.07	2.49*	1.08

* Denotes $p < .005$ (i.e., that the obtained t value is statistically significant)

** Denotes $p < .0005$ (i.e., that the obtained t value is statistically significant)

Note. VMI = Developmental Test of Visual Motor Integration

G1: Group with development delays receiving treatment

G2: Group without disabilities receiving treatment

G3: Group without disabilities and not receiving treatment

To assess whether or not preschool children with developmental delays exhibited a rate of gain consistent with children without disabilities, the mean standard scores following therapy were compared to the mean standard scores obtained prior to therapy for all three measures. The results of these comparisons and the effect sizes are shown in Table 3. The comparison of the mean standard scores of the VMI following occupational therapy to the mean performance on the VMI prior to therapy revealed that preschool children with developmental delays (G1) made a positive gain of 7.09 standard scores. However, while this mean gain is large compared to the gains of the other 2 groups, it is not statistically significant, $t(78) = 2.29$, when evaluated against the adjusted alpha level of .008. In contrast, the children without disabilities exhibited only small positive gains on the VMI (see Table 3). Comparisons of the standard scores of Visual Perception supplemental test and the standard scores of the Motor Coordination supplemental test also showed that children with developmental delays demonstrated small positive gains (2.91 and 2.0, respectively). Children without disabilities exhibited larger gains than the children with developmental delays on these two supplemental tests although these gains were not statistically significant.

Discussion

This study found that occupational therapy might be beneficial to preschool children with visual-motor skill delays. As discussed below, the results provide evidence that preschool children with developmental delays who receive

occupational therapy not only made significant gains on the VMI after 8 months of therapy, but also that these gains were acquired at a rate that exceeded typical development.

In answering the first research question, preschool children with developmental delays (G1) did demonstrate significant improvements in visual-motor skills as shown by their ability to copy a greater number of forms on the VMI following occupational therapy when compared to their performance on the VMI prior to therapy. This study did not provide evidence that children who received therapy (G1 and G2) gained significantly more skills than the children without disabilities who did not receive therapy (G3). Since the group of preschool children without disabilities and no therapy also demonstrated the ability to copy significantly more forms during the post-test when compared to the pre-test, the gains of G1 may be attributed to maturation. However, the group of children with delays that received therapy (G1) did obtain effect sizes that exceeded the preschool group without disabilities that received no therapy (G3) for the VMI and the Visual Perception tests, although not the Motor Coordination test. These larger effect sizes do provide evidence to address the effectiveness of therapy.

The second research question asked whether preschool children with developmental delays exhibit a rate of gain consistent with typical peers by obtaining a standard score following therapy that is equal to or greater than the standard score obtained prior to therapy. Note that statistical significances pre- to post-therapy in standard scores are not necessarily expected or necessary in order for children with developmental delays to have a rate of gain similar to typically developing peers (see Davies and Gavin [1999] for further discussion of interpreting standard scores). In the present study, the preschool children with developmental delays treatment group (G1) showed a substantial, but not statistically significant, improvement from the pre-test VMI standard scores ($M = 78.64$) to the post-test standard scores ($M = 85.73$). This finding suggests that the preschool children with developmental delays who received treatment (G1) developed visual-motor skills at a rate that exceeds typically developing peers when compared to either the standardization sample of the VMI or the groups of preschool children without disabilities included in this study. The preschool children without disabilities who received treatment (G2) had similar VMI standard scores at the pre-test ($M = 96.0$) and the post-test ($M = 96.6$) suggesting that they obtained visual-motor skills at a rate similar to the standardization sample. The preschool children without disabilities who receive no occupational therapy (G3) also demonstrated similar pre-test standardized scores

Table 3. Mean Performance (Standard Deviations) as Measured by the Standard Scores on the VMI, the Visual Perception Supplemental Test, and the Motor Coordination Supplemental Test for Each Group Before and After Therapy. Differences Between Group Means Pre- and Post-Therapy (i.e., Gain) were Evaluated Using One-Tailed, a priori t tests where the $df = 80$. All Differences Were Found to be Nonsignificant

Scale and Group	Mean Pre-Therapy	Mean Post-Therapy	Gain	Tukey t value	Effect Size
VMI Total					
G1 $n = 12$	78.64 (10.25)	85.73 (11.65)	7.09	2.29	1.15
G2 $n = 16$	96.0 (9.32)	96.56 (9.84)	.56	.18	.09
G3 $n = 15$	100.8 (17.57)	101.8 (19.06)	1.00	.32	.16
Visual Perception					
G1 $n = 12$	74.17 (21.59)	77.08 (23.64)	2.91	.52	.24
G2 $n = 16$	94.50 (16.28)	105.12 (16.40)	10.62	1.89	.89
G3 $n = 15$	98.33 (20.34)	104.07 (21.61)	5.74	1.02	.48
Motor Coordination					
G1 $n = 12$	75.00 (13.24)	77.00 (19.46)	2.00	.57	.13
G2 $n = 16$	86.50 (16.86)	92.06 (13.67)	5.56	1.09	.35
G3 $n = 15$	91.0 (17.30)	95.20 (12.67)	4.20	.82	.27

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 G1: Group with development delays receiving treatment
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 G3: Group without disabilities and not receiving treatment

($M = 100.8$) to post-test standardized scores ($M = 101.8$) suggesting that they also gained skills at a rate similar to the standardization sample. Only the group of preschool children with developmental delays who received occupational therapy showed a substantial increase in standard score, thus moderately lessening the gap that existed at the beginning of the study between this group and the groups of children without disabilities (see Table 3).

The intervention approach used in this study, guided by two frames of reference (acquisitional and developmental), resulted in improvements in visual-motor skill, especially in the group of children with developmental delays. Including a variety of activities in the group therapy sessions (i.e., not training to specific drawing skills) is consistent with recent ideas about the development of tool use, such as writing tools. Lockman (2000) has recently proposed a perception-action perspective on tool use development. He suggests that the interaction between tools (e.g., pencil and paper, mallet and wooden block) and the actions used may be as important in the development of tool use as the ability to hold or manipulate the tool itself. He further suggests that early movement patterns (i.e., actions) lay the foundation for later tool use. This supports the idea of using multiple intervention strategies in early intervention and preschool environments that include movement patterns without tools to develop foundations for the use of drawing and writing tools.

The use of the VMI as an outcome measure in studies involving preschool children is supported by some recent research by Adi-Japha and Freeman (2001). Adi-Japha and Freeman provide evidence suggesting that, in preschool-aged children, the same motor and thinking process is used whether they are writing letters or drawing geometric figures. Alternatively, starting around age 6 years, separate mechanisms and processes for drawing and writing begin to emerge and by age 12 the separation of the two processes is well developed. This timing is similar to that reported by Vinter (1999). She suggests that around 8 to 9 years of age there is a transition from drawing being driven by geometric rules to drawing being driven or influenced by meaning. Thus, the use of the VMI, a test of drawing geometric figures, may be more appropriate in effectiveness studies involving younger children than in studies involving older children (i.e., older than 6 years of age) if the outcomes of interest are academic or handwriting function.

Beyond the research questions posed, this study further contributes to the field of occupational therapy by providing evidence for the use of the VMI with the preschool population. The VMI standard scores of the preschool children without disabilities in this present study ranged from 75 to 125 with a mean of 100.8 and these results agree with the

findings of the VMI standardization sample (Beery, 1997). These findings support use of the standardized scores for the VMI in rural preschool settings such as the one in which this study was conducted. More importantly, data from this study show that the VMI and supplemental tests are sensitive to detecting change due to intervention or development as seen by the significant gains in raw scores achieved by all preschool children in this study.

Due to some limitations of this study, the results reported here should be interpreted cautiously. First, the VMI does not provide equal interval scores so the raw scores were used to indicate gains in visual-motor skills. Although raw scores determined in a manner such as the VMI may not be true equal interval measures, if the obtained data meet the assumptions of parametric procedures (e.g., normalcy and homogeneity) statistical analysis of the raw scores can be used to reflect gain in skills though the term "gain in skills" here does assume that each additional VMI form scored is more complex than the previous one (see Davies & Gavin, 1999). Second, the person administering the assessments and providing the therapy was not blinded to the study purpose or group membership. Third, although the amount and type of group therapy emphasizing visual-motor skills was identical for the two treatment groups, the children with developmental delays received additional therapy to address needs other than visual-motor. Thus, the total amount of therapy provided to the 2 treatment groups was not identical; consequently, the comparison of the different outcomes of these 2 groups should be interpreted with caution because the difference in gain could be due to the difference in therapy amount. Finally, the sample size was relatively small, but the effect sizes reported suggest that even with the small sample size the results have clinical significance.

In summary, the primary finding of this study is encouraging in that children with developmental delays were able to maintain their standings with the two groups of preschool children without disabilities and even showed an effect size on VMI standard scores greater than one and exceeded that of the other two groups. The results of this study demonstrate that intervention, including occupational therapy, can effectively improve visual-motor skills in preschool-aged children. ▲

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