Relationship Between Visuomotor and Handwriting Skills of Children in Kindergarten

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Key Words: gross and fine motor evaluation

Objective. The purpose of this study was to examine the relationship between the performance of children in kindergarten on the Developmental Test of Visual-Motor Integration (VMI) and their ability to copy letters legibly.

Method. Sixty typically developing children in kindergarten aged 64 months to 75 months (30 girls and 30 boys) were administered the VMI and the Scale of Children's Readiness In PrintIng (SCRIPT). The SCRIPT requires children to copy 26 lower case letters and 8 upper case letters from a model.

Results. A significant relationship was found between subjects' performance on the VMI and ability to copy letters legibly. In addition, as subjects' ability to copy the forms on the VMI increased, a concomitant increase in ability to copy letters was also found. There were no gender differences in performance on the VMI or on the SCRIPT.

Conclusion. The findings of this study suggest that most children in kindergarten similar to those in this study will be ready for handwriting instruction in the latter part of the kindergarten year.

Handwriting is an important functional skill for the young school-age child to acquire. Despite the advances in technology that may be viewed as reducing the need to produce legible handwriting, children continue to spend a considerable part of the school day engaged in handwriting tasks (Lindsay & McLennan, 1983; McHale & Cermak, 1992). Educators are primarily responsible for overall writing instruction, which includes the substance or meaning of writing as well as legibility. This writing instruction in the classroom is commonly achieved through whole language programs, other writing development practices, and actual handwriting instruction (Graham, 1992). Occupational therapists in school settings frequently receive referrals for children who are experiencing difficulties with handwriting in the classroom (Oliver, 1990; Reisman, 1991). The occupational therapist's role with these children is to determine whether there are underlying motor, sensory, postural, or perceptual deficits that might interfere with the development of legible handwriting and, if appropriate, to provide intervention for children with identified deficits (Stephens & Pratt, 1989).

Other roles of the occupational therapist in a school setting may involve determining a child's readiness for handwriting instruction as well as providing writing readiness programs for children with developmental delays (Oliver, 1990). A number of authors (Alston & Taylor, 1987; Domoghuie, 1975; Lamme, 1979; Lawton & Currie, 1980; Wright & Allen, 1975) have emphasized the importance of mastery of writing readiness skills before handwriting instruction is initiated. The readiness factors necessary for writing require the integrity of a number of sensorimotor systems. Letter formation requires integration of the visual, motor, sensory, and perceptual systems. Sufficient fine motor coordination also is needed to form letters accurately (Alston & Taylor, 1987)

Literature Review

Some controversy exists regarding when children are ready for formal handwriting instruction. Some children may be ready to write at age 4 years but others may not be ready until age 5 or 6 years (Lamme, 1979; Laszlo & Bairstow, 1984). Many children, taught by parents who find them highly motivated, learn to write their names at home. Partly because of the assumption that children who write their names are ready for handwriting instruction, an increasing number of kindergarten classes and early childhood programs include handwriting lessons in the school day. Consequently, some children are taught handwriting before they acquire adequate prerequisites for handwriting skills. Children who are not ready to write may become discouraged and develop poor writing habits that could be difficult to correct later. Thus, respecting the differing rates of maturity or development of children

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in a group of early writers is of critical importance (Lamme, 1979).

Donoghue (1975) and Lamme (1979) identified six prerequisite skills of children necessary before handwriting instruction begins:

1. small muscle development
2. eye-hand coordination
3. the ability to hold utensils or writing tools
4. the ability to form basic strokes smoothly, such as circles and lines
5. letter perception, including the ability to recognize forms, notice likenesses and differences, infer the movements necessary for the production of the form, and give accurate verbal descriptions of what was seen
6. orientation to printed language, which involves the visual analysis of letters and words along with right-left discrimination.

Other authors (Beery, 1989; Benbow, Hanft, & Marsh, 1992) defined readiness for writing on the basis of a child’s ability to copy geometric forms. The developmental process in learning to copy geometric shapes has been well documented and researched. Children typically draw a circle at 3 years, a cross at 4 years, and a triangle at approximately 5½ years of age (Beery, 1989). Beery (1982) suggested that instruction in handwriting be postponed until after the child is able to master the first nine figures in his Developmental Test of Visual-Motor Integration (VMI). The nine figures are

1. a vertical line
2. a horizontal line
3. a circle
4. a cross
5. a right oblique line
6. a square
7. a left oblique line
8. an oblique cross (X)
9. a triangle.

According to Beery’s normative sample, a child is usually able to complete the first nine figures at an age equivalent of 5 years, 3 months. As a revision to his earlier suggestion, Beery stated that “it seems prudent to postpone formal pencil and paper writing until at least such time as a child can easily execute copy of the VMI Oblique Cross” (1989, p. 97). This ability occurs at approximately 4 years, 11 months. He also purported that the oblique cross (the eighth figure) requires the ability to draw the diagonal lines used in many letters and it also requires crossing the child’s midline of the body, which he believed might be the source of many reversal problems (Beery, 1989). Among a similar line of thought, Taylor (1985) stated that if a pupil can manage to copy the circle, cross, and square, he is in a position to learn to write most of the letters, with the exception of k, v, w, x, and z. The diagonal line of these letters may require very precise teaching because the drawing of these lines will be a newly acquired skill. (p. 206)

Although a number of authors (Beery, 1989; Donoghue, 1975; Lamme, 1979; Taylor, 1985) have stressed the importance of mastery of writing readiness skills before handwriting is initiated, no studies have been reported that explored the relationship between writing readiness skills and successful handwriting production. Several studies, however, have explored the relationship between handwriting and performance on the VMI with children between the ages of 7 and 11 years. Phelps and Stempel (1987) examined the relationship between children’s performance on the VMI with their performance on the Children’s Handwriting Evaluation Scale (CHES). The CHES was designed for students in grades 3 through 8 and measures speed as well as qualitative aspects of cursive handwriting (Phelps, Stempel, & Speck, 1984). Results indicated that scores on the VMI were not significantly related to cursive writing scores after the third grade level. The authors hypothesized that although a certain amount of visuomotor skill is required to produce letter forms, after a small amount of visuomotor skill is achieved, it is not the dominant factor in developing writing skill. Klein (1978) also reported that the VMI’s ability to predict academic achievement declines as children move up in the grade levels. Beery (1989) speculated that this finding may indicate that children learn to compensate for visuomotor weaknesses by using other skills as they get older.

In contrast to the findings of Phelps and Stempel (1987) that VMI scores were not significantly related to handwriting scores after the third grade, studies by Sovik (1975) and Maeland (1992) found significant relationships between performance on the VMI and handwriting among children aged 7 to 11 years. Sovik (1975) found that visual-motor integration was the underlying key factor for handwriting performance when factor analysis studies were performed. For 180 children aged 7, 9, and 11 years, the average correlation between the VMI and handwriting was .42, which was higher than correlations between handwriting and any other measures, including general intelligence, finger dexterity, and visual perception. Maeland (1992) also found that among various perceptual motor tests, only visual-motor integration as measured by the VMI was significant in predicting the accuracy of handwriting performance. The sample of 59 fourth-grade students consisted of 19 children defined as clumsy (those who scored below average in fine and gross motor coordination skills), 22 children defined as nonclumsy and dysgraphic, and 18 typically developing children who produced cursive and manuscript handwriting samples.

To date, no studies have been reported that have explored the relationship between visual-motor integration and manuscript handwriting ability in 5- to 6-year-old children, an age group that traditionally is expected to be
ready for formal handwriting instruction. Concerns about readiness for handwriting are commonly addressed with the kindergarten age group because beginning writing is often an academic curriculum objective (Simner, 1982).

The purpose of this study was to examine the relationship between children in kindergarten's performance on the VMI and their ability to copy letter forms legibly. The three research hypotheses that were addressed for the study were as follows:

1. There is a significant relationship between children in kindergarten's performance on the VMI and the ability to copy 24 letter forms (26 lower case letters and 8 upper case letters).
2. There is a significant difference in the ability to copy letter forms between children who are able to copy the first nine forms of the VMI (a raw score of 9 or more) and children who are not able to copy the first nine forms of the VMI (a raw score of 8 or less).
3. There is a significant difference in the ability to copy letter forms that have diagonal lines (A, K, k, M, N, V, u, W, w, Y, y, Z, z) between children who are able to copy an oblique cross and children who are not able to copy an oblique cross.

Method

Subjects

The subjects for this study included 30 boys and 30 girls, aged 64 months to 75 months. This convenience sample of typically developing children was selected from regular kindergarten programs in the Bellevue School District in the greater Seattle area. Children in this school district do not typically receive formal handwriting instruction in the kindergarten year. The schools selected to participate in the study were chosen on the basis of demographic information supplied by the district, which indicated that the schools represented high as well as low socioeconomic groups and a variety of ethnic backgrounds.

Six kindergarten classrooms from three elementary schools participated in the study. The kindergarten teachers sent home the consent forms describing the testing procedures with the children in kindergarten. In an effort to obtain a sample of typically developing children, the kindergarten teachers were instructed to exclude children receiving special educational services or children with obvious upper extremity impairments or visual impairments (not correctable with lenses). The teachers also chose to exclude six children for whom English was a second language because the parents may have been unable to read and understand the consent form. All parents interested in having their child participate in the study signed and returned the consent forms. One hundred eight consent forms were sent out. From the 73 consent forms returned, children were stratified by age category and gender. Thus, 10 boys and 10 girls were included in the following age categories: 64 to 67 months, 68 to 71 months, and 72 to 75 months. Thirteen children with returned consent forms were not included in the study sample for one of the following reasons: the child did not meet the age criteria for the study, the age or gender categories were already filled, or the child was left-handed. Only right-handed children were included in this study because a representative sample of left-handed children could not be obtained. Of the 60 children remaining, 72% were white, 17% were Asian, 3% were Native American, and 2% were in each of the following four categories: Asian/white; white/Iranian; Asian/Latino; and Other.

Instrumentation

The Scale of Children's Readiness In Printing (SCRIPT), a letter form copying task developed by the first author for this study, was used to measure a child's ability to copy manuscript alphabet letters from models on the writing page. The SCRIPT protocol booklet consists of five pages with a maximum of eight letters per page using the Zaner-Bloser manuscript alphabet (Zaner-Bloser Company, 1976). Letters are presented in alphabetic order beginning with lowercase letters, followed by the eight uppercase letters. The SCRIPT included primarily lowercase letters for two reasons. First, the review of the literature indicated that the uppercase letters are easier to master; second, many children in kindergarten may have already learned to print uppercase letters (Lewis & Lewis, 1965; Sennett, Smythe, Hardy, & Wilson, 1972; Tan-Lin, 1981). Thus, it appeared that the ability to copy lower case letters would be a more challenging and valid measure of handwriting ability in children in kindergarten. Eight uppercase letters in the SCRIPT were included to test a child's ability to draw letters with diagonal lines (hypothesis 3).

The SCRIPT protocol booklet requires that children copy letters without writing guidelines. The decision to not use writing guidelines was based on the results of a pilot study in which children in kindergarten copied letters within 1-in. guidelines. The children appeared to have a difficult time copying the letters accurately within the guidelines and the lines appeared to confuse rather than assist the children with letter production. Thus, writing guidelines were not used in the SCRIPT because they appeared to detract from the children's letter-copying ability. The purpose of the current study focused on children in kindergarten's ability to copy letters, rather than the ability to copy letters accurately within guidelines.

The letters on the SCRIPT are scored as correct or incorrect according to the following criteria:

Correct: 1. The letter is recognizable and legible.
2. All parts of the letter are complete,
The second author was trained to score the SCRIPT individually and can be used with ages ranging from preschool to adult. The geometric forms are arranged in increasing difficulty; a person's score is calculated according to the number of forms copied successfully up to three consecutive failures. The forms were scored as either correct or incorrect according to the criteria in the manual (Beery, 1989), is to help prevent learning and behavioral problems through early screening identification. The VMI can be administered with a group or individually and can be used with ages ranging from preschool to adult. The geometric forms are arranged in order of increasing difficulty; a person's score is calculated according to the number of forms copied successfully up to three consecutive failures. The forms were scored as either correct or incorrect according to the criteria in the VMI manual (Beery, 1989).

For this study, the primary investigator administered the VMI and the SCRIPT. An undergraduate occupational therapy student was trained to score the VMI protocols. The second author was trained to score the SCRIPT protocols. Before scoring the VMI and SCRIPT protocols for the study, point-by-point agreement (Kazdin, 1982) was established between raters of the VMI and SCRIPT protocols and the primary investigator with six children not included in the study. These six children were in the same age range as the sample. It was determined that the averaged point-by-point agreement on the six VMI and the SCRIPT protocols would be at least 90% agreement before the raters could begin to score the protocols. Point-by-point agreement was also checked every 20th protocol to ensure that the raters scored the tests consistently. Obtained point-by-point agreement levels between the raters and the primary investigator ranged from 90% to 100%.

Procedural agreement of the test administrator was assessed by an experienced occupational therapist using point-by-point agreement on the six children not included in the study sample and at random three times during the test administration phase of the study. Procedural agreement was at 100% before data collection began and continued at that level during the three spot checks.

**Procedures**

Subjects were tested in pairs during the last 2 months of the first semester of the school year. Each pair of subjects was tested at a table and chair appropriate for their height in a room just outside the classroom or in a corner of the classroom without distractions. The examiner was seated across from the subjects. The primary investigator administered the VMI first, using the standardized set of instructions, and SCRIPT second, following administration procedures that closely approximated the VMI administration procedures. All subjects used a standard Number 2 pencil without an eraser. The time required to complete both the VMI and the SCRIPT varied from 7 min to 15 min per pair of subjects.

**Data Analysis**

Descriptive statistics including means, medians, and standard deviations were computed on the subjects' performance on the VMI as well as on their ability to copy letter forms on the SCRIPT. Because the data on the SCRIPT and VMI total scores were approximately normally distributed, a Pearson product-moment correlation coefficient was used to test the first hypothesis. Mann-Whitney U tests (Siegel, 1956) were used to test the second and third hypotheses for two reasons. First, when comparing groups, the sample size in one group was small; second, the scores were not normally distributed in all groups. The data were analyzed with the SPSS statistical package (Norusis, 1991).

**Results**

The data from one child's performance were not included in the data analysis because this child scored substantially lower (VMI SD = 4.4, SCRIPT SD = 4.8) than the rest of the group and later was referred for special education testing. Thus, this child appeared not to represent chil-
Children in kindergarten who were typically developing. Table 1 provides the descriptive data regarding the children’s total scores on the SCRIP and on the VMI. There were no significant differences between boys and girls in their performance on these tests.

Pearson product-moment correlation coefficient revealed a moderate correlation ($r = .47$, $p < .001$) between performances on the VMI and SCRIP, supporting the first hypothesis that there is a significant difference between the performance of children in kindergarten on the VMI and the ability to copy 34 letter forms. Additionally, as children’s ability to copy the forms on the VMI increased, a concomitant increase in ability to copy letters was found (see Table 2).

The second hypothesis is there is a significant difference between groups of children in kindergarten who are able to copy the first nine forms of the VMI (a raw score of 9 or more) and children who are not able to copy the first nine forms of the VMI (a raw score of 8 or less) and the ability to copy letter forms, was supported; the difference between the two groups was significant (2-tailed, $p = .02$) (see Table 3).

The third hypothesis is there is a significant difference in ability to copy letter forms on the SCRIP that have diagonal lines (A, K, R, M, N, V, v, W, w, Y, y, Z, z) between children who are able to copy an oblique cross on the VMI and children who are not able to copy an oblique cross, was not supported. The difference between the groups was not significant (2-tailed, $p = .26$) (see Table 4).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>SCRIP and VMI Total Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>n</td>
</tr>
<tr>
<td>SCRIP</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>29</td>
</tr>
<tr>
<td>Girls</td>
<td>30</td>
</tr>
<tr>
<td>Total group</td>
<td>59</td>
</tr>
<tr>
<td>VMI</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>29</td>
</tr>
<tr>
<td>Girls</td>
<td>30</td>
</tr>
<tr>
<td>Total group</td>
<td>59</td>
</tr>
</tbody>
</table>

Note: SCRIP = Scale of Children’s Readiness in Printing, VMI = Developmental Test of Visual-Motor Integration.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Mean SCRIP Scores by VMI Total Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMI Total Score</td>
<td>n</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
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<tr>
<td>10</td>
<td>12</td>
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<td>11</td>
<td>11</td>
</tr>
<tr>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: SCRIP = Scale of Children’s Readiness in Printing, VMI = Developmental Test of Visual-Motor Integration.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>SCRIP Total Scores for Groups Scoring Below 9 and 9 and Above on the VMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>VMIscores &lt; 9</td>
<td>7</td>
</tr>
<tr>
<td>VMIscores ≥ 9</td>
<td>52</td>
</tr>
</tbody>
</table>

Note: SCRIP = Scale of Children’s Readiness in Printing, VMI = Developmental Test of Visual-Motor Integration.

Discussion

The significant relationship found between the performance of children in kindergarten on the VMI and ability to copy letter forms supports Sovik’s (1975) and Maeland’s (1992) research in this area. These authors found that visual-motor integration, as measured by the VMI, was the underlying key factor in predicting handwriting performance in children. Sovik’s study found that the average correlation between the VMI and handwriting was .42 for children ages 7, 9, and 11 years, whereas Maeland’s study found the correlation between the VMI and handwriting was .43 for children 10 years of age. Results of Sovik (1975) and Maeland’s (1992) studies and the similar correlation of .47 obtained from the present study between the VMI and handwriting suggest that visual-motor integration plays an important role in handwriting production in children in kindergarten as well as in elementary school-age children. In addition, results of this study revealed that as children’s ability to copy the forms on the VMI increased, a concomitant increase in ability to copy letters was also found. Results of the present study suggest that copying ability or visual-motor integration plays an influential role in the primary stages of learning letter formation.

Children in kindergarten in the present study were able to copy on the average 10.1 forms on the VMI and 26.2 letter forms on the SCRIP. The large standard deviation on the SCRIP indicates the wide variations in letter-copying ability of children in kindergarten; this supports Lamme’s (1979) statements about the differing rates of maturity in a group of early writers. There were no significant differences between boys and girls on these tests. These findings are consistent with normative studies on the VMI (Beery, 1989) that did not find significant gender differences in performance. The lack of gender

<table>
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<tr>
<th>Table 4</th>
<th>SCRIP Diagonal Letter Scores for Groups Unable and Able to Draw an Oblique Cross (X) on the VMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>n</td>
</tr>
<tr>
<td>Unable to draw X</td>
<td>14</td>
</tr>
<tr>
<td>Able to draw X</td>
<td>45</td>
</tr>
</tbody>
</table>

Note: SCRIP = Scale of Children’s Readiness in Printing, VMI = Developmental Test of Visual-Motor Integration.
differences in performance on the SCRIPT contrast with the opinions of Goetz (1980) and Anderson (1969). Goetz (1980) reported that girls’ motor skills may be more advanced than those of boys at an early age, so that girls have an easier time when learning to write letters; Anderson (1969) reported that girls tend to like to write more than boys do and thus write better than boys.

Contrary to Beery’s beliefs, findings from this study suggest that children who can copy an oblique cross cannot copy a significantly greater number of letters with diagonal lines than children unable to copy an oblique cross. Beery (1989) stated that handwriting instruction should be postponed until a child can easily copy the VMI oblique cross, because the oblique cross requires the ability to draw the diagonal lines as required in many letters. Taylor (1985) purported that if a child can draw a circle, cross, and square, the child will be able to write most of the letters except those containing diagonal lines. The ability to draw an oblique cross would appear to influence a child’s ability to draw letters with diagonal lines; however, this was not validated by the results of this study, possibly because of the effects of children’s prior experience with writing. Many children enter school able to write their names (Lamme, 1979) and uppercase letters (Tan-Lin, 1981). This background may have influenced the children’s ability to draw letters with diagonal lines, particularly if their names contained letters with diagonal lines.

The finding that subjects who were able to copy nine forms or more on the VMI were able to copy a significantly greater number of letter forms than subjects who copied eight or fewer forms on the VMI validates the opinions of Beery (1982) and Benbow et al. (1992), who suggested that children are ready for handwriting instruction after they can copy the first nine forms of the VMI. In this sample of typically developing children, 52 of 59 children were able to copy the first nine forms of the VMI (a raw score of 9 or more) and the whole group, on average, was able to copy 78% of the letters presented correctly, when tested at the end of the first semester of their kindergarten year. Furthermore, these children were able to attain high levels of success in letter-copying ability without receiving formal handwriting instruction. This finding suggests that most children in kindergarten, similar to those in this study, will be ready for handwriting instruction and will be able to acquire letter formation skills during the latter half of the kindergarten school year.

Clinical Implications

The results of this study indicate that: (a) the VMI may be a useful evaluation tool to assess perceptual-motor readiness for successful handwriting production, at least with a group of typically developing children in kindergarten; and (b) although the topic of when children are ready for handwriting instruction continues to be controversial, the results of this study suggest that most children in kindergarten will be ready for beginning handwriting instruction during the latter half of the kindergarten school year.

An important clinical finding from this study was related to writing on lined versus unlined paper. Observations made during a pilot study indicated that the writing guidelines appeared to add an element of confusion to children who were initially learning letter formation. Thus, no writing guidelines were used in the SCRIPT. This clinical observation was consistent with the research of Lindsay and McLennan (1983) who found that unlined paper may aid legibility for beginning writers because the addition of lines to the paper acted as an interference rather than an aid. Thus, when providing initial handwriting instruction to children who are typically developing, unlined paper may be advised. After children learn the correct sequence, order, and direction of strokes necessary for letter formation, then they may be ready to write letters within guidelines or on a line.

Study Limitations and Strengths

The two primary limitations of this study relate to the sample. First, the sample was a convenience sample drawn from one school district. Second, six children for whom English was a second language were excluded from the sample because the teacher assumed that their parents would not be able to read and understand the consent forms. Thus, the results from this study may not be generalizable to all children in kindergarten.

Despite these limitations, this study had a number of strengths. It provided a balance of boys and girls, it divided the age categories into small groups to ensure equal representation of all ages of children in kindergarten, and it obtained high levels of procedural agreement and agreement between the raters and the primary investigator.

Directions for Future Research

Replication of this study with a representative sample would improve the generalizability of the results. Because handwriting is a complex skill requiring the integrity of a number of sensory and motor systems, additional clinical studies exploring the relationship between handwriting ability and other sensorimotor components such as kinesthesia, fine motor dexterity, in-hand manipulation, and visual perception also are warranted. Efficacy studies are also needed to assess the effectiveness of classroom as well as occupational therapy treatment techniques (Lamme, 1979; Oliver, 1990) that are directed toward improving perceptual motor skills that are thought to be prerequisite components for handwriting.
Summary

The results of this study suggest that (a) visual-motor integration as measured by the VMI significantly relates to children in kindergarten’s ability to copy letters; (b) there were no significant differences between girls and boys in performance on the VMI or ability to copy letters; and (c) the ability to draw an oblique cross does not result in a significantly increased ability to draw letters with diagonal lines. Children able to copy nine or more forms on the VMI were able to copy a significantly greater number of letters on the SCRIP. This finding supports for various authors’ contentions that children are ready for handwriting instruction when they are able to copy nine or more forms on the VMI and also indicates that most children in kindergarten will be ready for beginning handwriting instruction in the latter half of the school year.

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