Objective. This study examined the influence of pencil grasp on handwriting legibility during both short and long writing tasks in 46 fourth-grade students who were typically developing. Matched samples were used to control for variability.

Method. Regular classroom writing assignments were scored for word and letter legibility, and scores were compared using a mixed repeated-measures analysis of variance design. The two independent variables were pencil grasp (dynamic tripod grasp vs. atypical grasp) and task length (short vs. long).

Results. A significant difference was found between the letter legibility scores on the short task and the letter legibility scores on the long task. Students' legibility was greater on the short task than on the long task across both grasp conditions. No significant difference was found in scores between students who used dynamic tripod grasps and those who used atypical grasps, nor was there a significant interaction between grasp and task length. No significant differences were found between word legibility scores.

Conclusion. The results indicate that although the students in this study wrote more legibly on the short task than on the long task, the type of grasp they used did not affect their legibility. Because of the limited sample size, the results of this study should be interpreted cautiously. More research in handwriting performance and pencil grasp is needed to provide clear expectations and treatment options for students.

Throughout their educational careers, students use writing to record, express, and communicate ideas (Tseng & Cermak, 1993). Students who struggle to acquire and master handwriting skills may experience frustration and anxiety, which in turn may negatively affect overall school performance (Bonney, 1992). Many students with handwriting difficulties are referred to occupational therapy either as the primary reason for referral or in conjunction with other issues (Bonney, 1992; Weil & Amundson, 1994). Occupational therapists who practice in the school setting need to understand what factors influence writing performance so that they are better able to help children improve these skills.

Several researchers have investigated the effects of pencil grasp, amount of pressure on pencil, perceptual-motor abilities, and kinesthetic sensitivity on handwriting speed, accuracy, and legibility (Bailey, 1988; Harris & Livesey, 1992; Schneck, 1991; Weil & Amundson, 1994; Ziviani & Elkins, 1986). Only a limited number of studies, however, have examined how these factors influence handwriting...
endurance, or the ability to maintain consistent performance over longer periods. Students frequently use writing to record notes and complete exams, particularly in higher grades. As students progress through school, they are generally expected to be able to write for longer periods. The handwriting grasps that may affect performance during these longer writing tasks have usually been established by the end of elementary school and may be difficult to change as the child matures. Teachers and therapists who work with elementary-age children need more concrete evidence regarding the relationship between pencil grasp and endurance in order to provide effective instruction and treatment in this area.

Background

Children typically develop their preferred pencil grasp at a young age (Erhardt, 1994; Rosenbloom & Horton, 1971). Erhardt (1994) outlined a normal progression from immature to mature grasp patterns that occurs from 1 year to 6 years of age. Between 1 year and 2 years of age, children usually grasp their pencils or crayons in a palmar-supinate pattern (see Figure 1). The hand is fisted around the pencil, with the ulnar side toward the pencil tip, and the arm moves as a whole unit from the shoulder. Next, around 2 years to 3 years of age, the digital pronate grasp emerges. The thumb and index finger lie closest to the pencil tip, with the other digits curling around the upper shaft and the end of the pencil extending beyond the ulnar side of the hand. A static tripod grasp emerges around 3 years to 4 years of age. In this grasp, the pencil is held against the radial side of the middle finger, with the pad of the index finger on top of the shaft, and the pad of the thumb in opposition to the index finger. The arm is still moving as a unit, with some mobility at the wrist and elbow. As the child’s fine motor control improves, the dynamic tripod grasp emerges, usually between 4 years and 6 years of age. The position of the pencil in the fingers is identical to the static tripod, but the proximal arm joints are stable, and the writing movement is controlled by the intrinsic hand muscles.

Because of this distal control, the dynamic tripod grasp is generally considered by both occupational therapists and teachers to be the optimal grasp for handwriting performance (Amundson & Weil, 1996; Bonney, 1992; Tseng & Cermak, 1993). This grasp, however, is not the only one used by persons without handwriting difficulties. Grasp patterns in addition to those just outlined have been described by other researchers. Bergmann (1990) conducted a descriptive study of pencil grasps with occupational therapy students, medical students, and voters. Of the 447 right-handed adults studied, 64 (14.3%) used grasps other than the dynamic tripod grasp while signing their name. The most common atypical grasp was the lateral tripod in which the thumb lies adducted against the lateral aspect of the index finger rather than in opposition as in the dynamic tripod (see Figure 1). Bergmann noted that most of the participants with atypical grasps still displayed mature grasp patterns, characterized by the use of intrinsic hand musculature, dynamic wrist control, and distal finger con-

![Figure 1. Typical developmental progression of pencil grasp: (a) palmar supinate grasp, (b) digital pronate grasp, (c) static or dynamic tripod grasp. Atypical pencil grasps: (d) quadropod grasp, (e) lateral tripod grasp, (f) lateral quadropod grasp, (g) tripod grasp without web space, (h) four finger with tips only grasp.](http://ajot.aota.org/pdfaccess.ashx?url=/data/journals/ajot/930134/ on 03/23/2018 Terms of Use: http://AOTA.org/terms)
trol of the writing tool. This finding suggested that perhaps emphasis should be on immature versus mature grasp patterns rather than on the specific type of grasp.

Another descriptive study of pencil grasp focused on children who were typically developing, ranging in age from 3 years to 6 years, 11 months (Schneck & Henderson, 1990). The 320 children were observed during drawing and writing tasks, and the data on pencil grasp were separated according to 6-month age groups. The dynamic tripod grasp was the most common across all age groups. Some children used the lateral tripod grasp as well, particularly the older children. Approximately 25% of the children between 5 years and 6 years, 11 months of age used the lateral tripod grasp. The authors classified only the dynamic tripod and lateral tripod grasps as being mature grasps. It is not clear, however, whether the researchers classified the grasps on the basis of hand and wrist movement patterns, as in the Bergmann’s study, or whether the grasps were listed as mature simply because they were seen more frequently in the older children.

The distributions of pencil grasps in these two descriptive studies were similar. In both cases, most participants used the dynamic tripod, though a substantial minority used the lateral tripod grasp. This similarity suggests that many people establish their preferred pencil grasp at an early age. In fact, other authors have noted that therapists or teachers who wish to attempt to change a student's grasp pattern should do so by the second grade (Amundson & Weil, 1996).

Researchers have not found a clear relationship, however, between pencil grasp and handwriting performance. Ziviani and Elkins (1986) examined four components of grasp for 282 children between 7 years and 14 years of age who were typically developing: degree of index finger flexion, degree of forearm pronation and supination, number of fingers used on the pencil shaft, and opposition of the thumb and fingers. They found that neither speed nor legibility was affected by atypical grasp patterns and concluded that grasp patterns may not significantly affect overall handwriting performance. A similar study also investigated the relationship between pencil grasp and handwriting speed with children who were normally developing (Sassoon, Nimmo-Smith, & Wing, 1986). The 294 participants, 7 years to 14 years of age, were grouped according to their grasp, and writing speeds were compared. As in Ziviani and Elkins’s study, the researchers did not find a relationship between type of pencil grasp and speed of writing.

In contrast, Schneck (1991) found differences in grasp between children with good and poor handwriting, as rated by classroom teachers. The first graders’ pencil grasps were scored according to a 5-point scale on the basis of a drawing task. The scale, devised previously by the author, assigned a rank to specific grasps on the basis of the age at which each grasp was seen in young children. Then the children were rated on legibility and accuracy of letter formation after printing the alphabet in lowercase letters and copying a sentence. The participants were also evaluated for proprioceptive finger awareness. Results indicated that students with poor handwriting received lower grasp scores. In addition, the children with lower grasp scores displayed decreased proprioceptive awareness, indicating a possible relationship between decreased proprioception and lower grasp scores on the scale used in this study.

In all these studies, the tasks used to evaluate the relationship between pencil grasp and handwriting performance were short writing samples consisting of only one or two sentences. Some authors have suggested that performance during longer tasks, or endurance, could be affected by grasp patterns (Bailey, 1988; Bonney, 1992; Tseng & Cermak, 1993). One study of 40 adult participants examined the influence of pencil grasp on fatigue, legibility, and speed after writing three paragraphs (Jaffe, 1987). No significant differences were found on any of the dependent variables between participants using the dynamic tripod grasp and those using other grasp patterns. The author noted, however, that the writing samples used in the study may not have been long enough to reveal differences in fatigue for adults.

Because endurance during handwriting tasks has not been given much attention in school-age populations, the current study focused on the relationship between pencil grasp and performance on short and long writing tasks in elementary school children. Legibility was chosen as the measure of handwriting performance because legible writing is crucial for successful written communication, though other important factors also exist. From previous research, it is unclear whether the use of specific pencil grasps, such as the dynamic tripod, might affect students’ abilities to write legibly during longer tasks. Thus, the purpose of this study was to examine the influence of pencil grasp on handwriting legibility during both short and long writing tasks in fourth-grade students who were typically developing.

Method

Design

A quasi-experimental, mixed repeated-measures design, as described in Portney and Watkins (1993), was used in this study, with one independent factor and one repeated factor. The independent, or between-subjects, variable was grasp pattern (atypical vs. dynamic tripod), and the repeated, or within-subjects, variable was length of writing task (short vs. long). The dependent variables were letter legibility and word legibility. Matched samples were used to control for variability due to age, gender, hand dominance, and classroom. This design enabled the researchers to compare the performance of students with atypical grasps on short tasks with their performance on long tasks as well as to compare their performance on both tasks to that of their peers who used the dynamic tripod grasp. The mixed
design also allowed the researchers to examine the interaction between the two independent variables.

Participants

Students in the fourth grade were thought to be appropriate participants because instruction in cursive handwriting has usually been completed at this point and the amount of writing expected from students has increased (Cornhill & Case-Smith, 1996). In addition, in Washington State, the Commission on Student Learning (1997) provided standards for several academic subjects, including writing, and the first set of standards was developed for the fourth-grade level. A convenience sample of 46 fourth-grade students from two western Washington school districts participated in the current study. In the first district, 20 students attended two classrooms in the same elementary school, whereas 4 more students attended another school in the same district. The remaining 22 students attended two classrooms in the same school in the second district. Both districts used the D’Nealian curriculum for handwriting instruction (Hillandale Elementary School, 1999). Participants with an atypical grasp were first identified by the primary researcher after observation in the five different fourth-grade classrooms. These participants were then matched with the participants with a dynamic tripod grasp on the basis of gender, age, hand dominance, and classroom. None of the students was receiving occupational therapy treatment or any other support services related to motor or cognitive development.

Instrument

The writing tasks used in this study were the participants’ regular class assignments so that the level of difficulty would be appropriate for fourth-grade students. In the first district, 14 participants (two classrooms) performed creative writing tasks. The teachers asked the participants to write about the topics “What I Do at Recess” and “The Things That Bother Me.” The remaining 10 participants (one classroom) performed copying tasks. The teacher selected passages about the history of St. Patrick’s Day and the original 13 colonies, which were relevant to the current classwork. In the second district, the primary researcher assisted the teachers in creating the passages for the participants to copy in order to lessen the burden on the teachers at a busy time of year. Both passages (short and long) were about Washington State government because both classes were currently learning about that topic. The teachers read over the text to check for level of difficulty.

For all classrooms, the shorter samples consisted of 2 to 4 sentences, with approximately 5 to 10 words per sentence. Longer samples consisted of at least 8 sentences. The participants wrote in either manuscript or cursive, depending on the teacher’s instructions, although the teachers were asked to try to give the same instructions for both short and long tasks. Decisions about specific instructions were left up to each teacher so that the tasks would reflect the participants’ typical performance based on the usual practices in each class. Legibility of the samples was scored according to the letter and word legibility criteria used in the Evaluation Tool of Children’s Handwriting (ETCH) scale (Amundson, 1995).

For short samples, the entire sample was scored. On longer samples, the first, middle, and last 5 words were scored. For example, if the sample consisted of 100 words, then words 1 through 5, 48 through 52, and 95 through 100 were scored. For all samples, each letter and word was determined to be either legible or illegible. The number of legible items was divided by the total number of items to produce letter and word percentage legibility scores for the total sample. Letter legibility scores were also calculated for each subsection of the longer writing samples. Word legibility for the longer samples was calculated only for the total score because each subsection contained only 5 words.

The ETCH manual provided a set of specific criteria for determining legibility of cursive or manuscript writing for children in grades 1 through 6 (United States). Although the manual provided several examples of legible and illegible letters and words, the test author clarified that raters must still use their own clinical judgment in determining whether a given letter met the criteria for legibility. Because the words in the current samples differed from the words used when administering the ETCH, scoring decisions for word legibility were based on the general written criteria. For total letter legibility, the ETCH manual reported intraclass correlation coefficients for interrater reliability of .84 on the manuscript scale and .89 on the cursive scale, and .48 on the manuscript scale and .94 on the cursive scale for total word legibility. Because the ETCH scale was published while still under construction, normative data have not been compiled to provide an expected range of performance for students.

The ETCH manual provided two practice tests for test administrators or researchers to establish proficiency in administering the scale. Before the study, the researchers achieved a reliability of .90 with the practice tests, the level required by the test author. The primary researcher scored all of the samples, and every fifth writing sample was also scored by the secondary researcher to check for rater drift. Both point-by-point reliability and percent agreement on total legibility scores were calculated for interrater reliability.

Procedure

Before any contact with the participants, this study was approved by the Institutional Review Board at the University of Puget Sound and by the participating school districts. The parents or guardians of all children in the five classrooms were contacted in writing to explain the purpose and procedure of the study and to obtain consent.
Participants were given an opportunity to ask questions about the study and to give their consent, and they were reassured that their performance during the study would have no bearing on their academic evaluations. Permission forms were sent out for all 118 students, and permission was obtained for 51. When possible, the primary researcher spent at least 30 minutes observing in the classroom before data collection began to allow the participants to become accustomed to the researcher’s presence. Each teacher introduced the researcher and the purpose of the study.

The participants who used an atypical grasp \( (n = 23) \) were identified first by the primary researcher. Then each participant who used the dynamic tripod grasp \( (n = 23) \) was selected at random from a pool of the remaining students who matched on gender, hand dominance, classroom, age (i.e., within 6 months of age of each participant with an atypical grasp). Any students who were receiving support services for cognitive or motor development were not included. The primary researcher then coordinated with the teacher to observe both the short and long writing tasks, which were completed on the same day in each classroom. Field notes were recorded regarding the structure of the classroom and the reactions of the participants to the assignments, such as signs of muscle fatigue, as well as the prevalence of atypical grasps in each class. These qualitative data were taken to check the validity of the quantitative data. Photocopies were made of the writing samples, and the originals were returned to the teacher. The copies were kept in a secure location to which only the researchers had access. The researchers then scored the letter and word legibility of each sample. Information regarding each participant’s grasp pattern was kept separate from the writing samples so that the researchers were blind to grasp type while scoring.

**Data Analysis**

The legibility scores were grouped according to type of grasp and length of writing task. The letter legibility scores for each subsection of the long task (first, middle, last) were also included in the analysis for a total of five data sets for letter legibility (short task, long task, three subsections of the long task). As stated previously, for word legibility, only the total scores for each sample were analyzed because each section of the long task only contained 5 words. Means and standard deviations were calculated for each set of scores, and the means were compared using a two-way analysis of variance (ANOVA) with one repeated measure (Portney & Watkins, 1993). The ANOVA for the letter legibility scores was conducted separately from the ANOVA for the word legibility scores. An \( F \) ratio was calculated for each main effect of grasp or writing task and for the interaction between grasp and writing task. For letter legibility, post hoc tests were also conducted between the mean for the short task and the mean for the total long task as well as between each of the means for the three sections of the long task. A separate comparison between the mean for the total long task and the means for the three sections was not conducted because the total scores were averages of the three subscores. An alpha level of .05 was used to determine significance of all statistical comparisons.

**Results**

The 18 boys and 28 girls who participated in this study ranged in age from 9.3 years to 10.9 years \( (M = 10.2 years, SD = .40) \). Four participants were left-hand dominant, and 42 were right-hand dominant. Half used the dynamic tripod grasp during writing, whereas the other half used an atypical grasp (one other than dynamic tripod). Of those who used an atypical grasp, the quadrupod (four finger) grasp was the most common \( (n = 13) \). The next most common grasp was a combination of the lateral tripod and quadrupod grasps, referred to as the lateral quadrupod grasp \( (n = 4) \), followed by the lateral tripod grasp \( (n = 2) \), a tripod grasp without web space between the thumb and index finger \( (n = 2) \), the static tripod grasp \( (n = 1) \), and a quadrupod grasp where only the tips of the fingers were used \( (n = 1) \). All atypical grasps are illustrated in Figure 1.

**Letter Legibility**

The ANOVA data for letter legibility are summarized in Table 1. No significant main effect was found for grasp pattern, \( F(1, 44) = 3.90, p = .054 \), nor was a significant interaction effect for grasp by task length found, \( F(4, 176) = 1.75, p = .142 \). A significant main effect was found, however, for task length, \( F(4, 176) = 12.42, p = .000 \). Because the repeated-measures ANOVA is sensitive to violations of the assumption of homogeneity of variance (Portney & Watkins, 1993), the variables were tested for homogeneity of variance. Unequal variances can lead to an increased risk of Type I errors, or an increased risk of finding significant differences when none exist. The variances for the scores of the third section of the long task were found to be unequal, so correction factors (epislon) were generated and used to calculate new \( p \) values (Portney & Watkins, 1993). Even with these correction factors, the main effect for task length was still significant (see Table 1).

Post hoc testing using Tukey’s honestly significant difference revealed an overall significant difference between

<table>
<thead>
<tr>
<th>Table 1: Comparison of Letter Legibility Scores by Grasp Pattern and Task Length</th>
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<tbody>
<tr>
<td>Source of Variance</td>
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<td>---------------------</td>
</tr>
<tr>
<td><strong>Between subjects</strong></td>
</tr>
<tr>
<td>Grasp (A)</td>
</tr>
<tr>
<td>Error</td>
</tr>
<tr>
<td><strong>Within subjects</strong></td>
</tr>
<tr>
<td>Task (B)</td>
</tr>
<tr>
<td>Grasp x Task (A x B)</td>
</tr>
<tr>
<td>Error</td>
</tr>
</tbody>
</table>

*Note. Values in parentheses represent mean square errors. G-G = Greenhouse-Geisser corrected \( p \) values; H-F = Huynh-Feldt corrected \( p \) values.

the short task and the long task, with participants scoring higher on the short task than on the long task. Within the long task, significant differences were found between the first section and the middle section and between the first section and the last section, but not between the middle and last sections. The scores on the first section were higher than those on the second and last sections. Thus, participants’ letter legibility was greater on the short task than on the long task and greater at the beginning of the long task than at the middle or end of the long task.

Word Legibility
The ANOVA summary data for word legibility scores are presented in Table 2. No significant main effects were found for grasp pattern, $F(1, 44) = 4.8$, $p = .042$, or task length, $F(1, 44) = 3.86$, $p = .056$, nor was any significant interaction effect for grasp by task length found, $F(1, 44) = .16$, $p = .689$. Because none of the comparisons yielded significant differences, correction factors were not generated. Additionally, because each independent variable only contained two levels, no post hoc comparisons were calculated.

Other Analyses
Interrater reliability on every fifth writing sample ranged from 89.0% to 98.7% for letter legibility and from 86.7% to 100% for word legibility using the point-by-point agreement method. Total percent agreement ranged from 96.9% to 99.4% for letter legibility and from 86.7% to 100% for word legibility.

The field notes collected during the writing tasks revealed several interesting patterns. First, the participants in one classroom that used creative writing assignments were allowed to move about the room, retrieving dictionaries and washing hands. Because spelling was not scored on the creative writing samples, the teacher discouraged the dictionary use by telling the participants to write as if it were a first draft. Second, one of the participants in that same class who used an atypical grasp (quadropod) was observed shaking out her hand once during the longer writing task. After the legibility scoring was completed, this participant’s scores were found to be at or above the mean for each subsection of the long task.

In one classroom in the second district, many of the participants shook their hands several times and took breaks during the long task. They also made comments about the length of the task. These participants required at least 15 additional minutes to complete the task compared with the other class in the same school. After the assignments were completed, their teacher mentioned that the writing sample was longer than what she usually required during a typical writing assignment. The other class in the same school did not display similar reactions to the identical task. Averages of the legibility scores for these two classrooms were almost identical.

Not all students who used atypical grasps were included in this study. This was because their parent or guardian did not grant permission for their participation, they did not meet the inclusion criteria, or they were absent during administration of one of the writing tasks. All of the atypical grasp patterns noted previously were seen in these students as well. On the basis of the primary researcher’s observations, between 25% and 48% of the students in the five classrooms used atypical grasp patterns.

Discussion
The results of this study support previous findings that pencil grasp does not have a significant effect on handwriting legibility (Sassoon et al., 1986; Ziviani & Wilkins, 1986). The significant main effect for task length indicated that endurance may have influenced legibility for the participants, regardless of pencil grasp. According to the field notes, several other issues arose regarding the variables examined.

Grasp Pattern
All of the atypical grasps were more mature, developmentally; that is, no participants displayed a primitive grasp, such as the palmar-supinate or digital pronate grasp. This finding was expected because the study focused on upper elementary students with typical motor development. Any student who still used immature grasp patterns likely would have been referred to an occupational therapist or other special education service provider and, thus, would have been exempt from the study.

The atypical grasps observed in this study were not consistent with the distributions or descriptions reported in previous literature (Bergmann, 1990; Erhardt, 1994; Rosenbloom & Horton, 1971; Schneck & Henderson, 1990). Instead of the lateral tripod, the quadropod grasp was the most common atypical grasp. Two grasp patterns were also observed that had not been described in previous studies. These grasps were labeled by the first author as the lateral quadropod grasp and the tripod grasp without web space. These two grasps were possibly included in the lateral tripod groups of previous studies because they are similar, yet neither one fits the descriptions provided in earlier research.

Although the main effect for grasp was not significant, the difference in the means was close to achieving signifi-

### Table 2
Comparison of Word Legibility Scores By Grasp Pattern and Task Length

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>df</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grasp (A)</td>
<td>1</td>
<td>0.48</td>
</tr>
<tr>
<td>Error</td>
<td>44</td>
<td>(119.6)</td>
</tr>
<tr>
<td>Within subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task (B)</td>
<td>1</td>
<td>3.86</td>
</tr>
<tr>
<td>Grasp X Task (A x B)</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Error</td>
<td>44</td>
<td>(29.23)</td>
</tr>
</tbody>
</table>

Note. Values in parentheses represent mean square errors.
cance (p = .054), and the mean for the participants who used an atypical grasp (95.14% legibility) was higher than the mean for the dynamic tripod grasp (92.87% legibility). This finding could simply be random variation, or error, in the legibility scores. Another possible explanation is that among participants with poorer handwriting, those who use an atypical grasp may be referred for intervention in fine motor skills more frequently than those who use a dynamic tripod grasp. Teachers may see the use of an atypical grasp as further evidence of fine motor deficits. Therefore, students with poor legibility who use an atypical grasp would have been underrepresented in this study because students receiving support services were excluded. The development of the atypical grasps may also be an effective adaptation for these students. Other aspects of a student’s pencil use, besides just the grasp pattern, need to be examined if handwriting problems are present. For students who do not have handwriting difficulties, the use of an atypical grasp may not be a sufficient reason to provide intervention.

On the other hand, all of the atypical grasps that were observed, except the static tripod grasp and the four finger with tips grasp, seemed to allow greater surface area of contact between the fingers and the pencil shaft. This may reflect a need for more stabilization of the pencil and may result in less use of intrinsic hand musculature during writing. The long-term biomechanical effects of these grasps on the soft tissue structures of the hand are not known. By allowing greater contact with the pencil shaft, these grasps could also allow greater pressure to be placed on the pencil. Writing with too much pressure on the pencil, regardless of grasp pattern, can cause greater muscle fatigue (Tseng & Cermak, 1993).

**Legibility Scores**

Although the ETCH scale was useful for providing specific guidelines for legibility, decisions about individual letters were still based on the researchers’ opinions and interpretations of those guidelines. The procedure outlined in the manual requires raters to examine each word or letter out of context, which is difficult because so much of reading depends on context. The situation also arises where individual letters may be illegible when considered alone, but the whole word is legible. The reverse can also be true, where all the letters may be legible, but the word is scored as illegible because of poor erasures or inadequate spacing between words (see Figure 2). Any test for handwriting legibility is likely to encounter the same problems because it must be specific enough to produce reliable scores yet flexible enough to be useful in clinical settings.

Related to the need for interpretation in scoring, the raters found it more difficult to achieve reliability using a point-by-point reliability, where agreement is checked letter by letter or word by word. Agreement on overall legibility scores, however, was easier to achieve. The difference may be partly because the actual ETCH tool was not administered; rather, the ETCH criteria were used on different writing tasks. Because the Washington State standards only provide a general guideline for legibility (Washington State Commission on Student Learning, 1997), a more global score, such as total word or letter legibility, may be more appropriate. Additionally, the ETCH manual notes that the interrater reliabilities for the total legibility scores are generally greater than the reliabilities for the individual tasks (Amundson, 1995). Because other states may have established writing standards that address legibility differently than Washington, therapists who frequently work with handwriting issues may want to review the specific standards for their state.

**Strengths and Limitations**

By matching the participants in the two grasp pattern groups on several demographic variables, some of the error variability in the scores was reduced. The two research groups contained equal distributions of students on gender, age, classroom, and hand dominance. Another strength of the study was the use of classroom assignments for the writing samples. By using these samples, the data reflected real-life performance of students in their natural environment. Although the participants did not all perform the same tasks, this was also a realistic situation because teachers make decisions about a student’s handwriting performance that are based on comparisons with peers who may not be completing an identical task.

The classroom differences in tasks introduced more error variability in the legibility scoring, which was a limitation. The variety of writing samples made group differences more difficult to identify particularly because some participants produced creative writing samples rather than copied samples. A school-based practitioner with experience in handwriting intervention noted that she has observed students reverting to immature or atypical grasps when presented with a more challenging task, such as creative writing (S. J. Amundson, personal communication).
June 25, 1999). This did not appear to be a factor in this study because the classrooms that performed creative tasks had 36% of participants using atypical grasps, whereas the classrooms that performed copying tasks ranged from 25% to 48% of students using atypical grasps. The results of this study also have limited generalizability due to the small sample size and the narrow age range from which the sample was drawn. Using copies of the students’ work, rather than original writing samples, presented another limitation; edges of words were occasionally cut off, and the writing was not always as dark on the copy as on the original because pencil marks do not copy well.

Directions for Future Research

A replication of the design of this study is needed to investigate the validity of the results for other school districts in other states. Future studies should also be expanded to include a greater range of grade levels to examine the relationship between grasp and handwriting performance throughout a student’s academic career. Once a clearer picture of this relationship is established for students who are typically developing, researchers then need to conduct studies with students with disabilities. The use of an atypical grasp may affect the performance of a student with a particular disability in a different way than the use of the same grasp would affect the performance of a child without that disability. Occupational therapists could then use the results of these studies to determine when and whether any intervention to change a student’s grasp pattern is appropriate. Future researchers using a similar design as the current study may also wish to use only copying tasks, which would allow them to examine writing speed or efficiency as another measure of writing performance because the students would not have to pause during writing to create the text.

Other suggestions for future research arose from the observations made in this study. The percentages of students in the classrooms who used an atypical grasp were higher than reported in previous studies. This difference indicates that the prevalence of atypical grasps may have increased since those previous studies were conducted. Further descriptive studies that document the distributions of types of pencil grasps would give teachers and therapists current information regarding the prevalence of atypical grasps. Researchers could then also follow students who use atypical grasps in a longitudinal study. Given that the atypical grasps seen in this study may allow students to exert greater pressure on the pencil, longitudinal studies could address whether long-term use of such grasps results in biomechanical changes to the soft tissue structures of the hand. In addition, investigators could compare the grasps that students use during creative tasks with the grasps used during copying tasks to determine whether students revert to more primitive grasps or to atypical grasps during creative writing tasks.

Another issue raised by this, and previous, research is how to consistently critique legibility of handwriting. The Washington State criteria for writing only specify that students should demonstrate “correct cursive letter formation and legible handwriting” (Washington State Commission on Student Learning, 1997, p. 32), leaving interpretation of what is legible up to individual teachers and therapists. Legibility is certainly a crucial component of written communication but can be quite difficult to define. An in-depth qualitative evaluation of how legibility is defined by practitioners would determine whether teachers and therapists across school districts and states have a consistent method for grading legibility. A further component of such research could focus on establishing norms for students’ handwriting legibility on the ETCH or other assessments.

Summary

This study examined the effects of pencil grasp and length of writing task on fourth-grade students’ handwriting legibility. A significant difference was found between the letter legibility scores on the short task and the letter legibility scores on the long task. Participants’ handwriting was more legible on the short task than on the long task across both grasp conditions. No significant difference was found in scores between participants who used dynamic tripod grasps and those who used atypical grasps, nor was there a significant interaction between grasp and task length. No significant differences were found between word legibility scores by grasp or by task length. Because of the limited sample size in this study, the results should be interpreted with caution. The results do indicate that although endurance was a factor in handwriting performance, the type of pencil grasp the students used was not, suggesting that changing a student’s grasp to “improve” legibility may not always be appropriate. More research in handwriting performance and pencil grasp, particularly related to endurance and legibility standards, is necessary to establish clear expectations and treatment strategies for students.

Acknowledgments

We thank Katherine B. Stewart, MS, OTR/L, and Martins Linauts, PhD, PT, for serving as thesis committee members and providing editorial assistance; George Tomlin, PhD, OTR/L, for statistical support; and Sandi Koch, OTR/L, for serving as a liaison between the researchers and participating teachers.

This article is based on research conducted in partial completion of a Master of Occupational Therapy degree at the University of Puget Sound.

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