Development of Handwriting Speed and Legibility in Grades 1–9

STEVE GRAHAM
University of Maryland

NAOMI WEINTRAUB
Hebrew University of Jerusalem

VIRGINIA BERNINGER
University of Washington

WILLIAM SCHAFER
University of Maryland

ABSTRACT **The development of handwriting speed and legibility in 900 children in Grades 1–9 was examined. Each student completed 3 writing tasks: copying a paragraph, writing a narrative, and writing an essay. The children's speed of handwriting on the copying task typically increased from one grade to the next, but the pace of development was uneven during the intermediate grades and leveled off in Grade 9 as speed began to approximate adult speeds. In contrast, improvement in handwriting legibility on the 3 writing tasks was primarily limited to the intermediate grades. Girls' handwriting was more legible than boys' handwriting, and the girls wrote faster in Grades 1, 6, and 7. Right-handers were also faster than left-handers, but there was no difference in the legibility of their written products. Finally, handwriting speed contributed significantly to the prediction of legibility on the narrative and expository writing tasks, but the contribution was small, accounting for only 1% of the variance.**

Horace Greely, the founder of the *New Yorker*, was famous for his poor penmanship. On one occasion, an employee used a letter of dismissal written by Mr. Greely as a letter of recommendation. It was so illegible that prospective employers were unable to read it (Hendrickson, 1994).

Although Horace Greely's handwriting difficulties did not appear to hamper his development as a writer, findings from recent studies indicate that handwriting plays an important, but often unappreciated, role in learning to compose. Graham, Berninger, Abbott, Abbott, and Whitaker (1997) reported that handwriting speed accounted for a significant proportion of the variability in children's composing, whereas Berninger et al. (in press) found that explicit instruction in handwriting improved children's composition as well as their penmanship. Moreover, writing theorists have indicated that handwriting can constrain the ease with which competence in composing is obtained (Graham, 1990). McCutchen (in press) noted that the physical act of transcribing text is so demanding for young writers that they develop an approach to writing (i.e., knowledge telling) that minimizes the use of self-regulatory processes, such as planning and revising, because they also exert considerable processing demands. Berninger, Mizokawa, and Bragg (1991) further observed that difficulties in acquiring handwriting skills may lead children to avoid writing and to develop a mind-set that they cannot write, resulting in arrested writing development.

Handwriting legibility can also influence perceptions about a child's competence in composing. When teachers or other adults evaluate two or more versions of a paper differing only in their legibility, neatly written papers are assigned higher marks for composing quality than are papers of poorer penmanship (Briggs, 1980; Chase, 1986; Hughes, Keeling, & Tuck, 1983; Sweedler-Brown, 1992). Children's handwriting competence can further affect how long it takes children to complete written assignments, their facility at taking notes during lectures, and how frequently they write (Graham, 1992; Graham & Weintraub, 1996).

Despite its importance to school success and learning to write, educators' knowledge of the course of handwriting development is incomplete. Competence in handwriting is usually described in terms of speed and legibility (Graham, 1986; Graham & Miller, 1980). It is surprising that we located only four studies conducted since 1980 that examined children's mean speed of handwriting (average number of letters written per minute) at two or more grade levels. The findings from those studies are summarized in Table 1. There was considerable variability in handwriting speeds reported in the four studies. The relatively slow speeds obtained by students in the study by Phelps, Stempel, and Speck (1985) were undoubtedly influenced by the large number of students with special needs included in their sample. The findings reported by Ziviani (1984) may have also underestimated how fast children write. The mean handwriting speed almost doubled in a subsequent replication involving a single grade level (Ziviani, 1996). Although data were not available for each grade (see Table 1), the overall impression from these studies is generally consistent with the assumption that handwriting speed develops gradually, becoming faster at each succeeding grade level

Address correspondence to Steve Graham, Department of Special Education, University of Maryland, College of Education, 1308 Benjamin Building, College Park, MD 20742–1161.

Table 1.—Mean Handwriting Speed in Previous Studies

Grade	Hamstra-Beltz & Blote (1990)			Phelps et al. (1985)	Sassoon et al. (1986)		Ziviani (1984)
	Group 1	Group 2	Group 3		Normal	Rapid	
2	24	25	25	—	46	55	—
3	35	34	39	25	—	—	33
4	46	42	49	37	64	82	34
5	54	59	—	47	—	—	38
6	66	—	—	57	—	—	46
7	—	—	—	62	—	—	52
8	—	—	—	72	—	—	—
9	—	—	—	—	—	—	—
10	—	—	—	—	117	140	—

Note. Handwriting speed was calculated as number of letters written per minute.

(Graham & Weintraub, 1996). The findings of several handwriting studies involving the use of a computer-controlled digitizer to record handwriting movement, however, suggest that this may not be the case. Mojet (1991) and Zeisger, Mounoud, and Hauert (1993) found that pseudowords took progressively less time for elementary-grade students to write at each succeeding grade level, until they reached Grade 4, at which point their rate of writing became constant through sixth grade. As Graham and Weintraub (1996) noted, the relationship between handwriting speed and grade may not be linear. Instead, it may be characterized by developmental spurts and plateaus.

Recent research charting the course of handwriting legibility has focused primarily on children in Grades 2–6. Although Ziviani and Elkins (1984) reported that the legibility of the handwriting of students in their study steadily improved at each of these grade levels, Hamstra-Bletz and Blote (1990) found that the legibility of children's penmanship improved only during the course of formal handwriting instruction (through Grade 3). Mojet (1991) also indicated that handwriting legibility plateaued at Grade 4, but the students in his study evidenced small but steady improvements in Grades 5 and 6. In contrast, several researchers did not find a relationship between handwriting legibility and grade. Maeland and Karlisdottir (1991) and Sovik and Arntzen (1991) reported no significant difference in the legibility of students in Grades 3 and 6, whereas Tarnopol and de Feldman (1987) indicated that the handwriting legibility of students in Grades 2 and 5 was similar.

Like handwriting speed, the nature of the relationship (i.e., linear or higher degree of trend) between handwriting legibility and grade has yet to be examined. In addition, little is known about the development of legibility after elementary school. Presumably, handwriting legibility continues to evolve beyond this point; Zeisger et al. (1993) reported a large gap between the handwriting performance of children in Grade 6 and a control group of adults.

In the present investigation, we extended the study of handwriting development from the start of elementary school to the end of junior high school, providing normative data on the speed and legibility of 900 children in Grades 1–9. We also examined the nature of the relationship of speed and legibility to grade, as well as possible differences in the handwriting of girls and boys and left- and right-handed students.

Each student completed three tasks: copying a paragraph, writing a narrative, and writing an essay. All three tasks were scored for legibility, but only the copying task was scored for speed. The narrative and expository tasks could not be used for this purpose, as speed on these tasks depended not only on speed of handwriting but on time spent planning while composing, pausing to spell unknown words, and so forth.

On the basis of previous research, we expected that speed of handwriting would increase from grade to grade, but that the pace of development would be uneven and punctuated by brief plateaus. We also expected that the legibility of children's writing would improve but that development would be even more uneven, punctuated by long periods with little or no growth. Consequently, we anticipated that relationships of speed and legibility to grade would be nonlinear. We further predicted that girls would have more fluent and legible handwriting than boys would. Previous research has shown that girls typically outperform boys on both of these variables (Biemiller, Regan, & Gang, 1993; Blote & Hamstra-Bletz, 1991; Hamstra-Bletz & Blote, 1990; Judd, Siders, Siders, & Atkins, 1986; Massey, 1983; Tarnopol & de Feldman, 1987; Ziviani & Elkins, 1984). We made no prediction concerning handedness, however. More current research supports the view that the speed (Suen, 1983; Ziviani, 1984) and legibility (Tarnopol & de Feldman, 1987; Ziviani & Elkins, 1986) of left- and right-handers are similar, but previous research produced conflicting evidence (Graham & Miller, 1980).

Finally, we examined whether handwriting speed contributes to legibility once variance related to grade is accounted for. Studies in which the correlation between these two variables was examined yielded contradictory findings. Ziviani (1984) reported a positive correlation (.41)

between speed and legibility, as did Wills (1938) in a much earlier study. Nevertheless, the two variables were not significantly related in studies by Rubin and Henderson (1982), Sovik and Arntzen (1991), and Weintraub and Graham (1997). Blote and Hamstra-Bletz (1991) argued that nonsignificant correlations were found because the relationship between speed and legibility is not linear, and this nonlinearity was not taken into account in these studies. We assessed this contention in the current study by examining whether the relationship between speed and legibility is best described by a linear, quadratic, or cubic trend.

Method

Participants

Nine hundred children in Grades 1–9 attending schools in the Pacific Northwest participated in the study. Fifty boys and 50 girls were included at each grade level. The students were ethnically diverse: 13% Asian American, 7% Black, 4% Hispanic, and 76% White. Mother's education level was used as an index of socioeconomic status (cf. Wagner, Spratt, Gal, & Paris, 1989). Of the participants' mothers, 3% had less than a high school education, 18% had a high school diploma, 27% had a high school diploma plus some continued education, and 51% had a college degree or college plus some postgraduate study; education level was not reported for 1%.

The students in Grades 1–3 (the primary sample) attended eight different suburban and urban elementary schools. Their reading performance on the Word Attack, Word Identification, and Passage Comprehension subtests of the Woodcock Reading Mastery Test–Revised (WRMT–R; Woodcock, 1987) is reported in Table 2. Mean standard scores were within the average range of performance at each grade level. For students in the primary sample, their mean prorated verbal IQ, based on four subtests (information, similarities, vocabulary, and comprehension) from the Wechsler Intelligence Scale–Revised (WISC–R; Wechsler, 1974) was also in the average range (M = 108.8; SD = 15.7). Nine percent of the children were left-handed.

The students in Grades 4–6 (intermediate sample) attended five different urban and suburban schools. Their mean standard scores on the Word Attack, Word Recognition, and Passage Comprehension subtests of the WRMT–R were within the average range (see Table 2). The mean prorated WISC–R verbal IQ score for the students in the intermediate sample were within the average range (M = 108.4; SD = 12.9). Ten percent of the children were left-handed.

The students in Grades 7–9 (junior high sample) attended two different suburban schools. In contrast to the elementary schools, the two junior high schools did not grant permission to administer achievement and IQ measures for the purpose of describing the participating students. According to the principals of the two schools and the director of research for the district, each school's achievement was in the average range, based on national norms, on group-administered achievement tests mandated by the district. In each school, the principals made sure that letters of opportunity to participate were made available to lower, average, and higher achieving students. The resulting sample appeared to reflect the normal range of achievement at the junior high level for schools in which average performance approximates the national average. Eight percent of the children were left-handed.

Procedures

Three samples of handwriting were collected from each student. One handwriting sample was obtained via the Copying subtest from the Group Diagnostic Reading Aptitude and Achievement Tests (Monroe & Sherman, 1966). With this subtest, the student is asked to copy a short paragraph as quickly as possible without making any mistakes. The student is asked to stop copying at the end of 1.5 min. In the current study, the paragraph was printed at the top of a page, and the student copied it on the writing lines below.

We obtained the other two handwriting samples by asking each child to generate two compositions, one narrative and the other expository. On both of these free-writing tasks, the student was asked to write about a familiar topic. For the narrative task, the student was asked to complete the choices in the following topic frame and then continue writing the story for 5 min: "One day (**choose person**) had the (**choose best or worst**) day at school." For the expository task, the student completed the choices in the following

Table 2.—Standard Scores on the Woodcock Reading Mastery Test–Revised

Grade		Word Attack	Word recognition	Passage comprehension
1				
	M	101.21	105.67	100.99
	SD	13.45	13.11	11.78
2				
	M	104.66	108.21	103.01
	SD	16.33	16.35	13.62
3				
	M	104.85	108.28	100.03
	SD	14.52	13.35	11.11
4				
	M	102.58	99.90	96.37
	SD	12.94	11.16	12.51
5				
	M	105.91	104.04	101.66
	SD	12.46	11.43	14.57
6				
	M	107.18	105.44	102.37
	SD	11.67	11.45	13.21

Note. The Woodcock Reading Mastery Test–Revised has a mean of 100 and a standard deviation of 15; N = 100 at each grade level.

topic frame and then continued writing the essay for 5 min, explaining: "I like (**choose person, place, or thing**) because _____." Once the 5-min time interval had elapsed, the student made a slash mark after the last letter written, but was allowed to complete the sentence. Only the material generated during the 5-min writing interval (before the slash) was scored in the subsequent analyses of the two free-writing tasks. The order of the two free-writing tasks was counterbalanced.

On all three handwriting tasks, the students were told that they needed to write throughout the specified time period. If a student stopped writing, the examiner encouraged the student to continue writing. It was rarely necessary to prompt students to write during the assigned interval. Furthermore, the children never seemed anxious and appeared to enjoy the three handwriting tasks, even though their performance was timed during each task.

Handwriting Measures

Speed. A measure of handwriting speed was obtained by counting the number of letters copied correctly in 1.5 min on the Copying subtest from the Group Diagnostic Reading Aptitude and Achievement Tests. The number of correctly copied letters was then divided by 1.5 min to obtain an index of the number of letters copied correctly per minute. At each grade level, the handwriting samples of 20 students (10 boys and 10 girls) were rescored. Interobserver reliability for handwriting speed on the copying task was .99.

Legibility. We used the scales from the Test of Legible Handwriting (TOLH; Larsen & Hammill, 1989) to establish the overall legibility of each of the three handwriting samples (copying and two free-writing samples). With this test, a handwriting sample is matched as closely as possible to a set of graded specimens with scores that range from 1 to 9. The higher the score, the more legible the writing sample.

Two teachers independently scored all handwriting samples. They were told that the sole consideration in making the match between a handwriting sample and the graded specimens from the TOLH was handwriting legibility. They were also told that slant, spacing, letter formation, size, and so forth were important only as they contributed to or distracted from handwriting legibility and that no single attribute should be singled out for special emphasis. They were further instructed to ignore writing features such as literary merit, spelling, word usage, grammar, and so forth, and to focus exclusively on the physical aspect of the handwriting sample.

Before scoring the handwriting samples collected in the current study, the two teachers participated in sessions where the use of the TOLH scoring procedures were modeled and practiced. At the end of these sessions, the two teachers used the graded specimens from the TOLH to independently score 20 handwriting samples. Interobserver reliability after training was .92. More important, the two raters maintained high levels of interobserver reliability as they scored the handwriting samples collected in the current study. Interobserver reliability for all scores on the copying and free-writing tasks (narrative and expository) was .87. Furthermore, at each grade level (1–9), interobserver reliability was always above .80 for each of the three handwriting tasks.

Results

Handwriting Speed

Table 3 contains means and standard deviations for handwriting speed on the copying task by gender, handedness, and grade. The development of handwriting speed was examined using a 9 × 2 × 2 (Grade × Sex × Handedness) analysis of variance (ANOVA). The main effects for grade, $F(8, 866) = 364.64$, $p < .00$ ($MSE = 315.92$); gender, $F(1, 866) = 47.19$, $p < .00$ ($MSE = 315.92$); and handedness, $F(1, 866) = 9.35$, $p < .01$ ($MSE = 315.92$), were significant, as was the interaction between grade and gender, $F(8, 866) = 2.26$, $p < .05$ ($MSE = 315.92$). Post hoc analyses using Tukey's honestly significant difference (HSD) indicated that girls were faster handwriters than boys in Grades 1, 6, and 7 (all $ps < .05$). Although the mean handwriting speed of girls was higher than that of boys at all other grade levels, differences were not large enough to be statistically significant (see Table 3).

An additional follow-up of the significant interaction between grade and gender involved conducting polynomial contrasts for both girls and boys to test for linear, quadratic, or cubic trends in the relationship between grade and handwriting speed. For girls, the linear, $F(1, 442) = 1{,}851.00$, $p < .00$ ($MSE = 281.16$); quadratic, $F(1, 442) = 8.74$, $p < .01$ ($MSE = 281.16$); and cubic terms, $F(1,442) = 4.07$, $p < .05$ ($MSE = 281.16$), were all significant. Girls' mean handwriting speed increased from one grade to the next (see Table 3). Follow-up analyses with Tukey's HSD indicated that all but three gradewise comparisons of mean handwriting speed were statistically significant (all $ps < .05$). Girls' handwriting speed was not statistically different in Grades 4 and 5, Grades 7 and 8, and Grades 8 and 9. Thus, girls' handwriting speed increased significantly at each grade through Grade 4, leveled off between Grades 4 and 5, increased significantly again at Grades 6 and 7, and continued to increase significantly between Grades 7 and 9 but at a slower pace.

For boys, only the linear, $F(1, 442) = 1{,}134.55$, $p < .00$ ($MSE = 363.80$), and quadratic, $F(1, 442) = 5.97$, $p < .05$ ($MSE = 363.80$), terms were significant. Similar to that for girls, boys' mean handwriting speed increased from one grade to the next (see Table 3). Follow-up analyses with Tukey's HSD indicated that all but three gradewise comparisons of mean handwriting speed were statistically significant (all $ps < .05$). Boys' handwriting speed was not statistically different in Grades 4 and 5, Grades 5 and 6, and Grades 8 and 9. Thus, boys' handwriting speed increased

Table 3.—Speed of Handwriting on the Copying Task by Gender, Handedness, and Grade

Grade		Boys	Girls	Right-handed	Left-handed	All students
1						
	M	17.44	20.51	19.16	17.27	18.97
	SD	5.60	7.91	6.75	9.14	6.99
2						
	M	31.55	36.77	34.63	26.67	33.96
	SD	8.63	15.14	12.74	5.09	12.50
3						
	M	44.80	49.80	47.10	50.44	47.30
	SD	12.57	13.88	13.55	11.56	13.41
4						
	M	60.58	65.78	63.96	56.22	63.26
	SD	14.70	19.41	17.40	14.57	17.24
5						
	M	70.91	74.57	73.05	70.24	72.74
	SD	14.74	15.59	15.01	17.34	15.21
6						
	MD	78.29	91.19	85.83	72.17	84.74
	SD	17.56	18.31	18.45	21.87	18.96
7						
	MD	91.01	108.56	100.15	92.67	99.96
	SD	22.89	18.79	22.38	28.82	22.59
8						
	MD	112.43	117.87	113.89	92.33	115.20
	SD	19.20	19.50	22.88	39.77	19.44
9						
	MD	113.66	121.44	116.05	108.73	117.63
	SD	20.36	19.02	23.58	40.81	19.97

Note. $N = 100$ at each grade level. Speed of handwriting was calculated as number of letters written per minute.

significantly at each grade through Grade 4. It continued to increase between Grades 4 and 6, but at a slower pace, increasing significantly again in Grades 7 and 8, before leveling off.

Consequently, children's speed of handwriting tended to improve from one grade to the next, although the rate of development was not even across grades for either girls or boys. The girls also were faster handwriters than the boys at the start and end of elementary school and the beginning of junior high school. Finally, right-handed writers ($M = 73$) in the present study were faster than left-handed writers ($M = 65$).

Handwriting Legibility

Table 4 contains means and standard deviations for handwriting legibility of the writing samples by gender and grade. We used three $9 \times 2 \times 2$ (Grade × Sex × Handedness) ANOVAs to examine the development of handwriting legibility from elementary through junior high school. We completed a separate analysis for each type of writing task (i.e., copying, narrative, and expository).

For the copying task, the main effects for grade, $F(8, 866) = 14.34$, $p < .00$ ($MSE = 1.32$), and gender, $F(1, 866) = 101.43$, $p < .00$ ($MSE = 1.32$), were significant. We conducted polynomial contrasts to test for linear, quadratic, or cubic trends in the relationship between grade and handwriting legibility. Both the linear, $F(1, 892) = 7.15$, $p < .01$ ($MSE = 1.47$), and quadratic, $F(1, 892) = 42.24$, $p < .00$ ($MSE = 1.47$), terms were significant. Follow-up analyses using Tukey's HSD indicated that the legibility of copying in Grades 5 and 6 was superior to the legibility of copying in Grades 1, 2, 3, 7, 8, and 9: the legibility of copying in Grade 4 was superior to the legibility of copying in Grades 1 and 3; and the legibility of copying in Grade 6 was superior to the legibility of copying in Grade 4 (all $ps < .05$). Thus, there was little change in the legibility of students' copying in the primary grades (see Table 4). In the intermediate grades, copying legibility improved significantly, reaching a maximum in Grades 5 and 6. In junior high school, however, copying legibility returned to the level of achievement attained by primary grade children.

For the narrative writing task, the main effects for grade, $F(8, 866) = 12.75$, $p < .00$ ($MSE = 1.27$), and gender, $F(1, 866) = 106.00$, $p < .00$ ($MSE = 1.32$), were significant, as was the interaction between grade and gender $F(8, 866) = 2.54$, $p < .01$ ($MSE = 1.32$). Post hoc analyses using Tukey's HSD indicated that the girls produced qualitatively better handwriting than the boys did on the narrative task in all grades but first grade (all $ps < .05$; see Table 4).

For both the boys and the girls, we conducted polynomial contrasts to test for linear, quadratic, or cubic trends in the relationship between grade and handwriting legibility.

Table 4.—Handwriting Legibility on the Three Writing Tasks, by Gender and Grade

Grade	Boys		Girls		All students	
	M	*SD*	*M*	*SD*	*M*	*SD*
1						
Copy	3.3	0.9	3.8	1.1	3.5	1.0
Narrative	3.0	1.0	3.4	1.1	3.2	1.1
Expository	3.0	1.0	3.4	1.0	3.2	1.0
2						
Copy	3.8	1.1	4.2	1.0	4.0	1.1
Narrative	3.4	1.0	3.8	1.0	3.6	1.0
Expository	3.3	1.0	3.8	0.8	3.6	0.9
3						
Copy	3.3	0.8	4.0	1.0	3.7	1.0
Narrative	2.9	0.9	3.5	0.9	3.2	1.0
Expository	3.1	0.9	3.5	1.0	3.3	1.0
4						
Copy	3.9	1.2	4.7	1.3	4.3	1.3
Narrative	3.2	1.1	3.8	1.1	3.5	1.1
Expository	3.2	1.1	3.9	1.2	3.6	1.2
5						
Copy	4.1	1.1	5.1	1.4	4.6	1.4
Narrative	3.5	1.1	4.6	1.2	4.0	1.4
Expository	3.8	1.1	4.7	1.2	4.2	1.2
6						
Copy	4.5	1.3	5.3	1.4	4.9	1.4
Narrative	4.0	1.1	4.6	1.2	4.3	1.2
Expository	3.9	1.2	4.8	1.3	4.3	1.3
7						
Copy	3.4	0.9	4.3	1.1	3.9	1.1
Narrative	3.4	1.0	4.4	1.2	3.9	1.2
Expository	3.5	1.1	4.3	1.3	3.9	1.2
8						
Copy	3.4	1.3	4.3	1.4	3.9	1.4
Narrative	3.4	1.1	4.7	1.6	4.0	1.5
Expository	3.3	1.2	4.5	1.6	3.9	1.5
9						
Copy	3.4	1.0	4.5	1.3	4.0	1.3
Narrative	3.5	1.0	4.7	1.3	4.1	1.3
Expository	3.6	1.3	4.8	1.3	4.2	1.4

Note. $N = 100$ at each grade level.

For the girls, only the linear term, $F(1, 442) = 64.21$, $p < .00$ ($MSE = 1.49$), was significant. Follow-up analyses with Tukey's HSD indicated that the handwriting legibility of girls' narrative writing was better in Grades 5–9 than it was in Grades 1–4 (all $ps < .05$). The only exceptions involved the comparison between Grades 2 and 7 as well as the comparisons of Grade 4 with Grades 5 and 7, where no statistically significant differences were obtained. Thus, the handwriting legibility of the girls' narrative writing changed little in the primary grades but improved significantly at the intermediate level. These improvements were maintained throughout junior high school.

Similarly, only the linear term, $F(1, 442) = 64.21$, $p < .00$ ($MSE = 1.49$), was significant in the polynomial contrasts conducted with boys. Follow-up analyses with Tukey's HSD indicated that there was very little change across grades in the handwriting legibility of the boys' narrative papers. The only significant pairwise comparisons involved Grade 6, where handwriting legibility of narratives was superior to the handwriting legibility of narratives produced in Grades 1–4 and Grades 7 and 8 (all $ps < .05$). Thus, for narrative writing, significant improvement occurred only in Grade 6 (see Table 4).

For the expository writing task, the main effects for grade, $F(8, 866) = 12.82$, $p < .00$ ($MSE = 1.31$), and gender, $F(1, 866) = 96.28$, $p < .000$ ($MSE = 1.31$), were significant. We conducted polynomial contrasts to test for linear, quadratic, or cubic trends in the relationship between grade and handwriting legibility. Both the linear, $F(1, 892) = 54.48$, $p < .00$ ($MSE = 1.46$), and quadratic, $F(1, 892) = 8.19$, $p < .00$ ($MSE = 1.46$), terms were significant. Follow-up analyses using Tukey's HSD indicated that the legibility of expository papers in Grades 5, 6, and 9 were superior to those produced in Grades 1–4, and legibility of expository papers in Grades 7 and 8 were superior to those produced in Grades 1 and 3 (all $ps < .05$). Thus, there was little change in the legibility of students' expository papers in Grades 1–4 (see Table 4). In Grades 5 and 6, the legibility of expository

papers improved. Although these gains in legibility were maintained in junior high school, there was a slight decline in legibility in Grades 7 and 8.

We used a 9 x 3 (Grade x Writing Task) ANOVA with repeated measures design to determine if the legibility of students' handwriting differed on the samples from the three writing tasks. The main effects for grade, $F(8, 2674) = 30.98$, $p < .00$ ($MSE = 1.46$), and writing task, $F(2, 2674) = 18.06$, $p < .00$ ($MSE = 1.46$), were significant, as was the interaction between grade and writing task, $F(8, 2674) = 2.38$, $p < .01$ ($MSE = 1.46$). Post hoc analyses using Tukey's HSD indicated that in Grades 1–6, handwriting legibility was better on the copying task than it was on either of the two free-writing tasks (all $ps < .01$). Also, in Grade 5, the handwriting legibility of the expository paper was superior to the handwriting legibility of the narrative paper. No other significant differences were noted.

In summary, the legibility of children's handwriting was not related to their handedness, but girls consistently produced handwriting of higher legibility than boys. In contrast to handwriting speed, little improvement in handwriting legibility was observed in the first four grades of elementary school. Handwriting legibility did improve in the later part of elementary school, however, and the gains made at that point were typically maintained during the junior high school years. The only exceptions involved copying legibility, which declined in Grades 7 through 9, and the handwriting legibility of boys' narrative writing, which remained relatively constant in all grades except for Grade 6 where it improved briefly. Finally, throughout the elementary school years, the students produced their best handwriting when copying text material. In junior high school, handwriting legibility on copying and free-writing tasks was similar.

Relationship Between Handwriting Speed and Legibility

We used regression analysis to examine the relationship between handwriting speed and legibility. We were interested in determining the extent to which variance in handwriting speed contributed to the prediction of handwriting legibility once the variability related to grade was accounted for. In addition, we examined whether the relationship between handwriting speed and legibility was best described by a linear, quadratic, or cubic trend. We conducted three regression analyses—one for each of the handwriting legibility measures. Predictors were entered in the following order in each analysis: grade, handwriting speed, the quadratic term (handwriting speed squared), and the cubic term (handwriting speed cubed). Correlations between handwriting speed and the three legibility measures by grade are presented in Table 5. Table 6 contains the results from the three regression analyses.

For copy legibility, the initial entry of grade into the regression formula accounted for approximately 10% of the variance ($p < .00$). However, neither the subsequent inclusion of handwriting speed nor the entry of either the quadratic or cubic terms resulted in a significant increase in the multiple correlation coefficient (see Table 6). In contrast, handwriting speed did make a significant contribution to the prediction of narrative and expository handwriting legibility. On the narrative task, grade accounted for 9% of the variance in handwriting legibility ($p < .00$), and the subsequent inclusion of handwriting speed resulted in a small but statistically significant increase in the multiple correlation coefficient (see Table 6). Entry of the quadratic and cubic terms, however, did not result in a significant change. Similarly, grade accounted for 9% of the variance in handwriting legibility on the expository task ($p < .00$), and the subsequent inclusion of handwriting speed resulted in a small but statistically significant increase in the multiple correlation coefficient (see Table 6). Entry of the quadratic and cubic terms, however, did not result in a significant change. Similarly, grade accounted for 9% of the variance in handwriting legibility on the expository task ($p < .00$), and the subsequent inclusion of handwriting speed resulted in a small but statistically significant increase in the multiple correlation coefficient (see Table 6). Entry of the quadratic and cubic terms, however, did not result in a significant change.

Table 5.—Correlations Between Handwriting Speed and Legibility, by Grade

Grade	Writing task		
	Copy	Narrative	Expository
1	.24*	.16	.27**
2	−.20*	.01	−.03
3	−.20*	−.04	−.03
4	.04	.21*	.24*
5	.04	.15	.22*
6	−.15	−.01	−.02
7	.13	.18	.12
8	.07	.06	.08
9	−.11	.00	.06

*$p < .05$. **$p < .01$.

In summary, a linear relationship existed between handwriting speed and the three measures of handwriting legibility in this study. When students copied textual material, however, handwriting speed did not contribute to the prediction of handwriting legibility once the variability associated with grade was accounted for. Although handwriting speed did result in a statistically significant increment in the explained proportion of variability on the legibility measures for the two free-writing tasks, the increase was small, accounting for only 1% of the variance.

Discussion

In the present study, we examined the course of handwriting development from elementary school through junior high school, providing normative data on the handwriting speed and legibility of children in Grades 1–9. We further

Table 6.—Hierarchical Regression Analyses for the Three Writing Tasks

Source	R^2 cumulative	R^2 adjusted	R^2 change	F	p
Copy					
Grade	.10	.10		12.95	.000
Speed	.11	.10	.00	.26	.612
Quadratic term	.11	.10	.00	.00	.955
Cubic term	.11	.10	.00	.00	.990
Narrative					
Grade	.09	.08		11.27	.000
Speed	.10	.09	.01	6.66	.010
Quadratic term	.10	.09	.00	.71	.401
Cubic term	.10	.09	.00	.40	.530
Expository					
Grade	.09	.09		11.50	.000
Speed	.10	.10	.01	10.57	.001
Quadratic term	.11	.10	.00	.60	.440
Cubic term	.11	.10	.00	.15	.701

Note. Quadratic term = fluency squared; cubic term = fluency cubed.

examined the relationship between the two handwriting skills to see if speed made a significant and unique contribution to the prediction of legibility.

Handwriting Speed

As expected, the children's handwriting speed typically increased from one grade to the next, but the relationship between grade and speed was not linear. From Grades 1–4, the pace of development was relatively constant for boys and girls, averaging 13 to 16 letters per min increase at each grade. Between Grades 4 and 5, however, rate of development slowed; boys and girls averaged an increase of only 9 and 10 letters per min, respectively. For boys, this change in tempo extended to a 2nd year, before their pace of development returned to previous levels between Grades 6 and 7, eventually leveling off in Grade 9. For girls, the change in tempo was more transitory, as they evidenced an increase in handwriting speed of 17 letters per min over each of the next 2 years, before their pace of development again slowed in Grades 8 and 9. It is not necessarily surprising that students' handwriting speed leveled off at this point, as Grade 9 speeds approximated the speeds typically obtained by adults (Freeman, 1954).

Like previous investigators (Biemiller et al., 1993; Judd et al., 1986; Ziviani, 1984), we also found that girls were faster writers than boys. However, the significant advantage the girls evidenced in handwriting speed was limited to three grades: 1, 6, and 7. Although in the present study we did not attempt to identify the mechanisms responsible for girls' superiority, gender-related differences are likely the result of both biological and environmental factors (Graham & Weintraub, 1996). There is a substantial literature documenting the more advanced development of fine-motor coordination in girls relative to boys (Hartley, 1991). Cultural stereotypes are also likely to influence handwriting development; it is usually assumed that girls are better handwriters than boys (Spear, 1989).

In contrast to less current studies (Suen, 1983; Ziviani, 1984), we found that right-handers wrote faster than left-handers. If this finding is subsequently replicated, attention should be directed toward identifying the mechanisms responsible for this difference. One possible contributor involves how left-handed writers place their paper when writing. Enstrom (1957) identified 15 adjustments in paper positions used by left-handed students and found that students who used 4 of these adjustments generally wrote above grade level in both rate and legibility. In a recent study by Athenes and Guiard (1991), however, left-handed students did not typically use the more effective adjustments. Another possible contributor involves the quality of handwriting instruction received by left-handed students. It is possible that teachers do not take into account the needs of left-handed students when teaching handwriting, gearing their instruction to the more numerous right-handed student instead. For example, all students may be encouraged to place their paper directly in front of them on the desk and rotate it 30° or 40° counterclockwise. Although this is the preferred position for right-handed writers, this is not an effective position for left-handed writers (Enstrom, 1957; Graham & Miller, 1980).

We should further note that the students in the present study generally wrote faster than the students in previous studies. The only exceptions to this result involved students in a study by Sassoon, Nimmo-Smith, and Wing (1986) and the youngest students in a much earlier study by Freeman (1915). The "normal" handwriting of students in the Sassoon et al. study was 10 letters per min faster in Grade 2 than in the current study and approximately the same in Grade 4 (see Table 1). In the Freeman study, handwriting speeds were equivalent in Grades 2 and 3, but the students in the present study wrote faster in Grades 4 through 8.

One likely explanation for why children in the present study generally wrote faster involves how frequently students actually write connected text. It is generally assumed that the more children compose, the more their handwriting skills become automatic or habitual, resulting in a gradual increase in speed (Graham, 1992). Many of the students in the present study were in schools that used a process approach to writing instruction. Children in process writing classrooms typically spend more time composing than children in traditional skill-oriented writing programs do (Fisher & Hiebert, 1990; Graham & Harris, 1994). Because data for the previous studies of handwriting speed were collected before 1985, it is likely that the students in these investigations received traditional instruction, emphasizing skill development, and spent less time actually composing connected text.

A second explanation involves the types of instructions given to students as they copied textual material. The children's handwriting was generally faster in studies in which they were asked to write quickly, as in the current investigation, than in studies in which they were asked to write at their usual rate, as in the study by Hamstra-Beltz and Blote (1990). This is congruent with previous research, demonstrating that children are able to adjust the speed of their handwriting to meet demands to be more fluent or legible (Martlew, 1992; Sassoon et al., 1986; Sovik, Arntzen, & Karlsdottir, 1993; Weintraub & Graham, 1997). Thus, practitioners wishing to use the normative data in the present study to gauge the speed of their own students should observe the following recommendations. First, teachers should use the same procedures applied in the present study to collect samples, paying special attention to the directions to copy "as quickly as possible without making any mistakes." Second, separate norms should be used for girls and boys and left- and right-handers (see Table 3), because gender and handedness were both related to children's handwriting speed. Third, caution must be exercised in using these norms when making comparisons because of the considerable variability in children's handwriting speeds at each grade level tested. For instance, children's handwriting speed ranged from 43 letters per min to 125 letters per min in Grade 5.

Handwriting Legibility

In general, the findings support our hypotheses concerning the development of legibility. First, the children's handwriting became more legible during the elementary grades, and this improvement was maintained in Grades 7–9. The only exceptions to this pattern involved the copying task in which gains were not maintained during junior high school and the narrative task in which the boys evidenced a temporary improvement in legibility in Grade 6 only. Second, the development of legibility was punctuated by long periods with little or no change in performance. This occurred during the primary grades and junior high school. Third, for the copying and expository writing tasks, the relationship between grade and legibility was not linear. This was not the case, however, for the narrative task. Fourth, the handwriting of the girls was more legible than that of the boys on all three writing tasks, supporting the findings from previous investigations (Blote & Hamstra-Bletz, 1991; Hamstra-Bletz & Blote, 1990; Massey, 1983; Tarnopol & de Feldman, 1987; Ziviani, 1984).

In contrast to several earlier reports (Hamstra-Bletz & Blote, 1990; Mojet, 1991; Ziviani & Elkins, 1984), we did not detect any improvement in the legibility of handwriting produced by children in the primary grades. This discrepancy most likely reflects differences in how handwriting was assessed. In the present study, we used a holistic measure of legibility to assess handwriting, whereas the authors of the other studies focused on more specific components of legibility such as letter formation, alignment, size, smoothness, and so forth (Graham, 1986). Taken together, these findings imply that specific features underlying legibility do improve in the primary grades, but the improvements are not substantial enough to change the overall legibility of the written product. However, additional research is needed to verify this conjecture.

The finding that the handwriting of students in Grades 1–6 was more legible when the students were copying than when they were creating a narrative or expository text suggests that the processes involved in composing, at least during elementary school, interfere with the processes involved in writing legibly. Presumably, younger students have to devote considerable attention to composing processes such as generating ideas and planning, leaving fewer attentional resources for writing neatly. This relationship does not appear to be unidirectional, however, as previous researchers have shown that individual differences in handwriting contribute to individual differences in compositional fluency and quality (Berninger et al., in press; Graham et al., 1997). In any case, these findings provide support for the often-used instructional recommendation that young children do not worry about legibility until preparing the final draft of a paper—after most of the work of generating, organizing, and reworking ideas has already been completed.

Relationship Between Handwriting Speed and Legibility

The correlations between handwriting speed and legibility on the three writing tasks were small, ranging between –.20 and .27. This finding is consistent with the findings reported by Rubin and Henderson (1982), Sovik and Arntzen (1991), and Weintraub and Graham (1997), who found little association between these two variables. Although we did find that handwriting speed contributed significantly to the prediction of legibility on the narrative and expository writing tasks once variance associated with grade was accounted for, the contribution was small, accounting for only 1% of the variance. In addition, the findings from the present study did not support the contention by Blote and Hamstra-Bletz (1991) that past research underestimated the relationship between speed and legibility. They argued that

the association between these two variables is not linear and that this nonlinearity was not taken into account in prior studies. Contrary to their claim, however, we did not find a nonlinear relationship between speed and legibility for any of the three writing tasks in the present study.

Although these findings indicate that handwriting speed is of little value in predicting legibility, there is a trade-off between these two skills when children consciously attempt to speed writing up or write more neatly. For instance, Weintraub and Graham (1997) found that when children were directed to write quickly, there was a corresponding decline in legibility. Likewise, when the children were asked to write neatly, the speed of their handwriting decreased.

In summary, handwriting speed and legibility did not follow a parallel course of development in the present study. The development of speed was relatively steady, punctuated by a brief slowdown in the intermediate grades and a plateau in Grade 9 as children started to approximate the speeds typically obtained by adults. Overall improvement in handwriting legibility, in contrast, occurred primarily in the intermediate grades. Finally, the commonly assumed relationship between the development of speed and legibility received little support. Additional research is needed to replicate these findings and to identify factors that contribute to the development of speed and legibility.

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