Psychology in the Schools, Vol. 50(6), 2013
View this article online at wileyonlinelibrary.com/journal/pits

DOI: 10.1002/pits.21691

DOES THE HANDWRITING STYLE LEARNED IN FIRST GRADE DETERMINE THE STYLE USED IN THE FOURTH AND FIFTH GRADES AND INFLUENCE HANDWRITING SPEED AND QUALITY? A COMPARISON BETWEEN FRENCH AND QUEBEC CHILDREN

FLORENCE BARA

University of Brest

MARIE-FRANCE MORIN

University of Sherbrooke

An important issue relating to the teaching of handwriting concerns the style that should be learned at school (manuscript or cursive). Whereas some countries choose to teach both styles (e.g., Canada), other countries choose to teach only one (e.g., France). Our research had three main underlying goals, namely (1) to observe and describe the handwriting styles spontaneously used by fourth and fifth graders according to the first style learned at school; (2) to describe the evolution of handwriting between the fourth and fifth grades; and (3) to examine the relationship between speed, legibility, and handwriting style. The results revealed that the effects of country, grade level, handwriting style, and handwriting instruction were significant. Quebec children wrote faster than French children did, but their handwriting was less legible. Cursive handwriting was the slower style, whereas mixed handwriting seemed to be more efficient. Handwriting speed and legibility improved from fourth to fifth grade. © 2013 Wiley Periodicals, Inc.

Despite advances in computer technology and the availability of computers both at school and at home, handwriting continues to take up a large proportion of time in the course of daily school activities and, for this reason at least, handwriting is an important issue (Christensen, 2009). Handwriting is a complex task that requires attention and memory, as well as linguistic and motor skills (Bara & Gentaz, 2010a; Graham & Weintraub, 1996). It requires access to the motor program for a selected letter, a decision to be made regarding the spatial arrangement of the letters on the page, and the setting of the necessary parameters for executing the motor program (Graham, Struck, Santoro, & Berninger, 2006). Children have to learn the specific shapes that are used in writing (letter shape and allographic particularity) and the way these shapes are produced (direction and trajectory of movement).

As shown by Berninger et al. (2006), handwriting is not a purely motor or visual activity; it is "language by hand," which shares common processes with other kinds of language (listening, speaking and reading), but also some distinct processes that are unique to writing. Mastering handwriting is very important for children, as it places the earliest constraints on writing development. If children cannot form letters with a minimum of speed and legibility, they cannot translate their ideas into written texts. In fact, given the limited capacity of working memory and the number and complexity of writing processes, novice writers are likely to experience difficulty during the learning process (Berninger, Whitaker, Feng, Swanson, & Abbott, 1996; Bourdin & Fayol, 2000; Christensen, 2009; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; Graham, Harris, & Fink, 2000; Jones & Christensen, 1999; Olive, Favart, Beauvais, & Beauvais, 2009; Olive & Kellogg, 2002; Torrance & Galbraith, 2005). The need to switch attention from the composition process to the mechanical demands of handwriting may result in a writer forgetting his or her ideas for the text. It is therefore not surprising that handwriting quality affects academic performance and that there is a strong relationship between transcription and text generation.

Correspondence to: Florence Bara, CREAD, IUFM Bretagne, 8 rue d'Avranches, 29200 Brest, France. E-mail: Florence.bara@bretagne.iufm.fr

More precisely, individual differences in handwriting skills predict how much and how well children write (Berninger et al., 1997; Jones & Christensen, 1999). Basic measures of handwriting correlate with and predict compositional fluency (Berninger et al., 1996; Berninger & Fuller, 1992; Berninger & Swanson, 1994) but also compositional quality (Berninger & Swanson, 1994) for both primary and middle school students (Berninger et al., 1997). Automaticity, as defined by the ability to recall information from memory quickly, accurately, and effortlessly, is really important in order not to exceed the limited resources in terms of working memory. Thus, it is essential that producing letters becomes automatic and that information about letter shape and trajectory of movement can be retrieved without consuming attention. Research conducted by Medwell, Strand, and Wray (2009) at the end of primary school in the United Kingdom suggests that handwriting, specifically the ability to generate letters automatically, has an important role in text composition. As handwriting skills become more automatic, attention and cognitive resources for carrying out other learning processes become available (McCutchen, 2011). Throughout the school day, children have to take notes, copy, produce written texts, and perform written exams; all these tasks rely on handwriting ability. Therefore, handwriting strongly impacts academic performance. In Graham et al.'s (2008) study, only 46% of teachers reported that their students' handwriting was fast enough to keep up with classroom demands. Thus, handwriting teaching has to focus on better ways to improve handwriting automaticity, and this is linked with the choice of handwriting style that should be taught.

Handwriting Development

The acquisition of the motor programs for producing letters is gradual and develops throughout elementary school. Handwriting quality improves greatly during the first year of learning and much more slowly thereafter (Karsldotir & Stefansson, 2003). Mojet (1991) showed that children made a dramatic improvement from Grades 2 to 3, followed by a stagnation in Grade 4 and then by a steady improvement from Grades 5 to 6. In two longitudinal studies, Blöte and Hamstra-Bletz (1991) and Hamstra-Bletz and Blöte (1990) described the different stages of handwriting development from Grades 2 to 6. From Grades 2 to 3, they observed improved skills in making the fine movements required to write; letter size decreased, word and letter alignment improved, the written line became steady, and links were smoother. Handwriting changed after Grade 4, with the shapes of letters deteriorating, making for ambiguous letter shapes. Letter writing speed increases in a linear manner over the primary school years (Graham et al., 1994; Hamstra-Bletz & Blöte, 1990; Karlsdottir & Stefansson, 2003; Sassoon, 1986; Ziviani & Elkins, 1984). The development of handwriting is based on a gradual switch from a feedback to a feed-forward control of movement (Meulenbroek & van Galen, 1988). This change may occur at around the age of 10. However, the production of movement is not yet automatic at this age, and the lack of visual feedback leads to many modifications to the movement (Chartrel & Vinter, 2006).

Letter Production

Letter production can be achieved in different ways, using a pen or a keyboard, and using different styles of handwriting. Even though typing on a keyboard has become a widely used mode of transcription, handwriting is often commonly used and results in faster word production in elementary school children (Berninger, Abbott, Augsburger, & Garcia, 2009; Connelly, Gee, & Walsh, 2007). With regard to handwriting, different styles can be taught and used (most commonly manuscript and cursive). The motor output process is influenced by allographic variability when children have to choose which letter is going to be produced. Motor planning and motor execution are different for manuscript and for cursive handwriting (Meulenbroek & van Galen, 1990). In manuscript writing, letters are disconnected and correspond to letter shapes classically encountered

in printed books. Most of the manuscript letters are formed by a single continuous stroke or by two or more basic strokes (lines, circles, parts of circles, etc.).

On the contrary, cursive style is characterized by joined letters, continuous movement, and few pen lifts. Although this is considered to improve writing fluency, it is more demanding in terms of fine motor coordination (Paoletti, 1999). One of the most fundamental issues in teaching handwriting involves the style that should be taught at school. This point is a contested issue, and the style used depends on the country (Ediger, 2002). For example, in the United States and Canada, manuscript writing is generally learned first and cursive is taught in second or third grade. Despite the general practice of teaching both forms of writing, some educators recommend that only manuscript be taught or that cursive be taught from the start.

A common variation in the United States is to teach slanted manuscript letters that more closely resemble their cursive counterparts than the traditional manuscript alphabet. In France, cursive writing is learned as of the first year of formal education. Before entering elementary school, children learn to master the movements required to write, learn the strokes that form the letters, and begin to write cursive letters and words. In the first years of elementary school, specific handwriting activities are introduced, and children practice cursive handwriting. Letter shapes, both printed and cursive, are introduced simultaneously, but only cursive letters have to be written. After Grade 4, they stop performing specific handwriting exercises, but an emphasis is already placed on handwriting quality (French primary school syllabus, 2008).

In Quebec, the official specifications regarding the teaching of handwriting are less specific (Ministry of Education Quebec, 2001). In kindergarten, no specific indications are given regarding the nature of the graphic activities that can develop handwriting skills. In primary school, legibility, spacing between letters and words, and fluency of movement are identified as important components of handwriting. No clear recommendations exist regarding the use of the manuscript or cursive handwriting, and official texts state that "depending on the situation, pupils write in manuscript or in cursive style so that their texts can be read easily" (Ministry of Education Quebec, 2001). A clear tendency can be observed in schools, where pupils learn manuscript writing in first grade, both in reading and writing, and are taught cursive handwriting the following year. Some studies have tried to present arguments in favor of one handwriting instruction method or the other (Karlsdottir, 1996a). These arguments have focused on the complexity of the motor act, the speed of handwriting, and the link between reading and writing.

Teaching Manuscript or Cursive Style?

Some research supports the idea that the teaching of manuscript writing should be retained in lower grades because it is more easily learned, is more legible, and is as fast to produce as cursive handwriting (Gates & Brown, 1929; Gray, 1956; Houston, 1938; Turner, 1930). According to Duval (1985), cursive handwriting can be considered as the more difficult style. It was often assumed that manuscript writing fit more with the perceptual and motor skills of young children than cursive writing and could therefore be easily mastered. In fact, letters with high curvature and sudden curvature changes (which is the case in cursive handwriting) are difficult with regard to motor action (Thomassen & van Galen, 1992).

In children from Grades 2 to 6, Meulenbroek and van Galen (1990) observed that older children formed cursive letters using slightly curved lines, whereas younger children used straight lines. Manuscript also seems easier because letter shapes are stable and are not modified by the context (i.e., the joined letters before and after). Moreover, the numerous pen lifts in manuscript writing allow children to take the time to better plan the following movement (Meulenbroek & van Galen, 1986). To write their first letters, children generally use the drawing stroke-composition rules. Handwriting acquisition, particularly in cursive writing, requires children to reverse the preferential

rotational direction for producing loops and circles (Goodnow, Friedman, Bernbaum, & Lehman, 1973; Meulenbroek, Vinter, & Mounoud, 1993). The counterclockwise direction of cursive letters is not spontaneously used by young children because it imposes strong motor constraints. As a result, the changes in sequencing strategy could lead to difficulty in handwriting acquisition.

In manuscript writing, the direction of movement is less important than in cursive because letters are not joined. Production rules in manuscript writing are therefore closer to drawing, and children can more easily master the trajectory of these letters. However, even though, manuscript seems to be easier in terms of motor execution, this is not the case for the perceptual task of letter recognition. In manuscript writing, the simpler shapes and the high number of mirror letters make the differentiation between letters more difficult than in cursive (Paoletti, 1999).

With regard to the speed of writing, it has been reported that children wrote manuscript faster than cursive (Gray, 1956; Houston, 1938; Turner, 1930). These results are congruent with Meulenbroek and Van Galen's (1986) study, which showed that children copied patterns with clockwise and counterclockwise movements faster than patterns alternating the rotational direction of movements (which is the case in cursive writing because of the joined letters). However, these results were not reproduced in all studies, and it was shown that practice, more than handwriting style, influences handwriting speed (Graham, Berninger, & Weintraub, 1998; Laszlo & Broderick, 1991). Learning manuscript writing prior to cursive is considered to improve the development of quality and speed in subsequent cursive writing (Leung, Treblas, Cooper, & Porter, 1982; Otto & Rarick, 1969). However, Armitage and Ratzlaff (1985) did not find any significant correlation between the quality of manuscript and later cursive writing and concluded that teaching manuscript as the first style did not influence the quality of cursive handwriting. Poor printers do not necessarily become poor cursive writers, and the changeover from manuscript to cursive writing might slow down the development of subsequent cursive handwriting (Herrick, 1960).

Another argument in favor of the teaching of manuscript writing in first grade concerns the link between reading and writing. Manuscript letters should be better produced and recognized than cursive letters because they look more like the typeset letters found in books. Using the same letters in reading and writing should make these acquisitions easier (Myers, 1983). The deviation between the allographic shape of letters in books (manuscript) and the shape of letters taught at school in writing (cursive style) would lead to a cognitive overload that would damage the effective treatment of the written characters. However, the results of Bara and Morin's (2009) study did not bring to light any difficulties in reading caused by the learning of cursive handwriting.

The debate over the type of writing style to be taught in school has led scholars to suggest alternative styles of writing, such as disjointed cursive letters, slanted alphabet, and italic or modern cursive. In Australia, for example, modern cursive was introduced to facilitate the transition from manuscript to cursive. The style was oval, not circular; the lines were slanted, not vertical; and links were introduced in order for it to more closely resemble cursive handwriting (Ziviani, 1998). According to Karlsdottir (1996b, 1996c), the difficulty of cursive handwriting seems to stem more from the links between the letters than from the complexity of letter shapes. She compared two ways of teaching handwriting to first-grade children, namely, manuscript and disjointed cursive. In second grade, both groups of children learned to write in cursive. The results showed no differences between the two groups at any grade level with regard to handwriting quality. For 75% of letters, manuscript and cursive letter shapes were of comparable difficulty.

In the same way, the results of a study in Grade 2 that observed the effects of different styles on writing performances (Morin, Lavoie, & Montésinos-Gelet, 2012) showed this same non-effect for quality in three different groups (cursive, manuscript, and manuscript-cursive), even if this study reported results that suggest an effect of writing style on speed. As Graham et al. (1998) underlined, one issue that was not often addressed in the debate on the relative efficiency of manuscript and cursive

relates to the fact that many children used mixed handwriting. They showed that the handwriting of pupils who used a mixed style was faster than the handwriting of pupils who used either manuscript or cursive exclusively. It was assumed that children who mixed manuscript and cursive selected the allographic shape that they were able to retrieve and execute more efficiently.

The study by Berninger and colleagues (2006) investigated the developmental trajectories in producing manuscript, cursive, and keyboard letters and the predictors of these alternative modes of letter production. The results showed that cursive writing was less accurate and slower than manuscript writing and keyboarding. Manuscript writing, cursive writing, and keyboarding were only moderately correlated and each had a different set of predictors. In first and third grades, orthographic coding, phonemic skills, rapid naming, finger succession, inhibition, and inhibition/switching correlated and contributed to various factors in manuscript handwriting (automaticity, accuracy, speed, etc.). In fifth grade, orthographic coding appeared to be the only contributor. For cursive handwriting, both finger succession and phonemic skills contributed in third grade. In fifth grade, inhibition and orthographic coding were the only contributing factors.

Goals of the Study

There are few studies on handwriting style, and debate continues regarding the advantages of the different types of writing, which suggests that more research has to be carried out in this particular area. One issue that has not been addressed is the impact of the first handwriting style learned at school. In previous research, the relative merits of manuscript over cursive style were assessed in children who learned two scripts (manuscript and cursive). In that case, cursive writing was a secondary learning that may have interfered with the initial learning of manuscript writing

In our studies, we wanted to compare the two styles, taking into account the role of automaticity in handwriting. A high level of automaticity in retrieving letters from memory and in producing them should result in increased handwriting speed. A non-automatic transcription would impair writing fluency. In our view, automaticity should depend on the amount of handwriting practice put in during the school years. Thus, cursive learned as the first and only style should be faster than manuscript (which was replaced by instruction in cursive handwriting in second grade). We compared the styles spontaneously used by fourth and fifth graders who learned only cursive writing in first grade (French children) with the styles used by children who learned both manuscript and cursive writing (Quebec children). We chose to study fourth- and fifth-grade children because it was shown that handwriting tends to be personalized after Grade 4 (Hamstra-Bletz & Blöte, 1990).

Our studies had three main underlying goals: (1) to observe and describe the handwriting styles spontaneously used by fourth and fifth graders according to the first style learned at school; (2) to describe the evolution of handwriting style, speed, and legibility between the fourth and fifth grades; and (3) to examine the relationships among speed, legibility, and handwriting styles. We assumed that children who learned to write in a single style would be less likely to use mixed handwriting than would children who learned both styles.

We also assumed that cursive writing should be faster than manuscript because it was a single style learned at school and was thus practiced to a greater extent. In French children, cursive should be faster than mixed handwriting because manuscript was not formally taught in the first grade. Manuscript is taught informally during kindergarten and is then implicit through exposure to print in books. As shown by Vinter and Chartrel (2010), visual training contributed to learning the shapes of the letters, whereas motor training contributed to improving handwriting motor execution. For Quebec children, we assume that mixed handwriting would be faster than either the use of cursive or manuscript exclusively (as shown by Graham et al., 1998). The two handwriting styles having been formally learned during primary school, we can assume that children using mixed handwriting employ the more automated representation of the letter. With regard to overall legibility, we can

assume that for French children, cursive should be more legible than mixed handwriting because children were trained to produce cursive letters and not manuscript letters in first grade. For Quebec children, there should not be any differences between the different styles of handwriting because the tracing of letters was taught in the different styles of handwriting.

Study 1

Method

Participants. The participants of the study were 236 pupils. About half of them were attending schools in Quebec (58 in Grade 4 and 69 in Grade 5), and the other half were attending schools in France (50 in Grade 4 and 59 in Grade 5). Among the pupils in Grade 4, there were 57 boys and 51 girls, and among the pupils in Grade 5, there were 59 boys and 65 girls. All pupils were right-handed and had developed normally without any learning difficulties. Some information about how teachers view and teach handwriting in each school was collected in a previous study (Bara, Morin, Montésinos-Gelet, & Lavoie, 2011). First and second grade teachers in each school were interviewed on the way they see handwriting instruction and on the way they teach it. The questions asked were about the importance of teaching handwriting; the style of handwriting that they feel should be taught; the time devoted each day to handwriting teaching and practice; the teaching aids and mediums used to teach handwriting; and their demands concerning speed and legibility of handwriting in writing productions.

Materials and Procedure. The children were given 5 minutes to copy the text presented in the concise evaluation scale for handwriting (BHK) developed by Hamstra-Bletz, DeBie, and Den Brinker (1987) and adapted in France by Charles, Soppelsa, and Albaret (2003). They were asked to copy the text in their "usual handwriting" as quickly as possible while avoiding mistakes and in legible handwriting. The text was printed on the top of a white sheet of paper, and the pupils had to copy it below. Data were collected simultaneously in the classrooms. Handwriting style, speed, and legibility were measured and analyzed.

Handwriting Style. Each text was examined to determine the style of handwriting. Samples were classified as manuscript (all letters manuscript), cursive (all letters cursive), mixed–mostly manuscript (50% or more letters manuscript), and mixed–mostly cursive (50% or more letters cursive).

Handwriting Speed. The number of letters handwritten was counted for each writing sample. Handwriting speed was calculated based on the mean number of letters written per minute.

Handwriting Legibility. Handwriting quality was assessed by means of the BHK analytical scale. The first five sentences of the copied text were used to assess the quality of the handwriting on a 13-point scale. The points assessed were related to the spatial characteristics of the writing (spacing between letters and words, alignment of letters, etc.) and letter formation (size, shape, consistency of letter size, relative height of the various kinds of letters, etc.). The higher the BHK score was, the less legible was the writing.

Results

Handwriting Style. The percentage of pupils using each style of handwriting is reported in Table 1. In Grade 4, 86% of French pupils used cursive handwriting. Only 14% used mixed–mostly cursive handwriting. None of them wrote exclusively in manuscript. About half of Quebec pupils used manuscript handwriting only (55.2%). It is interesting to note that only 10.4% of Quebec children chose to use cursive handwriting (even though this style was explicitly taught in second

Table 1
Percentage of Children in Grade 4 and Grade 5 Using Each Style of Handwriting According to the Style Learned in First Grade

Grade	Handwriting	%
4		
Manuscript as the First Style Learned (Quebec)		
	Manuscript	55.2
	Cursive	10.4
	Mixed, mostly cursive	15.5
	Mixed, mostly manuscript	18.9
Cursive as the First Style Learned (France)		
	Manuscript	0
	Cursive	86
	Mixed, mostly cursive	14
	Mixed, mostly manuscript	0
5		
Manuscript as the First Style Learned (Quebec)		
	Manuscript	62.3
	Cursive	7.2
	Mixed, mostly cursive	1.5
	Mixed, mostly manuscript	29
Cursive as the First Style Learned (France)		
	Manuscript	0
	Cursive	59.3
	Mixed, mostly cursive	35.6
	Mixed, mostly manuscript	5.1

and third grade). In Grade 5, about 40% of French pupils used mixed handwriting (mainly mixed–mostly cursive). The majority of Quebec pupils used manuscript only (62.3%), mixed handwriting was essentially mixed–mostly manuscript, and cursive accounted for only 7.2%. Quantitative and qualitative analyses were carried out to better understand mixed handwriting. A ratio was established to determine the proportion of cursive to manuscript letters in mixed handwriting. For mixed–mostly cursive writing, the ratio was the number of letters written in manuscript to the total number of letters handwritten. For mixed–mostly manuscript writing, the ratio was the number of letters written in cursive to the total number of letters. Student t tests revealed that there were no significant differences between French and Quebec children and there were no differences between fourth and fifth graders. We noticed that mixed–mostly cursive and mixed–mostly manuscript handwriting styles were qualitatively different. In mixed–mostly manuscript, whole words and letter clusters (mostly syllables) were written in cursive style. In mixed–mostly cursive, some letters were in manuscript at the beginning of words or inside words written in cursive style. This concerned a few letters that were frequently written in manuscript (mostly p, t, d, v, and i for French children and b, i and l for Quebec children).

For the analyses relating to handwriting speed and legibility, we took into account the following three between-subjects variables:

1. *The country*: Quebec and France, which differed in terms of the instructional methods, used a single style being practiced during the primary school years in France and two styles (manuscript and cursive) being formally taught in Quebec.

Table 2
Mean Number of Letters Copied per Minute in Each Handwriting Style by Fourth and Fifth Graders

	Grade 4		Grade 5	
Location	Style Learned in Grade 1 Mean (*SD*)	Mixed Handwriting Mean (*SD*)	Style Learned in Grade 1 Mean (*SD*)	Mixed Handwriting Mean (*SD*)
Quebec	50 (11.87)	43.47 (14.95)	55.72 (9.87)	60.29 (11.64)
France	41.64 (9.12)	39.17 (11.12)	49.16 (12.01)	55.03 (11.51)

Table 3
Mean Scores in the BHK (Text Legibility) in Fourth and Fifth Graders and According to the Style Used

	Grade 4		Grade 5	
Location	Style Learned in Grade 1 Mean (*SD*)	Mixed Handwriting Mean (*SD*)	Style Learned in Grade 1 Mean (*SD*)	Mixed Handwriting Mean (*SD*)
Quebec	15.59 (6.36)	12.75 (4.23)	13 (5.32)	11.85 (4.22)
France	8.58 (4.03)	9.14 (3.93)	7.48 (4.29)	6.66 (3.01)

2. *The grade*: Fourth and fifth graders participated in this study.
3. *The handwriting style*: We chose to compare the style learned in first grade and henceforth used (cursive for French pupils and manuscript for Quebec pupils) with mixed handwriting. Because few writing samples were produced in cursive by Quebec pupils, these samples were not analyzed (11 texts were removed from the sample).

Handwriting Speed. The mean number and standard deviation of letters copied per minute are presented in Table 2. An analysis of variance (ANOVA) was performed with Country (France/Quebec), Grade level (fourth grade/fifth grade) and Handwriting style (style learned in first grade/mixed handwriting) as the between-subjects variables. The main effect of Country, $F(1,217) = 12.11$ $p < .01$, and the main effect of Grade level, $F(1,217) = 42.67$, $p < .01$, were ***significant.*** Quebec pupils wrote faster ($M = 52.86$) than French pupils ($M = 46.85$), and handwriting was faster in fifth grade ($M = 54.02$) than in fourth grade ($M = 44.81$). The Grade level × Handwriting style was significant, $F(1,217) = 7.64$, $p < .01$. Post-hoc analyses (with HSD [honestly significant difference] test for N different) were performed. In fourth grade, there were no significant differences between the use of the style learned in first grade and mixed handwriting. In fifth grade, mixed handwriting was faster than the style learned in first grade (cursive for French pupils and manuscript for Quebec pupils).

Handwriting Legibility. Mean overall scores and (standard deviation) in the BHK are reported in Table 3. A 2 (Country) × 2 (Grade level) × 2 (Handwriting style) ANOVA was performed on the overall quality of handwriting (overall BHK scores). The main effect of Country, $F(1,217) = 53.46$, $p < .01$, and the main effect of Grade level, $F(1,217) = 5.85$, $p < .05$, were significant. The overall legibility was higher for French pupils ($M = 7.84$) than for Quebec pupils ($M = 13.46$). The overall legibility of handwriting improved with grade level ($M^{\text{fourth grade}} = 12.13$; $M^{\text{fifth grade}} = 9.93$). The interactions were not significant.

We performed ANOVAs on each of the BHK items (which determine handwriting legibility). The texts copied by French pupils consisted of smaller letters, $F(1,217) = 26.38$, $p < .01$; the alignment of letters was better, $F(1,217) = 18.39$, $p < .01$; the trace was more regular, $F(1,217) = 2.49$, $p < .05$; and the consistency of letter size, $F(1,217) = 10.70$, $p < .01$, the relative height of the various kind of letters, $F(1,217) = 31.15$, $p < .01$, and the quality of letter forms, $F(1,217) = 22.95$ $p < .01$, were higher than in the texts copied by Quebec pupils. The main effect of Grade level was significant and showed improvement from Grade 4 to Grade 5 in terms of the letter size, $F(1,217) = 8.76$, $p < .01$, the consistency of letter size, $F(1,217) = 10.70$, $p < .01$, and the quality of letter shapes, $F(1,217) = 12.07$, $p < .01$. An interaction between Country and Handwriting style was found in terms of the consistency of letter size, $F(1,217) = 9.58$, $p < .01$, the relative height of letters, $F(1,217) = 5.59$, $p < .05$, and the steadiness of the trace, $F(1,217) = 5.18$, $p < .05$. The difference between Quebec and France with regard to handwriting quality was more significant for the first style learned (cursive in France and manuscript in Quebec) than for mixed handwriting.

Discussion

This study assessed the effect of the handwriting style learned in first grade on the style used in fourth and fifth grades and on the speed and legibility of handwriting. We compared handwriting in French pupils, who learned cursive in first grade, with the handwriting of Quebec pupils, who learned manuscript in first grade and cursive in second grade. Generally speaking, the first style learned at school was used by the majority of pupils in fourth grade. In French children, handwriting was not really personalized, and the majority of children used cursive handwriting. In fifth grade, mixed handwriting was more commonly used. However, there was a large prevalence of the first style learned at school. French children primarily used mixed–mostly cursive writing, whereas Quebec children primarily used mixed–mostly manuscript writing. Cursive handwriting was not used much by Quebec children, even though it was explicitly taught in the second and third grades. This finding addresses the question of the relevance of this supplementary learning at primary school.

We assumed that because French children were not taught manuscript, the proportion of manuscript letters in mixed handwriting should be smaller than the proportion of cursive letters in mixed handwriting for Quebec children. This was not the case; the proportion was not different between French and Quebec children. However, there was a difference between writing strategies with regard to mixed–mostly cursive and mixed–mostly manuscript writing. When the largest part of the text was written in cursive style (which was always the case for French children), only a few isolated letters were written in manuscript. This concerned a small set of letters (*p*, *d*, *t*, *v*, and *i*), which were produced several times in manuscript in the texts. When the largest part of the text was written in manuscript, whole syllables or words were written in cursive style. It could be assumed that the links between letters that characterize cursive style forced the children to write several letters in cursive at a time. We can also assume that because French children have not learned to write in manuscript, they were just able to memorize a small set of letters they had encountered in books. We can assume, too, that they have just selected some letters that are easier to produce with regard to the motor act. In fact, the letters *p* and *v* are less complex in manuscript than in cursive, which justifies a move from cursive to manuscript. However, the letters *t*, *d*, and *i* seem to be of the same difficulty in both cursive and manuscript. The reasons that prompted these changes in handwriting style should be the subject of further in-depth investigation.

The aim of this study was also to assess the changes in handwriting between the fourth and fifth grades and the handwriting speed and legibility in French and Quebec pupils. Handwriting speed and quality improved from fourth to fifth grade. This improvement concerned the letter size, the consistency of the letters, and the quality of letter shapes. Whatever the style used (mixed handwriting or manuscript), Quebec children wrote faster than French children. This seems to relate

more to a cultural difference in instructional methods than to a particularity of the style used. With regard to the comparison between mixed handwriting and the use of cursive style or manuscript exclusively, the results were significant only in Grade 5. In Grade 4, pupils who wrote in mixed style did not write faster than pupils who used the first style they learned at school (cursive for French pupils and manuscript for Quebec pupils). In Grade 5, mixed handwriting became faster than cursive or manuscript. Previous research, which was conducted with children who were taught both styles of handwriting during primary school, showed that mixed handwriting was faster than the exclusive use of cursive or manuscript (Graham et al., 1998). If we consider that children wrote faster in mixed style because they selected the allograph that was the most available when they were writing, the pattern of results should be a little different for French children, who were not taught both handwriting styles. For French children, mixed style should correspond to a search for personalization of handwriting and originality, but not necessarily to a search for efficiency. However, even for French children, mixed handwriting was faster than cursive.

With regard to handwriting quality, country and grade level also had an effect. Texts written by French children were more legible than were texts written by Quebec children. The elements that made the difference were the size and the alignment of the letters, the regularity of the trace, the consistency of letter size, the relative height of the various kinds of letters, and the quality of letter shapes. These differences may be due to differences in instructional methods in France and Quebec. The study by Bara, Morin, Montésinos-Gelet, and Lavoie (2011) highlighted differences in handwriting teaching and demands between French and Quebec teachers. It is important to note that the differences between Quebec and French children essentially concerned texts written in the style initially learned at school. With regard to mixed handwriting, there were fewer differences between the handwriting quality of French and Quebec children.

One issue that could not be addressed in our study pertained to the relative merits of cursive and manuscript styles. Indeed, one of the main limitations relates to the fact that two conditions (learning of cursive or manuscript first at school) were intertwined with the country. We have to take into account that there are cultural differences in the way handwriting is taught in France and Quebec. To carry on this research and address this question, we assessed handwriting style, speed, and legibility in Quebec pupils who had learned to write in cursive from the first grade. We found two classrooms in Quebec where cursive was taught as of the first grade. The aim of the second study was to compare manuscript and cursive handwriting independently of the culture.

Study 2

Method

Participants. The participants in this study were 96 pupils schooled in the fifth grade in Quebec. Of these, 48 (25 girls and 23 boys) were taught cursive in first grade and 48 (22 girls and 26 boys) were taught manuscript in first grade and cursive in second grade. We tried to control the instructional methods between the classes by interviewing teachers in first and second grade (Bara et al., 2011). We chose classes where practices were as similar as possible. In each school, when teaching handwriting, first- and second-grade teachers reported spending the same amount of time in handwriting teaching, using the same teaching aids, and having the same demands on legibility in writing production.

Materials and Procedure

The materials and procedure were the same as in Study 1. Pupils had to copy the BHK text. Handwriting speed (mean number of letters written per minute) and handwriting legibility (BHK scores) were assessed.

Table 4
Mean Number of Letters Copied per Minute According to Handwriting Style and Instruction

	Handwriting Style		
Handwriting Instruction	Manuscript Mean (*SD*)	Cursive Mean (*SD*)	Mixed Mean (*SD*)
Manuscript and Cursive	61.42 (9.94)	48.04 (15.15)	55.82 (9.52)
Cursive	63.90 (7.73)	50.58 (9.82)	57.99 (12.94)

Table 5
Mean Legibility Scores (BHK) According to Handwriting Style and Instruction

	Handwriting Style		
Handwriting Instruction	Manuscript Mean (*SD*)	Cursive Mean (*SD*)	Mixed Mean (*SD*)
Manuscript and Cursive	11.10 (3.28)	12.60 (3.91)	12.37 (4.37)
Cursive	8.58 (4.14)	10.33 (5.20)	11.66 (4.39)

Results

Handwriting Style. Among Quebec pupils who were taught cursive style in first grade, 19 pupils wrote in cursive, 16 pupils wrote in manuscript, and 13 pupils used mixed handwriting. Among Quebec pupils who were taught manuscript in first grade and cursive in second grade, 24 wrote in manuscript, 19 wrote in mixed handwriting, and 5 wrote in cursive.

Handwriting Speed. The mean number (and standard deviation) of letters copied per minute is reported in Table 4. An ANOVA with Handwriting instruction (cursive in first grade/manuscript in first grade) and Handwriting style (cursive, manuscript, and mixed handwriting) as the between-subjects variables was carried out. The main effect of Handwriting style, $F(2.90) = 8.37$, $p < .01$, was significant. Post hoc analyses (with HSD test for N different) showed that mixed and manuscript handwriting were faster than cursive handwriting. There were no significant differences between manuscript and mixed handwriting.

Handwriting Legibility. The mean overall scores (with standard deviations) in the BHK are reported in Table 5. A 2 (Handwriting instruction) × 3 (Handwriting style) ANOVA on the overall score in the BHK was carried out. There were no significant effects.

ANOVAs on each of the BHK items showed that there was a main effect of Handwriting style on the size of the letters, $F(2.90) = 5.66$, $p < .01$, the steadiness of the trace, $F(2.90) = 7.4$, $p < .01$, and the consistency of letter size, $F(1.90) = 6.36$, $p < .01$. In cursive and mixed handwriting, letters were smaller and the consistency of letter size was greater than in manuscript. However, the trace was less unsteady in manuscript and mixed handwriting than in cursive. One of the main effects of Handwriting instruction was on the relative height of the letters, $F(1.90) = 6.23$, $p < .05$, the alignment of the letters, $F(1.90) = 9.37$, $p < .01$, and the quality of letter shapes, $F(1.90) = 4.52$, $p < 05$. Pupils who learned to write in cursive in first grade produced letters of a higher quality with a less unsteady trace and with a better alignment on the page, regardless of the style used.

General Discussion

Handwriting teaching is more important than was initially assumed, and this component of writing is more than a matter of presentation. It has an important impact on academic performance

because a large number of school activities rely on handwriting ability (Sassoon, 1990). In fact, children spend 31% to 60% of their school day performing handwriting and other fine motor tasks (McHale & Cermak, 1992). If the motor production of letters is not automatic, activities that rely on handwriting cannot be performed with ease and quality because of cognitive overload. Thus, an important issue in educational research is how to help children to automate their handwriting and which style of handwriting should be taught to improve handwriting speed and legibility.

The aims of these studies were to (1) describe the styles spontaneously used by pupils according to the handwriting style learned in first grade at school, (2) examine the changes in handwriting between fourth and fifth grade, and (3) assess the relative merits of cursive, manuscript, and mixed handwriting in terms of speed and legibility. We investigated the relationship between handwriting style, speed, and legibility in French and Quebec pupils who were taught either cursive or manuscript style in first grade. The differences in handwriting instruction between Quebec and France are interesting and can provide answers to the educational issue of which style of handwriting should be taught. Handwriting was examined in fourth- and fifth-grade pupils because it was shown that handwriting tends to be personalized after Grade 4 and that children's style often deviates from the one they were initially taught (Blöte & Hamstra-Bletz, 1991; Hamstra-Bletz & Blöte, 1990).

Which Handwriting Style Do Pupils Use in Fourth and Fifth Grade?

In Grade 4, the handwriting of children who only learned cursive was not really personalized. In fact, the large majority of French pupils used cursive exclusively when copying a text (86%). In Grade 5, handwriting tended to be more personalized, and about half of the pupils used cursive or manuscript exclusively, whereas the other half used mixed handwriting. Even though handwriting changed, there was a large prevalence of the first style taught. Pupils who first learned manuscript largely used manuscript in fourth and fifth grades, and when they mixed handwriting, they chose to use the mixed–mostly manuscript style. Cursive style, learned at a later stage, did not replace manuscript and was rarely used exclusively. This result raises the question of the benefits of teaching two handwriting styles. Manuscript is commonly used to facilitate cursive handwriting acquisition. The goal of these instructional methods is for pupils to learn the cursive handwriting style quicker and use it throughout their schooling. Our study showed that cursive was quickly abandoned in favor of manuscript or mixed handwriting. We might therefore question the relevance of learning both styles.

The observation of the handwriting style spontaneously used at the end of primary school addressed questions about the way handwriting developed and the role of handwriting teaching. In Quebec pupils, mixed handwriting was largely used in fourth and fifth grades. It was not surprising because they had formally learned both handwriting styles and thus were able to master either style. If we consider that pupils who mixed manuscript and cursive selected the allographic shape of the letter they were able to retrieve and execute most efficiently, as suggested by Graham et al. (1998), it is natural that children who learned to write in both styles would mix their handwriting.

However, how could we explain that a child who only learned cursive also used mixed handwriting in fifth grade? It suggests that pupils' acquisition of allographic letter forms is also a visual task (through reading of printed books) that can be transferred to motor execution. Vinter and Perruchet (2002) have shown that motor training was not necessary to implicitly learn a new graphic behavior and that implicit learning occurred through visual observation, which suggests that perceptual learning can be transferred to a motor act. However, this transfer was limited because pupils who learned cursive exclusively used essentially mixed–mostly cursive handwriting and never wrote all the text in manuscript. The use of manuscript concerned only a few letters incorporated into words otherwise written in cursive. There is a need to conduct additional research to understand the choice

of these particular letters. The reasons may reside in the complexity of the motor act for producing letters and in the frequency of these letters in printed books.

In Study 2, it is surprising that a large proportion of Quebec children used manuscript exclusively, even though they were not taught this style. It could be that this is a cultural particularity. In fact, even though they were taught cursive at school, this is an unusual practice in Quebec, and these children may have been used to writing in manuscript at home and seeing their parents and friends writing in manuscript. Thus, we can assume that they were more exposed to manuscript in writing than were French children.

Handwriting Changes Between Fourth and Fifth Grade

We observed qualitative and quantitative changes in handwriting between Grades 4 and and 5. Handwriting speed and overall handwriting quality improved. As was shown previously, the personalization of handwriting, which was more significant in fifth than in fourth grade, may contribute to the improvement in handwriting speed. The changes in handwriting quality related to the letter size, the consistency of letter size, and the quality of letter shapes. As shown by Chartrel & Vinter (2006), Grades 4 and 5 are a specific period in which control of graphomotricity, from retroactive to proactive feedback, is evolving and leads to much variance in movement. At this age, the handwriting movement is still not automatic. We did not observe any changes relating to the spatial characteristics of the handwriting (spacing between letters and words and alignment of letters). Handwriting involves two types of movement, namely morphokinetics, which controls the production of the shape of letters, and topokinetics, which governs the spatial layout of the characters on the page. The topokinetic component is under feedback control, whereas morphokinetic movements are under the control of motor programs (Paillard, 1990; Teasdale et al., 1993). Considering our results, it appears that morphokinetic movements develop more slowly than do topokinetic ones. The spatial characteristics of the handwriting rely more on visual feedback than on an internal motor program. Between Grades 4 and 5, the changes related to the shape and the size of the letters, but not to the alignment of the letters.

The Relative Merits of Manuscript, Cursive, and Mixed Handwriting

To provide answers to the issue of the relative merits of manuscript, cursive, and mixed handwriting, we assessed handwriting speed and legibility in a copying task. We assumed that the speed and legibility of the handwriting would depend on the style used, but also on the amount of practice put in at school. Some pupils were taught cursive handwriting as of the first grade, whereas others were taught manuscript in first grade and cursive in second grade. We assumed that the superiority of manuscript over cursive found in some previous research (Berninger et al., 2006; Gray, 1956; Turner, 1930) is the consequence of less practice in cursive handwriting when pupils were taught manuscript handwriting first. In fourth grade, the handwriting style learned in first grade (cursive or manuscript) was faster than mixed handwriting. In fifth grade, mixed handwriting became faster. On the whole, cursive style was the slowest handwriting style.

This result challenges the educational idea that cursive style is produced faster than manuscript. Even though cursive was taught as of the first grade, handwriting was slower than either manuscript or mixed handwriting. This effect on handwriting speed appears to be significant because it was found in both studies, in both French and Quebec pupils. The superiority of manuscript over cursive in terms of speed could be explained in different ways. It has been reported that alternating rotational direction and making the connection between letters slow down writing (Karlsdottir, 1996b, 1996c; Meulenbroek & van Galen, 1986, 1990). Links between letters seem to constrain handwriting speed because they tend to disappear as pupils get older and as handwriting fluency

improves (Hamstra-Bletz & Blöte, 1990). Manuscript handwriting should bypass the problem of the changes in sequencing strategy involved in cursive style because it is produced by using the drawing production rules and because the direction of movement is less significant than in cursive (Meulenbroek et al., 1993). Finally, the simplicity of letter shapes and the numerous pen lifts should help to improve handwriting speed (Meulenbroek & van Galen, 1986).

Manuscript was superior to cursive in terms of handwriting speed but not overall legibility. In fifth grade, handwriting quality was higher in pupils who first learned cursive than in pupils who first learned manuscript. Moreover, the quality of letter shapes was higher in cursive and mixed handwriting than in manuscript. Cursive was superior to manuscript in terms of the size of the letters, the consistency of letter size and the relative height of the various kinds of letters. This result challenges the observation that manuscript is more compatible with the motor skills of young pupils and that the simpler, more stable shapes of the letters facilitate handwriting in terms of either speed or legibility. However, the quality of letter shapes in handwriting relies as much on visual perceptual abilities as on motor skills (Bara & Gentaz, 2010b; Berninger et al., 1997; Jongmans, Linthorst-Bakker, Westenberg, Smits-Engelsman, & Bouwien, 2003; Karlsdottir, 1996a; Karlsdottir & Stefansson, 2003; Vinter & Chartrel, 2010; Volman, van Schendel, & Jongmans, 2006; Weintraub & Graham, 2000).

In manuscript, even though the motor task is easier, this is not the case for the perceptual task. The high number of mirror letters and the simpler shapes might impair writing quality by creating interference between closely related shapes. The search for speed in writing might also reduce writing legibility. However, in some cases, mixed handwriting was as fast as it was legible. The results showed the effect of handwriting instruction. Handwriting quality in pupils who were taught both styles was poorer than handwriting quality in pupils who were taught a single style (French and Quebec). There is a need to investigate whether there are differences in instruction when a single rather than two styles are taught in school.

Conclusion

The question about the handwriting style that should be taught at school is an important educational issue that has been poorly investigated in recent research. Our results revealed that country, instructional method, and style of handwriting all had an effect on handwriting speed and legibility. Cursive handwriting was the slowest style but was more legible than manuscript. The more efficient style of writing seems to be mixed handwriting because it was as fast, if not faster, than manuscript and was similar to cursive handwriting in terms of legibility. Examining the development of fluency in handwriting is of particular importance because it is strongly linked to academic achievement because it is necessary for most daily school activities. It is also important in pupils' ability to produce long and coherent texts (Berninger et al., 1996; Berninger et al., 1997; Berninger & Fuller, 1992; Berninger & Swanson, 1994), and measures of handwriting fluency accounted for 25% to 42% of the variance in the writing quality (Graham et al., 1997).

Whatever the handwriting style taught initially, children grow more and more distant from this style and use more and more mixed handwriting. These changes in handwriting style might reflect a search for more efficiency and fluency. Making this choice, we can suppose that children tend to reduce the cognitive load generated by the motor production of letters by accessing the easiest allographic shape in memory. If this is the case, children who use mixed handwriting should produce texts of better quality. This link between the style of handwriting and compositional quality needs to be investigated in future research. Children inevitably develop their own style and combine letters from different scripts. They are able to learn letters either from motor or from visual experience, through print exposure. Thus, it is difficult to provide advice concerning the handwriting style that should be taught at school. Maybe we can suggest to teachers not to insist on a strict adherence to a

particular model so as not to reduce the automaticity in motor production necessary for written text production.

References

Armitage, D., & Ratzlaff, H. (1985). The non-correlation of printing and writing skills. Journal of Educational Research, 78, 174 – 177.

Bara, F., & Gentaz, E. (2010a). Apprendre à tracer les lettres: Une revue critique. Psychologie Française, 55, 129 – 144.

Bara, F., & Gentaz, E. (2010b). Haptics in teaching handwriting: the role of perceptual and visuo-motor skills. Human Movement Science, 30, 745 – 759.

Bara, F., & Morin, M.-F. (2009). Est-il nécessaire d'enseigner l'écriture script en première année? Les effets du style d'écriture sur le lien lecture/écriture. Nouveaux Cahiers de la Recherche en Education, 12, 149 – 160.

Bara, F., Morin, M.-F., Montésinos-Gelet, I., & Lavoie, N. (2011). Conceptions et pratiques en graphomotricité chez des enseignants de primaire en France et au Québec. Revue Française de Pédagogie, 176, 41 – 56.

Berninger, V. W., Abbott, R. D., Augsburger, A., & Garcia, N. (2009). Comparison of pen and keyboard transcription modes in children with and without learning disabilities. Learning Disabilities Quarterly, 32, 123 – 141.

Berninger, V. W., Abbott, R. D., Jones, J., Wolf, B. J., Gould, L., Anderson, M., Shimada, S., & Apel, K. (2006). Early development of language by hand: Composing, reading, listening, and speaking connections; three letter-writing modes; and fast mapping in spelling. Developmental Neuropsychology, 29, 61 – 92.

Berninger, V. W., & Fuller, F. (1992). Gender differences in orthographic, verbal, and compositional fluency: Implications for assessing writing disabilities in primary grade children. Journal of School Psychology, 30, 363 – 382.

Berninger, V. W., Graham, S., Vaughan, K. B., Abbott, R. D., Abbott, S. P., Woodruff Rogan, L. W., Brooks, A., Reed, E., & Graham, S. (1997). Treatment of handwriting problems in beginning writers: Transfer from handwriting to composition. Journal of Educational Research, 89, 652 – 666.

Berninger, V. W., Richards, T., Stock, P., Abbott, R. D., Trivedi, P., Altemeier, L., & Hayes, J. R. (2009). fMRI activation related to nature of ideas generated and differences between good and poor writers during idea generation. British Journal of Educational Psychology Monograph, Series II, 6, 77 – 93.

Berninger, V. W., & Swanson, H. L. (1994). Modification of the Hayes and Flower model to explain beginning and developing writing. In E. Butterfield (Ed.), Advances in cognition and educational practice. Children's writing: Toward a process theory of development of skilled writing: Vol. 2. (pp. 57 – 82). Greenwich, CT: JAI Press.

Berninger, V. W., Whitaker, D., Feng, Y., Swanson, H. L., & Abbott, R. D. (1996). Assessment of planning, translating and revising in juniors high writers. Journal of School Psychology, 34, 23 – 52.

Blöte, A. W., & Hamstra-Bletz, L. (1991). A longitudinal study on the structure of handwriting. Perceptual and Motor Skills, 72, 983 – 994.

Bourdin, B., & Fayol, M. (2000). Is graphic activity cognitively costly? A developmental approach. Reading and Writing: An interdisciplinary Journal, 13, 183 – 196.

Chao, L. L., & Martin, A. (2000). Representation of manipulable man-made objects in the dorsal stream. Neuroimage, 12, 478 – 484.

Charles, M., Soppelsa, R., & Albaret, J.-M. (2003). BHK – Echelle d'évaluation rapide de l'écriture chez l'enfant. Paris, France: Editions et Applications Psychologiques.

Chartrel, E., & Vinter, A. (2006). Rôle des informations visuelles dans la production de lettres cursives chez l'enfant et l'adulte. L'Année Psychologique, 106, 45 – 66.

Christensen, C. A. (2009). The critical role handwriting plays in the ability to produce high-quality written text. In R. Beard, D. Myhill, J. Riley, & M. Nystrand (Eds.), The SAGE handbook of writing development. London, UK: Sage.

Connelly, V., Gee, D., & Walsh, E. (2007). A comparison of keyboarded and written compositions and the relationship with transcription speed. British Journal of Educational Psychology, 77, 479 – 492.

Duval, B. (1985). Evaluating the difficulty of four handwriting styles used for instruction. Spectrum, 3, 13 – 20.

Ediger, M. (2002). Assessing handwriting achievement. Reading Improvement, 39, 103 – 110.

French primary school syllabus (2008). Horaires et programmes d'enseignement de l'école primaire. Bulletin officiel hors-série n° 3 du 19 juin. [Ministry of National Education. Schedules and programs of primary school, Bulletin, 3, 19 June.] Retrieved from http://www.education.gouv.fr/bo/2008/hs3/default.htm

Gates, A. I., & Brown, H. (1929). Experimental comparisons of print-script and cursive writing. Journal of Educational Research, 20, 1 – 14.

Goodnow, J. J., Friedman, S., Bernbaum, M., & Lehman, E. B. (1973). Direction and sequence in copying : The effect of learning to write in English and Hebrew. Journal of Cross-Cultural Psychology, 4, 263 – 282.

Graham, S., Berninger, V. W., Abbott, R. D., Abbott, S. P., & Whitaker, D. (1997). Role of mechanics in composing of elementary school students: A new methodological approach. Journal of Educational Psychology, 89, 170 – 182.

Graham, S., Berninger, V. W., & Weintraub, N. (1998). The relationships between handwriting style and speed and legibility. Journal of Educational Research, 5, 290 – 296.

Graham, S., Harris, K. R., & Fink, B. (2000). Is handwriting causally related to learning to write? Treatment of handwriting problems in beginning writers. Journal of Educational Psychology, 92, 620 – 633.

Graham, S., Harris, K. S., Mason, L., Fink-Chorzempa, B., Moran, S., & Saddler, B. (2008). How do primary grade teachers teach handwriting? A national survey. Reading and Writing, 21, 49 – 69.

Graham, S., Struck, M., Santoro, J., & Berninger, V. W. (2006). Dimensions of good and poor handwriting legibility in first and second graders: Motor programs, visual–spatial arrangement, and letter formation parameter setting. Developmental Neuropsychology, 29, 43 – 60.

Graham, S., & Weintraub, N. (1996). A review of handwriting research: Progress and prospects from 1980 to 1994. Educational Psychology Review, 8, 7 – 87.

Gray, W. S. (1956). The teaching of reading and writing. Chicago, IL: Scott Foresman.

Hamstra-Bletz, L., & Blöte, A. W. (1990). Development of handwriting in primary school: A longitudinal study. Perceptual and Motor Skills, 70, 759 – 770.

Hamstra-Bletz, L., DeBie, J., & Den Brinker, B. (1987). Concise Evaluation Scale for children's handwriting. Lisse, Netherlands: Swets & Zeitlinger.

Herrick, V. E. (1960). Handwriting and children's writing. Elementary English, 37, 248 – 258.

Houston, H. (1938). Manuscript writing and progress in reading. Elementary School Journal, 39, 116 – 118.

Jones, D., & Christensen, C. A. (1999). Relationship between automaticity in handwriting and student's ability to generate written text. Journal of Educational Psychology, 91, 44 – 49.

Jongmans, M. J., Linthorst-Bakker, E., Westenberg, Y., Smits-Engelsman, B. C., & Bouwien, C. (2003). Use of a task-oriented self-instruction method to support children in primary school with poor handwriting quality and speed. Human Movement Science, 22, 549 – 566.

Karlsdottir, R. (1996a). Development of cursive handwriting. Perceptual and Motor Skills, 82, 659 – 673.

Karlsdottir, R. (1996b). Print-script as initial handwriting style I: Effects on the development of handwriting. Scandinavian Journal of Educational Research, 40, 161 – 174.

Karlsdottir, R. (1996c). Print-script as initial handwriting style II: Effects on the development of reading and spelling. Scandinavian Journal of Educational Research, 40, 255 – 262.

Karlsdottir, R., & Stefansson, T. (2003). Predicting performance in primary school subjects. Perceptual and Motor Skills, 97, 1058 – 1060.

Laszlo, J. I., & Broderick, P. (1991). Drawing and handwriting difficulties: Reasons for and remediation of dysfunction. In J. Wann, A. M. Wing, & N. Sovik (Eds.), The development of graphic skills (pp. 259 – 280). London, UK: Academic Press.

Leung, E. K., Treblas, P. V., Cooper, J. O., & Porter, J. T. (1982). Effects of training for manuscript handwriting on generalization to cursive handwriting. Behavioural Psychotherapy, 10, 311 – 323.

McCutchen, D. (2011). From novice to expert: Implications of language skills and writing-relevant knowledge for memory during the development of writing skill. Journal of Writing Research, 3, 51 – 68.

McHale, K., & Cermak, S. A. (1992). Fine motor activities in elementary school: Preliminary findings and provisional implications for children with fine motor problems. American Journal of Occupational Therapy, 46, 898 – 903.

Medwell, J., Strand, S., & Wray, D. (2009). The links between handwriting and composing for Y6 children. Cambridge Journal of Education, 39, 329 – 344.

Meulenbroek, R. G., & van Galen, G. (1986). Movement analysis of repetitive writing behavior of first, second and third grade primary school children. In H. S. R. Kao, G. van Galen, & R. Hoosain (Eds.), Graphonomics: Contemporary research in handwriting (pp. 71 – 92). Amsterdam, Netherlands: North-Holland.

Meulenbroek, R. G., & van Galen, G. (1988). The acquisition of skilled handwriting: Discontinuous trends in kinematic variables. In A. M. Cooley & J. R. Beech (Eds.), Cognition and action in skilled behavior (pp. 273 – 281). Amsterdam: North-Holland.

Meulenbroek, R. G., & van Galen, G. (1990). Perceptual-motor complexity of printed and cursive letters. Journal of Experimental Education, 58, 95 – 110.

Meulenbroek, R. G., Vinter, A., & Mounoud, P. (1993). Development of the start-rotation principle in circle production. British Journal of Developmental Psychology, 11, 307 – 320.

Ministry of Education, Quebec (2001). *Programme de formation de l'école québécoise: Éducation préscolaire, enseignement primaire.* [School programs for kindergarten and primary school] Québec: National library.

Mojet, J. W. (1991). Characteristics of the developing handwriting skill in elementary education. In J. Wann, A. M. Wing, & N. Sovik (Eds.), Development of graphic skills (pp. 53 – 75). London, UK: Academic Press.

Morin, M.-F., Lavoie, N., & Montésinos-Gelet, I. (2012). Graphomotor skills, spelling and writing in Grade 2: The effects of teaching practices. Language and Literacy, 14, 110 – 124.

Myers, P. W. (1983). Handwriting in English education. Visible Language, 4, 333 – 356.

Olive, T., Favart, M., Beauvais, C., & Beauvais, L. (2009). Children's cognitive effort and fluency in writing: Effects of genre and of handwriting automatization. Learning and Instruction, 19, 299 – 368.

Olive, T., & Kellogg, R. T. (2002). Concurrent activation of high- and low-level production processes in written composition. Memory and Cognition, 30, 594 – 600.

Otto, W., & Rarick, G. L. (1969). Effect of time of transition from manuscript to cursive writing upon subsequent performance in handwriting, spelling and reading. Journal of Educational Research, 62, 211 – 216.

Paillard, J. (1990). Les bases nerveuses du contrôle visuo-manuel de l'écriture [The neural bases of the visuo-manual control of handwriting]. In C. Sirat, J. Irigoin, & E. Poulle (Eds.), L'écriture: Le cerveau, l'œil et la main (pp. 245 – 266). Turnhout, France: Brepols.

Paoletti, R. (1999). Éducation et motricité de l'enfant de 2 à 8 ans. Montréal, Canada: Gaëtan Morin.

Sassoon, R. (1990). Handwriting: A new perspective. Cheltenham, UK: Stanley Thornes.

Suen, C. Y. (1983). Handwriting generation, perception, and recognition. Acta Psychologica, 54, 295 – 312.

Teasdale, N., Forget, R., Bard, C., Paillard, J., Fleury, M., & Lamarre, Y. (1993). The role of proprioceptive information for the production of isometric forces and for handwriting tasks. Acta Psychologica, 82, 179 – 191.

Thomassen, A. J., & van Galen, G. (1992). Handwriting as a motor task: Experimentation, modelling and simulation. Amsterdam, Netherlands: North-Holland.

Torrance, M., & Galbraith, D. (2005). The processing demand of writing. In C. MacArthur, S. Graham, & J. Fitzgerlad (Eds.), Handbook of writing research. New York, NY: Guilford Press.

Turner, O. G. (1930). The comparative legibility and speed of manuscript and cursive handwriting. Elementary School Journal, 30, 780 – 786.

Vinter, A., & Chartrel, E. (2010). Effects of different types of learning on handwriting movements in young children. Learning and Instruction, 20, 476 – 486.

Vinter, A., & Perruchet, P. (2002). Implicit motor learning through observational training in adults and children. Memory and Cognition, 30, 256 – 261.

Volman, M. J., van Schendel, B. M., & Jongmans, M. J. (2006). Handwriting difficulties in primary school children: A search for underlying mechanisms. American Journal of Occupational Therapy, 60, 451 – 460.

Weintraub, N., & Graham, S. (2000). The contribution of gender, orthographic, finger function, and visual-motor processes to the prediction of handwriting status. The Occupational Therapy Journal Research, 20, 121 – 141.

Ziviani, J. (1998). Writing speed and legibility of 7–14-year-old school students using modern cursive script. Australian Occupational Therapy Journal, 45, 59 – 64.

Ziviani, J., & Elkins, J. (1984). An evaluation of handwriting performance. Educational Review, 36, 249 – 261.