Children’s cognitive effort and fluency in writing: Effects of genre and of handwriting automatisation

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Abstract

This study investigated the cognitive effort of 5th and 9th graders while writing a text. We manipulated genre (narrative text vs. argumentative text) and tested how level of handwriting automatisation contributes to cognitive effort and fluency in writing. The participants were 23 students from Grade 5 and 21 from Grade 9, who wrote two texts differing in genre while performing a secondary reaction time task. The results showed that cognitive effort interacted with genre. Cognitive effort decreased between Grades 5 and 9 only for writing argumentative text. Handwriting did not contribute to fluency in writing, but contributed to cognitive effort only in 5th-graders’ writing of narrative text. The findings are discussed in light of the factors contributing to cognitive effort and fluency in writing.

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1. Introduction

Learning to write efficiently a text is a long process that requires explicit and formal instruction. For students who have not yet acquired all the skills needed to translate their ideas into a coherent text, writing is difficult and effortful. Students have to integrate resource-demanding processes ranging from idea conceptualization to motor execution (Flower & Hayes, 1980; Hayes & Flower, 1980), while the working memory capacity required for such integration is limited (Baddeley, 1986, 2007; McCutchen, 1996). With instruction and practice, however, some of these processes become less costly (e.g., motor execution, spelling or reading). This frees up working memory resources that allow children to take into account constraints related to the writing task itself and the situation. For example, students acquire discourse schemata and genre knowledge that guide textual organization and coherence, making text composition easier to manage and writing less effortful. Yet, it is important to notice that even after several years of practice and instruction, composing a text remains a complex task; even in literate adults, all writing processes continue to place large demands on working memory (Kellogg, 1996; Olive, 2004).

The present study investigated how cognitive effort of students who write a text changes between Grades 5 and 9. More specifically, we compared cognitive effort related to writing narrative and argumentative texts. A second aim of the study was to assess the extent to which students’ handwriting skills contributed to cognitive effort and writing fluency. In what follows, we first discuss the processes in writing a text and their related cognitive effort. Next, we describe how handwriting in students contributes to the demands for cognitive effort in text writing. Finally, we assess students’ cognitive effort when writing two kinds of text.
1.1. Cognitive effort in writing

Writing involves several cognitive components that operate at different levels of mental representation (Hayes & Flower, 1980). At a conceptual level, planning processes construct a pre-verbal message that corresponds to the ideas a writer wants to communicate. During this stage, ideas are retrieved from long-term memory and (re-)organized if necessary. These planning processes also allow the various writing stages to be scheduled, by preparing composition action-plans. A second set of processes, namely the translating processes, operates at a linguistic level of representation, where the pre-verbal message resulting from the planning processes is transformed into a verbal message. The conceptual structure elaborated during planning is thus grammatically encoded by retrieving the syntactic, morphological and spelling properties of words in the mental lexicon. Then comes the actual motor execution, when writers write down (or type) the linguistic message. A third component, namely revision, allows writers to compare the newly written text with their mental representation of the intended text and evaluate their written product, launching procedures intended to improve the text at both the conceptual and linguistic levels.

All these processes require working memory resources. To account for such demands, Kellogg (1996) associated the writing processes used by adult writers with the components of working memory, namely the central executive, the phonological loop that is responsible for processing and storing verbal information, and the visuo-spatial sketchpad (Baddeley, 1986). Writing a text requires the central executive while some processes specifically engage the verbal or visuo-spatial components of working memory (see Olive, 2004 for a review). To explain inter-individual differences in writing acquisition, McCutchen (1996, 2000) proposed a capacity theory of writing in which the more efficient the writing processes are the fewer working memory resources they require. Accordingly, with practice that leads to more automatized processes in writing, more resources are freed and become available to writers for executing several processes concurrently and for coordinating them. Consequently, cognitive effort refers to the fraction of working memory resources that are momentarily allocated to the writing task, and more precisely to the resources that are needed to implement the writing processes in a particular writing task (Kellogg, 1996; McCutchen, 2000). Thus, cognitive effort is a function of the demands of the writing situation, the individual’s genre knowledge and writing skills, and the extent to which the writing processes have been automatized.

Regarding the writing processes, irrespectively from the writing situation and the task, planning and revision are always more effortful than translating (Olive, 2004). In a review of cognitive effort in text writing Piolat and Olive (2000) (see also Olive, Kellogg, & Piolat, 2002) showed that factors related to writers’ skills and to the writing situation differently affect the cognitive effort of text writing. In the present study, we studied one situation-specific factor, that is, genre knowledge, and one writer-specific factor, namely level of handwriting automatization.

1.2. Genre knowledge

Acquisition of genre knowledge is often assumed to begin before writing instruction takes place (Donovan & Smolkin, 2006; Halliday, 1975). Very young children (before six years of age) demonstrate emerging awareness of the different genres because they are exposed to a variety of genres very early in their life (Smolkin & Donovan, 2001). Acquisition of genre knowledge is also closely linked to instruction. For instance, in the French national curriculum in primary education (Programmes de l’École élémentaire, 2007a), the teaching of discourse knowledge in Grades 3–6 mainly focuses on the prototypical narrative structure, while the study of argumentation as such only comes to the fore in Grade 9, with an emphasis on textual organization and coherence. Exposure to different genres allows students to acquire knowledge about the micro-level features of texts, such as connectives or verbal tenses (Christie, 1986; Kamberelis, 1999; Martin & Rothery, 1986). Early exposure to genre also allows students to acquire textual superstructures (Adam, 1992; Donovan, 2001; Englert, Stewart, & Hiebert, 1988).

Superstructures are conventional structures that refer to the organization of information at the text level. They describe the required textual constituents, their possible ordering and hierarchical structure for a given genre. As such, they constitute an important device for helping writers to organize content. Their role has been clearly established in writing narrative texts (Fayol, 1985) as well as argumentative texts (Andriessen & Coirier, 1999). For instance, the narrative one with its five sections (Setting, Complication, Resolution, Evaluation and Coda) is the first that is learnt.

Because of this early acquisition, it is usually assumed that narratives are easier to write than argumentative texts. From Grade 5, students already use the narrative schema in their writing (Fayol, 1985). Consequently, to organize their text, they simply need to fill the different slots of this schema with content that they have retrieved from their long-term memory, according to a “schema-driven” strategy (Flower, Schriver, Carey, Hass, & Hayes, 1989) or a knowledge-telling strategy (Scardamalia & Bereiter, 1987). With the knowledge-telling strategy in writing, superstructural characteristics, such as the global and hierarchical organization of text, are generally not taken into account, resulting in weakly organized and insufficiently coherent end products. The textual product may, however, gain in quality if writing is driven by familiar genre knowledge (e.g., a stored schema such as the narrative one). By contrast, no such schema exists for argumentative texts where the organization of content is constructed by writers who organize by themselves the textual frame as they generate their arguments (Andriessen & Coirier, 1999). In this case, students have to use the knowledge-transforming strategy (McCutchen, 2000; Scardamalia & Bereiter, 1987) that requires them to (re-)organize the conceptual content with respect to the rhetorical and pragmatic goals. Argumentative texts are also considered more difficult to write than narratives because they involve logical and coherent reasoning, which are acquired late in cognitive
development (Siegler, 1996). Interestingly, Kellogg (1994, 2001) showed that even in undergraduates, cognitive effort when writing a narrative is lower than when writing an argumentative text.

Therefore, genre knowledge is crucial for the determination of the strategy to be applied when writing a text. With argumentative text writing, children have to use the effortful knowledge-transforming strategy, whereas when writing narratives they can use the easy and less demanding knowledge-telling strategy. From a writing process perspective, the main difference between these two genres lies in their planning demands, which are extremely high in argumentative text writing. However, students’ cognitive effort when writing a text also depends on the demands of all the other processes involved in writing, and not only of planning, or even of the processes based on genre knowledge. This is particularly the case in the youngest students for whom handwriting is not yet automated.

### 1.3. Handwriting demands in children

In the initial stages of writing, handwriting indeed uses up most of the resources of working memory and its cognitive demands might compromise the use of other writing processes (Bourdin & Fayol, 2002). Practising handwriting is thus indispensable to allow students to reduce as soon as possible its demands on working memory. Actually, students practise handwriting at school with exercises that vary according to grade level. In the French educational system, before entering elementary school, children learn to master all gestures and strokes constituting the letters and also begin to write cursive lower- and upper-case letters. After Grade 4, they are required to handwrite fluently. Only between Grades 9 and 12 can they simplify the line of their letters to make handwriting less costly (Sassoon, Nimmo-Smith, & Wing, 1989). Moreover, Chartrel and Vinter (2008) showed that handwriting performance increases in a quite linear way between Grades 5 and 7. In parallel with students’ acquisition of handwriting skills, other writing exercises target spelling and the high-level writing processes.

In an effort to give a detailed account of the changes that go along with grade as regards the demands placed by the writing processes on working memory, Berninger and Swanson (1994) modified Hayes and Flower’s (1980) original model by including text generation (consisting of lexical and syntactic choices) and transcription (i.e., handwriting and spelling) into the translating process. Accordingly, writing abilities in the first three elementary school grades (Grades 1–3) are highly constrained by the working memory demands of the transcription processes, which leave little room for the management of the planning and revision processes. In Grades 4–6, transcription becomes more automatized, enabling advanced macrostructural planning (i.e., planning of the main items of superstructure, grouping together micro-structural elements) to emerge and post-translating revision to take place at the text level. However, the working memory demands of writing are still mainly related to translating. In junior high school (Grades 7–9), all these components continue to develop, with macrostructural planning contributing the most to the working memory demands of writing. By this stage, the writing processes can interact and writers are capable of taking rhetorical constraints into consideration.

Graham and Weintraub (1996) precisely described how the mechanical demands of handwriting might interfere with the higher-level processes involved in writing a text. First, if children’s handwriting is very slow, they may not be able to keep up with their thoughts and ideas and so they may forget their ideas and intentions before they get them on paper. Second, switching attention from planning to handwriting may affect the coherence and complexity of the product. Third, competing attention demands may make it difficult for the child to translate his or her intentions into text. Accordingly, when attention is freed up from the lower-level processes of text generation and transcription, it can be devoted to the higher-level processes, such as planning or revising (Bourdin & Fayol, 2002). Planning and translating can then be more efficiently coordinated in working memory (Alves, Castro, & Olive, in press; Olive & Kellogg, 2002), ensuring that text writing fully meets the requirements of discourse structure.

Berninger and Swanson (1994) have also found that transcription skills are critical in the development of all writing processes. Transcription and text generation skills account for a decreasing proportion of variance of writing fluency (in terms of number of words written down in a limited time) and quality as students develop from elementary to junior high school. However, even if their influence declines, as children grow older, transcription continues to contribute to both writing fluency and quality across junior high school. Berninger (1999) summarized the results of cross-sectional studies in elementary school and junior high school grades — for Grades 1–3 (primary) see Berninger et al. (1992); for Grades 4–6 (intermediate) see Berninger, Cartwright, Yates, Swanson, and Abbott (1994); for Grades 7–9 see Berninger, Whitaker, Feng, Swanson, and Abbott (1996). Berninger (1999) showed that the contribution of transcription skills (spelling plus handwriting) is most evident in the primary grades (66%) and then decreases in intermediate grades (41%) and in junior high grades (16%). Moreover, Graham, Berninger, Abbott, and Whitaker (1997) found that handwriting was significantly related to writing fluency in primary and intermediate elementary school grades, suggesting that the impact of handwriting extended beyond primary and into the intermediate grades.
1.4. The present study — hypotheses

Although several studies have investigated the cognitive effort of text writing in adults (see Olive, 2004 for a review), to our knowledge no study has addressed such an issue in children. Berninger and her collaborators (see above) have carried out several studies to understand the role of working memory in writing acquisition. However, these studies did not analyze children’s cognitive effort in different writing situations and tasks, how it changes or varies with writing acquisition, and the factors that contribute to cognitive effort and its variability. Accordingly, the present study aimed at comparing the cognitive effort of 5th and 9th graders in two different writing tasks: narrative and argumentative text writing. The second aim of the study was to analyze the contribution of handwriting in students’ cognitive effort and writing fluency.

Students from Grades 5 and 9 were selected because each of these grades is associated with a specific step in writing acquisition in relation to the two variables we focused on in this study: genre and level of handwriting automatisation. According to Berninger and Swanson’s (1994) model of writing development, planning is not yet established in Grade 5 and handwriting is just becoming automatised. Conversely, in Grade 9, handwriting is automatised and allows cognitive resources to be allocated to planning and setting out of ideas in appropriate textual structures.

Students’ cognitive effort during writing was assessed by means of a secondary reaction time task. This task has been shown to be non-intrusive with writing but, of major interest, it has been successfully applied to study cognitive effort of skilled writers in different writing tasks (Olive et al., 2002). Students were asked to write their texts while responding as quickly as possible to auditory signals that were randomly distributed across the writing task. The latency of responses indicated the cognitive effort of writing: the longer the responses to the auditory signals, the greater the cognitive effort in the writing task. We expected less cognitive effort in Grade 9 than in Grade 5 (Hypothesis 1), and in the narrative than in the argumentative text (Hypothesis 2). We also expected the writing of an argumentative text to be especially difficult and costly in terms of working memory demands for 5th graders as compared to the 9th graders (Hypothesis 3).

To investigate how handwriting contributes to cognitive effort and fluency in writing, we first assessed handwriting skills and then used this measure of handwriting as a predictor of cognitive effort by means of regression analysis. Overall, we expected handwriting skills to explain higher percentage of variance of cognitive effort (Hypothesis 4) and of fluency (Hypothesis 5) in writing in Grade 5 than in Grade 9. It was also expected that handwriting skills should explain higher percentage of variance in narrative than in argumentative text writing (Hypothesis 6) because when writing requires more complex and effortful processes (as it is the case with argumentative texts) cognitive effort would result mainly from the implementation of these effortful high-level writing processes. By contrast, when the high-level writing processes are less demanding during writing (as it is the case with narratives) cognitive effort would result mainly from the implementation of handwriting processes.

Finally, students’ difficulty in writing the texts was assessed with textual structuring through the use of connectives. Management of cohesion through connectives is a good indicator of the development of text structuring (for a review see Favart, 2005). Several studies show that the number and diversity of connectives are related to the acquisition of planning (Favart & Passerault, in press) and vary according to the genre (see Favart & Chanquo, 2007, for a comparison between narrative and argumentative texts). For instance, conceptual organization is more difficult to achieve in an argumentative text than in a narrative one, for both 5th and 9th graders, and improves between these two grades (Favart & Coirier, 2006). Accordingly, we expected argumentative texts to be more structured by connectives than narratives ones (Hypothesis 7). We also expected that 9th graders would handle connectives in a more efficient way than 5th graders to improve the structure of their argumentative texts thus reflecting a more efficient conceptual organization of this genre between Grades 5 and 9 (Hypothesis 8). According to Favart and Chanquo (2007) the strong chronological order of narrative events bypassed the need to use a large number of diversified connectives to express narrative relations, whereas connectives have to be more numerous and more specifically produced in order to sustain content in the argumentative texts.

2. Method

2.1. Participants

The participants of the study were 44 students. Of them, 23 were 5th graders (13 girls, 10 boys; $M = 10.7$ years, $SD = 0.4$, range $10.2–11.9$ years) and 21 9th graders (9 girls, 12 boys; $M = 14.10$ years, $SD = 0.7$, range $14.2–15.8$ years). The elementary school (Angoulême, Charente, France) and the junior high school (Barbezieux, Charente, France), from which students came, were both situated in areas of medium socioeconomic status.

2.2. Tasks

2.2.1. Alphabet task

This task, used to assess the level of handwriting automatisation (Berninger & Rutberg, 1992), requires participants to write down all the letters of the alphabet as quickly as possible and in the right order in the period of 1 min. The instructions told the students to write the lower-case letters one after another, each separated by a space, and to use their usual handwriting. They were also told that if they finished writing down the complete set of letters in less than 1 min, then they had to start writing down the alphabet again, continuing on the same line from where they had left off. The number of letters written in the period of 1 min was calculated to assess level of handwriting automatisation.
2.2.2. Writing tasks

Students wrote two texts: a narrative text and an argumentative one. For the narrative text, they had to write down what they did during their Christmas holidays. For the argumentative text, they were told to explain why some students prefer to eat school lunches, while others prefer to have lunch at home. They also had to give their own opinion and explain where they themselves preferred to eat lunch. Each writing task lasted no more than 20 min. No other instructions were given as regards length, speed or cohesion.

We analyzed text structure according to the number and diversity of the connectives. More precisely, we calculated their proportion (number of connectives divided by total number of words in the text, multiplied by 100) and variety of connectives (number of different types of connectives). The diversity of connectives did not include the “and” connective (due to its lack of specificity) and analyzed the following categories:

- chronological connectives (e.g., then), the less diversified ones
- temporal connectives (e.g., when, suddenly)
- goal connectives (e.g., for, in order to)
- causal connectives (e.g., because, for)
- consequence connectives (e.g., hence, therefore)
- the adversative connective “but”
- concessive connectives (e.g., however, even if)
- specification connectives (e.g., above all, really)
- restrictive connectives (e.g., even though, even if)

We also measured students’ fluency in writing by dividing the total number of words produced (including those that were crossed out by the students themselves) by the time spent in writing. Thus, fluency in writing was measured by the number of words produced per minute.

2.2.3. Secondary reaction time task

To assess the cognitive effort in writing, the two texts were being written concomitantly with a secondary reaction time (RT) task. Students were asked to respond as quickly as possible to auditory signals (beeps) by pressing on the space bar of a computer keyboard with their non-dominant hand (ScriptKell program; Piolat, Olive, Roussey, Thunin, & Ziegler, 1999). Before carrying out the secondary RT task, students performed it in single-task condition in order their mean baseline RT to be recorded. During this task, 25 beeps were randomly distributed at intervals of between 5 and 15 s. The first five signals, which were regarded as warm-up responses, were not included in the mean baseline RT. During the writing task, beeps were once again randomly distributed, but this time at intervals of between 15 and 45 s. Cognitive effort was measured with the mean interference RT score, which was calculated by subtracting each participant’s mean baseline RT from his or her RTs obtained during the writing task.

2.3. Procedure

Students performed the Alphabet task collectively in the classroom, but the other tasks were performed individually with the experimenter (one of the last two co-authors), starting with the baseline RT task. Next, after receiving the instructions for the Writing task, students carried out the two writing texts, namely the narrative and the argumentative texts, concomitantly with the secondary RT task. The order of the texts (narrative vs. argumentative) was counterbalanced.

3. Results

3.1. Alphabet task

From the 44 participants 11 were removed (eight 5th graders and three 9th graders) from the analysis of the Alphabet task because they did not follow the instructions. Some of them put dashes between letters or started a new paragraph at the beginning of a new alphabet series, while others used capital letters. The analysis showed that the 9th graders wrote down more letters (M = 61, SD = 12.1) than the 5th graders (M = 36, SD = 7.3), t(31) = 6.902, p < 0.001, Cohen’s d = 2.49.

3.2. Cognitive effort in writing

A mixed ANOVA was carried out, with grade (5th, 9th) as a between subjects factor and genre (narrative, argumentative) as a within subject factor on cognitive effort scores, that is, the interference RT. Mean RT (and SD) scores are given in Fig. 1. As expected from Hypothesis 1, the analysis showed a significant main effect of grade, F(1, 42) = 4.94, p = 0.032, partial \( \eta^2 = 0.10 \). Interference RT was shorter in Grade 9 (M = 179 ms, SD = 51) than in Grade 5 (M = 227 ms, SD = 95). Contrary to Hypothesis 2, genre did not significantly affect cognitive effort, F(1, 42) = 1.34, p = 0.25. The Grade × Genre interaction was, however, significant, F(1, 42) = 4.54, p = 0.039, partial
\( \eta^2 = 0.11 \) (see Fig. 1). Scheffé’s post hoc tests did not reveal any difference in interference RT between the narrative and argumentative texts in the two grades, but did show that interference RT decreased between Grades 5 and 9 only in the argumentative text providing support to Hypothesis 3.

To investigate the extent to which level of handwriting automatization determines the cognitive effort in writing, simple regression analyses were conducted for each age group and for each type of text, with score on the Alphabet task as predictor of interference RT. It should be noted that due to problems with the Alphabet task (removal of 11 participants), the regression analysis included fewer participants than the ANOVA on interference RT. In Grade 5, scores on the Alphabet task significantly explained almost a third \( (R^2 = 0.31) \) of the variance of interference RT in the narrative text, \( F(1, 13) = 5.82, p = 0.03 \), partial \( \eta^2 = 0.31 \) \( (\beta = -0.55, t = 2.41, p = 0.03) \). In the argumentative text, the regression equation was marginally significant and explained a quarter of the variance \( (R^2 = 0.24) \) of interference RT, \( F(1, 13) = 4.13, p = 0.06 \), partial \( \eta^2 = 0.24 \) \( (\beta = -0.49, t = 1.56, p = 0.06) \). By contrast, in Grade 9, none of the regression equations was significant indicating that level of handwriting automatization does not explain the cognitive effort in writing. Taken together, these results validate Hypotheses 4 and 6.

3.3. Fluency in writing

A mixed ANOVA was carried out, with grade (5th, 9th) as between subjects factor and genre (narrative vs. argumentative) as within subjects factor on fluency in writing score. Means and standard deviations are given in Table 1. The only main significant effect was that of grade, \( F(1, 42) = 12.94, p < 0.001 \), partial \( \eta^2 = 0.23 \). More precisely, 9th graders \( (M = 14, SD = 3.6) \) wrote more words per minute than 5th graders \( (M = 10.6, SD = 3.7) \).

To find out whether fluency in writing was predicted by level of handwriting automatization, simple regression analyses were conducted in each age group, using the score on the Alphabet task as a predictor of fluency in writing scores. The regression analysis was nonsignificant neither in Grade 5 nor in Grade 9, \( F < 1, \) ns, in both cases, providing no support for Hypothesis 3. Contrary to Hypothesis 5 on fluency in writing, these results indicate that the level of handwriting automatization had little, if any effect, on fluency in writing, at least in these two age groups.

3.4. Text structure

3.4.1. Percentage of connectives

A 2(grade) × 2(genre) mixed ANOVA was conducted on the percentage of connectives included in each text. As expected, this percentage was affected by grade, \( F(1, 42) = 9.99, p = 0.002 \), partial \( \eta^2 = 0.19 \). Students from Grade 9 produced more connectives than students from Grade 5 (see Table 1). As predicted by Hypothesis 7, genre also reliably affected the percentage of connectives, \( F(1, 42) = 7.82, p = 0.007 \), partial \( \eta^2 = 0.16 \), with fewer connectives in the narrative than in the argumentative text (see Table 1). Contrary to Hypothesis 8, the Grade × Genre interaction was not significant, \( F(1, 42) = 2.24, \) ns.

3.4.2. Diversity of connectives

A 2(grade) × 2(genre) mixed ANOVA was conducted on the number of different categories of connectives used. As expected, the diversity of connectives was affected by grade, \( F(1, 42) = 7.85, p = 0.007 \), partial \( \eta^2 = 0.16 \). Students from Grade 9 produced a wider variety of connectives than students from Grade 5 (see Table 1). Confirming Hypothesis 7, genre also tended to affect the diversity of connectives, \( F(1, 42) = 3.43, p = 0.07 \), partial \( \eta^2 = 0.08 \). Connectives were less diversified in the narrative than in the argumentative texts (see Table 1). Again, Hypothesis 8 was not confirmed as the absence of Grade × Genre interaction indicates, \( F(1, 42) = 0.64, \) ns.

Focusing on the categories of diversified connectives, chronological connectives were used mainly in the narratives (29.5%), and less through grade levels (38.5% in Grade 5, and only 18.1% in Grade 9). They were followed (with close proportions at each grade level) by temporal connectives (17.2%) and goal connectives (13.3%), while “but” and causal connectives only reached 6.2% and 5%, respectively. Conversely, in the argumentative texts, the analysis showed a low use of chronological connectives (2.3%). Causal, goal, and consequence connectives were used intensively (about 40% in both grades). The “but” connective was also used in close proportions at each grade level (10%). Moreover, 9th graders used more restrictive connectives, highly specific to argumentation, than 5th graders (about 10% and 5%, respectively).

4. Discussion

The present study investigated cognitive effort of 5th and 9th graders in writing a text. Because cognitive effort directly results from the knowledge and skills that are involved in a particular writing task, we examined whether genre and grade affected their cognitive effort. Students wrote two texts of different genres: one narrative, the other argumentative. We also examined if handwriting demands contributed to students’ fluency and cognitive effort in writing.
The findings regarding developmental differences are as follows: higher grade level was associated with decreased cognitive effort, improved handwriting, increased fluency in writing, and higher percentage and diversity of connectives than lower grade level. The findings on text structure, as defined by the number and categories of connectives used, support the idea that writing a text is more difficult for young students. Overall, 9th graders used greater number of, and more diversified, connectives. The increase in the number and diversity of connectives between Grade 5 and 9 reflects acquisition of planning (Favart & Passarault, in press). Indeed, connectives are linguistic markers that contribute to text organization: the more sophisticated the planning, the more diversified and appropriate use of connectives. According to Hypothesis 8, older students structure the argumentative text in a more efficient way than younger students. The former used more connectives, which were also more diversified, suggesting that these students were able to take into account the specific relations between the ideas they provided in their text. It is, however, worth noticing that other measures of text structure or quality might have revealed, with age, other differences in the texts that were composed. However, as describing how text characteristics change with age was not the purpose of the present study, we did not further analyze the text students produced. It is only important to remember that the changes we observed in text structure imply that the differences in cognitive effort we found can be interpreted, at least partially, in terms of the difficulty the younger students have to plan and organize their text. Finally, it must be pointed out that the argumentative texts produced by the younger students do not represent real argumentation: they are only premises of argumentative texts.

As expected, the cognitive effort in text writing decreased as grade increased: 9th graders experienced less cognitive effort than 5th graders when writing their texts, thus validating Hypothesis 1. This presumably resulted from more automated writing processes in Grade 9, that is, not only handwriting but also the higher-level writing processes. For instance, with age, students acquire more factual knowledge that is also more structured in their long-term memory. Accessing this information is more rapid, and as this knowledge is more organized in schemas, writing requires less costly planning (McCutchen, 2000). With age, students’ revision skills also improve and important changes in revision occur across elementary- and high school years (Allal, 2004). However, planning and revision processes of older students are more complex (Scardamalia & Bereiter, 1987). Older students use the knowledge-transforming strategy; they also revise the semantic and organizational aspects of their text. Accordingly, there should be increase of cognitive effort. Yet, there was decrease of cognitive effort in Grade 9, and this seems to be a paradox. This paradox is actually only apparent. Students’ practice of writing at school makes the writing processes more efficient and more fluent, with some of the writing subprocesses becoming more automated (e.g., spelling, reading and handwriting). This fluency and automatization result in reduced demands on working memory and explain why the total cognitive effort in text writing decreased between grades in the present study.

The idea that some writing sub-processes, and particularly the low-level ones, become more automated in higher grades is observed in the case of handwriting. As expected, handwriting was more automated and contributed less to cognitive effort, in Grade 9 than in Grade 5 supporting Hypothesis 4. Indeed, the older students wrote down almost twice as many letters as the younger ones at the Alphabet task. This finding is in line with others showing that transcription becomes less costly from Grade 5 onwards (Berninger, 1999; Bourdin & Fayol, 1994; Graham & Weintraub, 1996; Sassoon et al., 1989). Several studies have shown the importance of automatized handwriting in writing acquisition. For instance, individual differences in handwriting skills have been shown to be related to writing achievement (Graham & Harris, 2000). Jones and Christensen (1999) observed that handwriting skills accounted for 50% of the variance in text quality of 2nd graders. Graham et al. (1997) also found that handwriting contributed to writing skills of students in Grades 1–6. This remains true even for undergraduate students (Connelly, Dockrell, & Barnett, 2005; Peverly, 2006). Therefore, if handwriting is enough automatized, more working memory resources are available for the high-level writing process related to planning and revision, which are most critical for writing achievement.

The general decrease in the demands of writing processes in Grade 9 is also supported by the lower fluency in writing of the 5th graders relative to the 9th graders. As fluency in writing is the end product of all the writing processes (McCutchen, 1988), an increased fluency in writing indicates more efficient writing processes. Interestingly, but conversely to Hypothesis 5, handwriting demands did not explain any variance of the fluency in writing neither in 5th graders nor in 9th graders. In sum, the increase in writing fluency between the two grades seems to result mainly from larger efficiency of the high-level writing processes than from a more automatized handwriting.

Although most genre differences were not significant, genre affected the structure of the text as indicated by the use of connectives, thus validating Hypothesis 7. There were fewer and less varied and specific connectives in the narrative than in the argumentative text, giving support to Hypothesis 8. This finding is consistent with that of Favart and Chanquoy (2007) for 5th graders and adults: even in adults, the strong chronological order of narrative events limits the need to use a large number of diversified connectives to express narrative relations, whereas connectives have to be more numerous and more specifically produced in order to sustain cohesion of content in the argumentative text. This specificity is mainly observed in Grade 9. The difficulty that students encounter when writing such texts comes from the fact that they are less exposed to this genre but also to the inherent characteristics of argumentative texts, which have a self-sustained structure, requiring logical and formal reasoning, needing knowledge not only in favour, but also against the writers’ opinion or ideas (Andriessen & Coirier, 1999).
Across grades, and by contrast to Hypothesis 2, students’
cognitive effort did not vary with the genre of the text they had
to write. This finding may mean low performance on the
argumentative text if other criteria of text structure or quality
were used. Moreover, this absence of effect of genre on
cognitive effort may be due to the fact that the texts produced by
children, and particularly the youngest ones, were not really
argumentative with articulated arguments. Thus, it is possible
that students composed their text using a knowledge-telling
strategy, which is less costly than the knowledge-transforming
strategy required for producing a strong argumentation. Thus,
at least for the students involved in the present study,
difficulties in writing narrative and argumentative texts were
not manifested in cognitive effort as measured by interference
RT. It is highly probable that students devoted all their
working memory capacity in writing texts of both genres.
However, the interaction between grade and genre indicated
that cognitive effort of only argumentative text decreased
from Grade 5 to Grade 9, with less cognitive effort in Grade
9, verifying Hypothesis 3. This finding confirms, first, that
students continue to improve their skills related to writing
argumentative texts between Grade 5 and 9 and, second, that
writing narrative texts is well mastered in Grade 5. One
possible explanation of such difference in mastering the
writing of narrative and argumentative texts lies in students’
exposure to these two genres. As was mentioned above
(Donovan & Smolkin, 2006), students’ earlier exposure to
narratives results in greater mastery of that genre. According
to Berninger and Swanson (1994), in Grade 5, planning is
just emerging whereas it is established in Grade 9. Because
planning is more involved in argumentative than in narrative
composition, students’ cognitive effort in writing argument-
native texts probably reflects changes in planning ability
across grades. Finally, handwriting did not contribute differ-
ently to cognitive effort of argumentative and narrative texts,
thus falsifying Hypothesis 6.

As expected, and despite the fact that students encountered
more difficulty to write argumentative texts, no difference in
writing fluency was observed between narrative and argu-
mentative texts. These previous results are in line with findings
reported by Favart and Coirier (2006), showing an effect of
grade but not of genre on writing fluency. In that study, 3rd,
5th, 7th and 9th graders had to write a narrative text, an
argumentative text, and an instructional text. To that end, they
were provided with three sets of 11 ideas presented in
a random order and told to reorder these ideas so as to
compose coherent texts. Their results showed an effect of
grade, but no effect of text structure on writing fluency. Taken
together, the absence of difference in both fluency and
cognitive effort in writing argumentative and narrative texts
confirms that students devoted all the working memory
resources to writing the two genres of text.

To summarize the present findings, 9th graders encountered
less difficulty in writing their texts and exhibited less cognitive
effort than 5th graders. Cognitive effort in 9th graders
presumably resulted from the demands of only the high-level
writing processes since handwriting was automatised and did
not affect cognitive effort. These high-level writing processes,
despite being more complex, were overall less demanding in
writing memory denoting more automatisation of other high-
level processes, particularly in the writing of argumentative
texts. By contrast, the larger cognitive effort of 5th graders
came to some extent from the handwriting demands and,
mainly, by the demands of high-level processes involved in
writing. Writing a narrative or an argumentative text did not
affect fluency in writing (i.e., number of words used), but it did
affect students’ cognitive effort. Gaining experience through
instruction leads to the easing of cognitive effort later on in
Grade 9.

4.1. Implications and limitations of the study

The educational implications of these findings relate to at
least two aspects of learning and teaching to write. First, they
underline that not only children’s early exposure to genres, but
also the explicit teaching of genres is important as young
writers’ cognitive effort varies with the type of text they are
writing. Second, this study showed the role of level of hand-
writing automatisation in writing. Recently, Graham et al.
(2008) surveyed how handwriting is taught in American
primary schools. They observed that despite the fact that
handwriting is being taught by the majority of teachers of
primary grades, the recommended instructional procedures are
applied unevenly in classrooms. Educational interventions
focusing on handwriting, however, succeed in improving
handwriting automatisation and writing achievement. In
addition, teachers may also be attentive to children with poor
handwriting skills in order to remediate their difficulty. Jones
and Christensen (1999) showed that instructions aimed at
improving handwriting fluency and letter formation of 1st
graders with poor handwriting enhanced their performance
when writing a story.

To conclude, this study complement experiments of
cognitive effort in text writing by adults, and is the first one to
address the issue of children’s cognitive effort associated with
text writing. It must be noticed that the decrease in cognitive
effort we observed between Grade 5 and 9 does not fit with the
idea of performance amplification in writing (Kellogg, 1994).
Performance amplification refers to the fact that in order to
compose a high-quality text, writers need to devote their full
working memory capacity to writing. So it may be expected
that students, as adults, devote all the working memory
resources on writing an argumentative text and that no
difference is observed between age groups. Actually, it is
highly probable that the reduction in cognitive effort we
observed in the 9th graders ceases after a certain time and
increases again when students use more elaborated writing
strategies later on. Accordingly, variations in cognitive effort
along with age may indicate shifts in acquisition of writing
processes. To deepen our understanding of acquisition of
writing in relation to working memory, more systematic
studies of age-related changes in the cognitive effort of
different writing situations in different writing tasks need to be
carried out.
References


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