Chapter 4

Influence of Typing Skill on Pause–Execution Cycles in Written Composition

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It is well known that the cognitive cost of programming motor movements in writing can be considerably high if execution is not automatized. However, it is not clear how this cost might affect the on-line production of a written text, namely the distribution of pauses vs. execution periods. Narratives were collected using ScriptLog. Keystroke interval within a word was measured and used to distinguish between fast typists — for whom execution was presumably automatic, and slow typists — for whom execution required attention. The relative distribution of pauses vs. execution periods between two consecutive pauses was examined. Results showed that the time ratio between pauses and execution differs between groups. Relative to fast typists, slow typists make more pauses, and have shorter execution periods. These results are discussed in light of two phenomena: the trade-off between execution and formulation processes, and the adoption of serial vs. parallel ways of composing.

4.1. Introduction

There is agreement in writing research that motor execution can have a cognitive cost (Bereiter & Scardamalia, 1987; Cooper & Matsuhashi, 1983; Fayol, 1999; Graham & Harris, 2000; Kellogg, 1996; Martlew, 1983; McCutchen, 1996). Nevertheless, there are few attempts to assess this cost. Exceptions are studies using written serial recall tasks (Bourdin & Fayol, 1994, 2000; Penney & Blackwood, 1989), and, more recently, written composition tasks (Kellogg, 2001; Olive & Kellogg, 2002). These studies, reviewed below, have shown that the cognitive burden from motor execution can be detrimental to both children and adults. However, it remains unclear how the on-line production of a written text is affected by motor execution skills. Here, we review this

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question, and report a study in which we explore how different levels of typing skill affect the on-line production of a narrative text.

Penney and Blackwood (1989) have asked college students to recall lists of digits either by typing, or by handwriting. They found a decrease in the recall of the last serial positions of the lists when the responses were typed, but not when they were handwritten. The suppression of the recency effect was attributed to the participants' low typing skill. Similarly, Bourdin and Fayol (1994) have used serial recall and compared spoken and handwritten responses from adults and children. They found that children performed worse than adults if the responses were handwritten, but not if they were spoken. They explained this finding as the lack of automaticity in low-level writing processes, such as handwriting and spelling, in beginning writers. Convincingly, they have supported this interpretation by showing that the performance of adults could be brought to levels similar to those of the children if they were required to write with untrained cursive capital letters. Thus, it seems that if attention has to be divided between the execution of untrained motor programs and the maintenance of memory traces, trade-offs are likely to occur and performance deteriorates.

Situations of divided attention are paramount in text production. In recent years, this feature has been captured by an increasing focus of writing research on working memory (WM). A good illustration is Kellogg's (1996) model which incorporates the demands of writing processes like formulation, execution, and monitoring on the multi-component WM model proposed by Baddeley and Hitch (1974). Regarding the execution process, Kellogg asserts that resources from the central executive are needed to program the motor movements in writing, but he adds that "execution can, when well-practised, proceed virtually automatically" (p. 59), thus allowing a more efficient management of demands from the formulation and monitoring components. However, if execution is not automatized, the simultaneous operation of the two other components might be impaired or impossible. Two recent studies tested this prediction of the model.

Kellogg (2001) addressed the question whether writing components compete for the same WM resources, using a reaction time (RT) interference paradigm (RTs to auditory probes are collected in single task — baseline, and while writing; interference RTs are taken as estimates of the spare capacity, higher scores indicating less available resources; for a complete description of this procedure see Olive, Kellogg, & Piolat, 2001; and for recent implementations, see chapters in this volume by Piolat, and by Kellogg, Olive, & Piolat). Kellogg (2001) manipulated the demands of planning by varying the type of text to be composed (narrative, descriptive, or persuasive), and the demands of execution by varying output mode (handwriting, or typing on a keyboard). He found that when planning demands are relatively low, as in writing a narrative as opposed to a persuasive text, interference scores are smaller not only during planning, but also during execution and monitoring. Similarly, when the execution cost was lifted, as in writing by hand as opposed to typing, interference scores were lower. These findings suggest that different writing components share a common pool of resources (i.e. the central executive in Baddeley's terms), so that if a given component requires less capacity, others can make use of it. However, because writing is typically a demanding and effortful task, competition among writing processes is most often the case.

How do adult writers manage to produce a text when required to use an untrained response mode, thus having to deal with the cognitive cost of execution? Olive and

Kellogg (2002) asked third graders and undergraduates to write a persuasive text and then to copy it. Half of the adults composed and copied the texts using their usual cursive script, and the other half used an unpracticed uppercase script. RT interference was measured in three conditions: (1) while copying (transcription), (2) in writing while pausing for longer than 250 ms (composition), and (3) in writing and not pausing (transcription + composition). Olive and Kellogg found less RT interference in the transcription condition of adults using cursive script. This finding indicates that, for adults, the execution of handwriting is automatized and allows other processes to be activated simultaneously. Indeed, the highest RT interference (in adults, cursive script) was found in the transcription + composition condition. A different picture emerged from the children's results, where transcription yielded the highest interference. Thus, children devoted more resources to motor transcription than to composition. The interference score of the transcription + composition condition was intermediate, and not reliably different from the other two. This indicates that transcription per se overloads the attention capacity of children, who may not be able to activate other writing processes during motor execution. Interference scores in the adult group writing in uppercase (the unpracticed script) were similar in the three measurement conditions. This indicates that the presumably more effortful execution exerts a toll on all other components of the writing process. Olive and Kellogg suggest that when execution is less practiced writers might strategically alternate between planning, monitoring, and execution, that is, they would adopt a serial mode of composing. Further evidence in favor of a serial mode of composing under highly demanding execution comes from Olive and Piolat (2002), who found that suppressing visual feedback during a composition task leads to similar interference RTs whether the writers were pausing or handwriting, thus showing a similar pattern to the writers using the uppercase script in the other study.

The studies reviewed above demonstrate that motor execution affects writing processes, and, overall, point to the role of typing proficiency. For example, if heightened demands from motor execution lead to the adoption of a serial mode of composing, then this is the mode that adults who are not proficient typists should use. In order to investigate this issue, however, we must be able to measure typing proficiency.

Strömqvist (1999) proposed that, in a composition task, the median keystroke interval within a word is the most reliable indicator of typing proficiency. The reasons for this are that within-word strokes are very common and fast, and their timing is marginally influenced by planning or monitoring. Here, we called this measure typing speed, and used it to distinguish between slow and fast typists. We assumed that for slow typists execution is resource demanding, and for fast typists execution is virtually automatic. We distinguished these two levels of typing skill on the basis of a median split procedure, and explored the composition process in both groups. The rationale reviewed above instigated us to query for differences in the distribution of pauses and execution periods.

One of the most striking observations of a writer producing a text is that huge amounts of time are spent not "writing", this is, not executing typing or handwriting. For instance, Wengelin (1999) reported that college students spend 41% of their writing time in pauses longer than 2 s. Why do writers spend so much time pausing? What are they doing while pausing? As noted by Schilperoord (2001), writers can pause for several reasons: physical causes (e.g. fatigue, motor execution of typing or handwriting), socio-psychological causes (e.g. writer's block, daydreaming), or cognitive causes (e.g. writing processes, cognitive overload). As pauses due to physical reasons are usually very brief, Schilperoord suggested a cut-off value of 1 s in order to exclude them from analysis. Specifically addressing writing on a keyboard, Wengelin (1999, see also this volume) argued that a good pause criterion should take into account the typing skill of the writer, and should be set well above the typing speed of the slowest writers. In our study, a pause criterion of 1 s would be too low to account for the pauses in the slow group. Thus, to make a fair comparison, we raised the cut-off value to 2 s. This is also a very common pause threshold (e.g. Levy & Ransdell, 1995; Severinson-Eklundh & Kollberg, 1996a; Strömqvist & Ahlsén, 1999), which is particularly suitable to examine high-level processes in writing.

Although what happens during pauses is important, it is at best only half of the picture. One should also look at periods between consecutive pauses — what we call execution periods. It is probably in execution periods that storage and processing demands are higher, and where Flower and Hayes's portrayal of a writer as "a thinker on a full-time cognitive overload" (1980b, p. 33) is most accurate. While typing, writers must literally keep in mind the representation of what they intend to write, pay attention to the output being produced, maybe plan further segments or revise the already written ones, or even pay attention to finding the keys on the keyboard. As discussed above, all these functions are likely to involve the central executive, whose capacity is well known to be limited (Baddeley, 1996, 2000). How does a slow typist manage this situation where a limited amount of resources has to be distributed among so many processes? One possibility is that slow typists have more difficulty in sustaining execution periods for as long as fast typists, since more resources are directed towards motor execution proper, and thus fewer resources are available to the other processes involved in on-line writing. This would lead to shorter execution periods in slow typists as compared to fast typists. Another possibility, suggested by Olive and Kellogg (2002), is that slow typists leave high-level processes unattended while typing, and pause to activate them. This would imply a serial mode of composing, a sign of which would be a greater number of pauses.

Together with the study of the on-line processes in slow and fast typists, we also explored the linguistic characteristics of the texts produced. We looked at holistic ratings of text quality, and explored lexical measures, namely the amount, type, and diversity of the words used. Does the quality of the narratives differ between slow and fast typists? This question is of concern because it has been found that the quality of a text can be affected by difficulties with the mechanics of writing, both in children (Bereiter & Scardamalia, 1987; Graham, 1990) and in adults (Bourdin & Fayol, 2002; Olive & Kellogg, 2002).

4.2. Method

4.2.1. Participants

Twenty-one first-year college students (mean age: 19.3 years; 11 female) from the University of Porto participated in this experiment. All participants had previous experience with writing on a computer keyboard, although frequency of using the computer and of writing on the keyboard varied among participants.

4.2.2. Materials

The picture story "Frog, where are you?" (Mayer, 1969) was used to elicit written and spoken narratives. The booklet is composed of 24 pictures that portray the adventures of a boy and his dog in search of their missing frog. The written narratives were collected using the computer program ScriptLog 1.04 (Strömqvist & Malmsten, 1998) running on a Macintosh computer, which was also used for the presentation of the pictures.

4.2.3. Procedure

Participants were instructed to tell a story from the pictures, either by writing on a computer, or by speaking into a microphone. Both tasks were performed without time limit. The order of these tasks was counterbalanced, so that 11 participants started by writing, and 10 by speaking. Data were collected in individual sessions that lasted for one hour on average. Before starting on the narratives, participants gave written answers to demographic questions, and reported their frequency of computer and keyboard usage in a Likert five-point scale. Also, they were allowed to leaf through the picture booklet. They were told that the pictures would be presented once at a time on the computer screen, and that they were required to produce text for each one of them. The presentation of the successive pictures was self-paced. When advancing to the next picture, the text written for the previous one was removed from the screen.

4.2.4. Treatments and Analysis

Although spoken narratives were collected, here we examined only the written ones. The narratives were transcribed and coded in CHAT (Codes for the Human Analysis of Transcripts) format to allow analysis by the Computerized Language Analysis software, CLAN (MacWhinney, 2000). CLAN was used to measure word length and frequency, to calculate lexical density, and to assess vocabulary diversity. Lexical density indicates the proportion of content words relative to total number of words. Nouns, verbs, adjectives, and modal adverbs ending in "-mente" (Portuguese equivalent to "-ly") were classified as content words. Vocabulary diversity was assessed with the *D* measure (McKee, Malvern, & Richards, 2000). This measure was chosen instead of the more common Type-Token Ratio (ratio of different words to total words, TTR) because it is not influenced by sample size, a problem that affects TTR. *D* was computed through a mathematical modeling procedure; it ranged from 5, a value typical for a 5-year-old child, to 120, for a sample of academic writing (Malvern & Richards, 2002).

Two experienced teachers of Portuguese, blind to the study, assessed independently the quality of the written narratives using Likert scales, ranging from 1 (very low quality) to 5 (very high quality). They rated each narrative on five scales: Overall Quality, Formal Use of Language, Creative Use of Language, Volume of Information, and Narrative Structure. Disagreements between judges higher than one point occurred only once in each scale. They were resolved through discussion between the judges so that only one-point disagreement remained. In order to establish a more conservative estimate of inter-rater agreement, the Weighted Kappa (Cohen, 1968) was computed. Moderate scores of agreement were found between judges in the five dimensions mentioned above, respectively, K_w = .50, .50, .48, .63, .69.

The narratives were analysed with ScriptLog on-line analysis module (Strömqvist & Malmsten, 1998; see also Strömqvist et al., 2006). One of the analyses was typing speed. To prevent typing speed from being inflated by extreme values (writers might just start pauses in the middle of a word), we computed first the median of the within-word keystroke interval for each participant, and then a mean for the whole group (Wengelin & Strömqvist, 2000). Further analyses required the establishment of a pause criterion, which, as discussed in the Introduction, was set at 2 s of keyboard inactivity. Using this criterion, the overall writing time can be divided between time spent in pauses, and time spent in execution periods. An execution period was defined as an instance of keyboard activity between two consecutive pauses in which at least one word is typed. We measured the duration and the number of words of each execution period. Transition times in selected discourse contexts (e.g. word, clause, and sentence) were also examined.

4.3. Results

We will start with a brief survey of the results for the whole group, and then concentrate on the comparison between the slow and the fast subgroups.

On average, participants spent 48 min on the writing task (*SD* = 23 min), 54% of which in execution periods, and 46% in pauses. Average fluency was 12.2 wpm, and average typing speed was .32 s. The narratives were written with about 500 tokens, 48% of which were content words (see Table 1 for more information). Generally, the variables analyzed here were not influenced by the fact that some participants wrote their stories after having

Table 1: Average writing time and lexical measures of the narratives for the whole group, and split by slow vs. fast typists.

	Groups		
	All (*N* = 21)	**Slow (*n* = 10)**	**Fast (*n* = 11)**
Total writing time (min)	48.4 (22.8)	59.1 (24.5)	38.6 (16.7)
Total pause time (min)	22.5 (14.4)	31.1 (15.0)	14.6 (8.3)
Total execution time (min)	25.9 (10.5)	28.0 (11.7)	23.9 (9.3)
Typing speed (s)	.32 (.14)	.44 (.1)	.21 (.03)
Fluency (wpm)	12.2 (5.3)	7.9 (2.8)	16.2 (3.6)
Number of words	514 (191)	431 (164)	589 (189)
Word length (in characters)	4.4 (.2)	4.4 (.2)	4.4 (.2)
Content words	245 (86)	206 (74)	280 (84)
Lexical density	.48 (.03)	.48 (.03)	.48 (.02)
Different words	227 (72)	195 (56)	257 (75)
Vocabulary diversity	72.4 (13.7)	70.6 (14.2)	74.0 (13.8)

Note: Standard deviations in parentheses.

produced them orally. However, there were two exceptions: pause length and vocabulary diversity. Writing a story that had been previously produced in the spoken modality was associated with shorter pause length [$M = 4.6.$ vs. 5.3; $F(1, 19) = 4.4$, $p < .05$], and less vocabulary diversity [$M = 66.2$ vs. 78.1; $F(1, 19) = 4.6$, $p < .05$].

A median split-half procedure was applied to typing speed in order to categorize subjects as slow or fast typists. Ten participants had a typing speed higher than .27 s, and were considered slow typists; half of them had started with the written narrative. Eleven participants had a typing speed equal to or lower than .27 s, and were considered fast typists; 6 of them had also started by writing (then produced the spoken narrative). The comparison between slow and fast typists is, thus, not biased by the order in which the spoken and written narratives were produced, since in both groups about half of the participants started in one condition, the other half in the other one. The slow group consistently reported less use of computer ($M = 2.6$ vs. $M = 4.4$), and less writing on keyboard ($M = 2.1$ vs. $M = 3.8$) than the fast group, respectively, $F(1, 19) = 10.7$, $p < .01$, and, $F(1, 19) = 9.6$, $p < .01$). This relates faster typing speed to greater amount of practice, and gives credit to self-report measures as a reliable means to screen typing automaticity.

Not surprisingly, slow typists took longer to compose their texts. On average they spent 59 min in the writing task, whereas fast typists spent 38 min [$F(1, 19) = 5.1$, $p < .05$]. Consequently, in 1 min slow typists produced only half the words produced by fast typists [$F(1, 19) = 34.0$, $p < .001$] (see Table 1). However, the difference in total writing time does not extend to both components of composition time, i.e. pauses and execution periods. Compared to fast typists, slow typists had more overall pause time [$F(1, 19) = 9.9$, $p < .01$], but similar overall execution time ($F < 1$). If, at this rough description, slow typists spend more time pausing, what happens at the level of pause–execution cycles? Table 2 clarifies this question.

Slow typists spend more overall time pausing not because their individual pauses are longer [$F(1, 19) = 1.8$, $p = .19$], but because they make a higher number of pauses [$F(1, 19) = 9.0$, $p < .01$; $d = 1.3$]. Regarding execution periods, while slow typists can sustain execution for 7.7 s, fast typists do it for a longer time, 11.6 s [$F(1, 19) = 10.2$, $p < .01$; $d = 1.4$]. During their execution periods, slow typists produce half the words produced by the fast typists. The higher cost of execution for slow typists is well demonstrated

Table 2: Characteristics of pause–execution cycles (whole group, and slow vs. fast typists).

	Groups		
	All ($N = 21$)	**Slow ($n = 10$)**	**Fast ($n = 11$)**
Number of pauses	266 (157)	358 (161)	184 (102)
Pause length, P (s)	5.0 (.8)	5.2 (.9)	4.7 (.7)
Execution period length, E (s)	9.7 (3.4)	7.7 (2.3)	11.6 (3.2)
Number of words typed	4.0 (2.0)	2.5 (.9)	5.4 (1.7)
Execution cognitive cost (P/E)	5.8 (2.6)	7.6 (2.4)	4.2 (1.5)

Note: Standard deviations in parentheses. Execution cognitive cost is the ratio of pause time over execution time (multiplied by 10, for ease of presentation), computed individually, and then averaged.

in the ratio between pauses and execution, which we will call execution cognitive cost. For clarity, the ratio was multiplied by 10. Thus, for each 10 s of execution, slow typists paused for 7.6 s, while fast typists paused for only 4.2 s.

In Table 3, instances of keyboard inactivity (absolute pauses) in selected discourse contexts — sentence, clause, and word — are presented for comparison between the slow and fast subgroups. There are only two contexts in which there are no statistical differences, Opening Sentence and After Comma. In all other contexts, slow typists have longer absolute pauses, although these differences seem to be of greater magnitude at the word level.

Now, let us move from processes to products. Do the observed differences between slow and fast typists have an impact on the characteristics of their final stories? Differences were found in Text Length, Content Words, and Different Words (see Table 1): slow typists produce smaller texts [$F(1, 19) = 4.1, p = .05$] with less content words [$F(1, 19) = 4.5, p < .05$], and with less different words [$F(1, 19) = 4.4, p < .05$]. Since the last two differences are dependent on text size, the basic finding here is a tendency for slow typists to produce smaller texts. Narratives composed by both groups are similar in terms of Word Length, Lexical Density, and Vocabulary Diversity. As these measures are typically sensitive to text quality, the fact that there are no differences is an indication that the major difference between the stories composed by slow and fast typists is at the lexical level, and concerns number of words.

Subjective ratings of the quality of the narratives seem to be concordant with the characterization of the written products as described above. Experienced judges did not rate differently the stories written by slow and fast typists according to Overall Quality, Formal Use of Language, Creative Use of Language, and Narrative Structure (see Table 4). The only difference occurred on Volume of Information: the stories written by slow typists were judged as having less information [$F(1, 19) = 4.6, p < .05$]. This result is consistent with the results, described before, regarding the total number of words, and particularly content words.

Table 3: Average duration of keyboard inactivity (in seconds) in selected discourse contexts (whole group, and slow vs. fast typists).

	Groups		
	All ($N = 21$)	**Slow ($n = 10$)**	**Fast ($n = 11$)**
Opening a sentence ._^a	1.6 (.9)	2.0 (.7)	1.3 (1.0)
Closing a sentence a^.	2.1 (.9)	2.6 (.8)	1.7 (.7)
After closing a sentence.^_a	.91 (.67)	1.3 (.8)	.6 (.4)
Before comma a^,	2.5 (1.4)	3.2 (1.6)	1.8 (1.0)
After comma ,^_a	.45 (.76)	.77 (1.0)	.17 (.04)
New word after comma,_^a	1.1 (.9)	1.7 (1.0)	.6 (.36)
Opening a word a_^a	.70 (.33)	.95 (.24)	.47 (.21)
Within a worda^a	.32 (.14)	.44 (.10)	.21 (.03)
Closing a word a^_a	.30 (.20)	.41 (.23)	.20 (.08)

Note: Standard deviations in parentheses. “a” stands for any letter, “_” for spacebar, and “^” for absolute pause. Periods and commas are indicated as such.

Table 4: Average ratings of text quality (whole group, and slow vs. fast typists).

	Groups		
	All *N* = 21	**Slow (*n* = 10)**	**Fast (*n* = 11)**
Overall quality	2.6 (1.0)	2.3 (1.1)	2.9 (.7)
Formal use of language	2.7 (.9)	2.6 (1.0)	2.9 (.9)
Creative use of language	2.5 (.9)	2.3 (1.0)	2.8 (.9)
Volume of information	3.2 (1.0)	2.8 (1.1)	3.6 (.8)
Narrative structure	2.9 (1.1)	2.5 (1.2)	3.1 (1.0)

Note: Standard deviations in parentheses.

4.4. Discussion

The results from this study have shown that the on-line writing of slow typists is characterized by shorter execution periods, and higher number of pauses than that of faster typists. These differences have considerably large effect sizes (thus indicating robust differences between the groups), and they can be a sign of different strategies concerning the on-line management of the writing processes.

Slow typists seem to be comparable to the participants in the studies by Bourdin and Fayol (1994), and by Olive and Kellogg (2002), who were instructed to write using unpracticed capital letters. Like the writers in the first study, slow typists may be suffering from a trade-off between the execution and the formulation systems. Not having mastered typing skill, slow typists may tend to forget part of what they had initially planned. They might be pausing to reread the text, and recover a lost idea. In order to cope with the limited cognitive resources and the high demands of execution, like the writers in the second study, slow typists might be using a serial way of composing. They may be devoting pauses to high-level writing processes, and execution periods to typing. Being unable to think and type at the same time, they might be alternating between execution, formulation, and monitoring, as suggested by Olive and Kellogg (2002).

While lack of typing automaticity is a prime factor to explain these findings, it might not be the only one, and other factors, too, might have played a role. Although their putative contribution cannot be ascertained with the present experimental design, it should be noted that the distinction between slow and fast typists would capture differences attributable to other explanatory factors only coincidently. Furthermore, when considering other possible factors, it is important to keep in mind that the subgroups studied here were divided looking at within-word keystroke, which is possibly the most sensitive context to typing proficiency (Strömqvist, 1999), and that self-report measures of keyboard and computer usage reliably distinguished both groups.

An alternative explanatory factor might be WM: the present findings might be due to lower WM capacity in slow typists. With less available cognitive capacity, overload should occur more often. However, this seems not to be the case. In a recently completed study, where WM capacity was measured independently, we replicated the finding reported here, and did not find differences in WM capacity between slow and fast typists (Alves &

Castro, 2004). Furthermore, WM capacity was not related with the length of execution periods, instead, it was related to pause length — writers with larger WM spans made longer pauses.

As noted by Torrance (personal communication), slow within-word typing rate could also be due to higher-level features of the writing task (e.g. lexical choice, syntactic planning, content-determination). There is evidence showing that difficulties with higher-level processes can be detrimental to lower-level processes (for a review, see Fayol, 1999). So, rather than a single bottom-up trade-off, possible top-down influences also need to be considered when analyzing the present findings. A comparison between typing and handwriting production tasks by slow typists should help clarify this issue.

Future research also needs to clarify the functional role of the pauses — if slow typists pause more often, and what is happening during these pauses? Two directions are promising to shed light into these questions. One is to use the triple task technique (Piolat & Olive, 2000) specifically on pauses. The other is to compare eye movements between slow and fast typists. Alamargot, Dansac and Chesnet (see this volume) report evidence on Parallel Events (PE) occurring during graphomotor execution. Concerning the distinction made here, one straightforward prediction is that PEs would be less common in slow typists.

Regarding absolute pauses, our results replicate the well-established finding that pause length tends to decrease as one moves from larger to smaller discourse units (Chanquoy, Foulin, & Fayol, 1996; Foulin, 1998; Schilperoord, 1996a, 2001). It also seems that slow and fast typists are different as soon as they start typing. However, since no reliable differences were found at the start of sentences, both groups might be devoting similar time and resources to planning at starting points of the written discourse. The differences between slow and fast typists were generally of greater magnitude at the lexical level, but with the present design it is not possible to ascertain specific effects, at the lexical level, from motor execution and translating skills (such as lexical choice and access).

The finding that slow typists tend to produce shorter texts is not trivial, if one takes into account that there was no time limit for the composition task. For slow typists, being concise can be a strategic way of dealing with the high cost of motor execution; conciseness was not associated with lesser text quality, but it is probably the reason why their texts were judged to have less information.

Although our distinction between slow and fast typists is concordant with the distinction between serial and parallel ways of composing, contrary to Olive and Kellogg (2002), in this study the final products of composition were similar in several lexical measures, and in text quality. Even though execution seems to be a burden for slow typists, it was one that they carried without prejudicing the quality of their narratives. This is not surprising, because they wrote in a well-known discourse genre, and no time limit was imposed. But, were we to alter one or more of those variables, we would predict differences in some of the lexical measures, maybe also on text quality.

Overall, our findings show that typing speed is a reliable way to assess the degree of typing automaticity, and that the distinction between slow and fast typists is a proper way to study the cognitive cost of execution. Furthermore, they reveal how effortful execution can be for slow typists, and that the lack of typing automaticity can substantially alter the composition task.

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