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16

Effects of Handwriting Skill, Output Modes, and Gender on Fourth Graders' Pauses, Language Bursts, Fluency, and Quality

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In a pioneering study, Kaufer, Hayes, and Flower (1986) made a seemingly evident, yet notable, observation: Writers compose in bursts, that is, written sentences are built up in a piecemeal fashion with bursts of writing activity interspersed by long production pauses (usually longer than 2 s). Whether for its apparent simplicity or for difficulties in setting up a complete scientific explanation of this otherwise exuberant writing behavior, this finding seems to have been forgotten. Only recently, Hayes has led a series of studies aimed at providing a detailed account of bursts of language production (Chenoweth & Hayes, 2001, 2003; Hayes & Chenoweth, 2006, 2007). Here, we add to this line of research by presenting a study in which, from a developmental standpoint, we argue that automatizing transcription can lead to larger language bursts and therefore to improvements in text quality.

Kaufer et al. (1986) have shown that, when producing a text, adult writers typically compose sentence parts of 9.3 words on average. They compared burst length between two groups of writers, one of expert, professional writers, and the other of graduate students, and showed that experts composed using larger bursts, an average of four words more. Moreover, the texts written by the experts were generally rated of better quality than those composed by novices, which was interpreted as evidence of more efficient translating processes. Translating refers to cognitive processes by which ideas are converted into written language (Hayes & Flower, 1980).

More recently, Chenoweth and Hayes (2001) conducted a series of studies that comprehensively characterize bursts of language production as a fundamental parameter of the translating process. In their first study, they reasoned that if writers have better translating skills in their native language than in a second, less practiced language, this relative strength with one's native language should be reflected in the length of language bursts. Indeed, they found that undergraduate students were more fluent and had larger bursts when composing in their first language rather than their second language. As in the study of Kaufer et al. (1986), better translating skills lead to larger bursts.

Translating processes have long been viewed, and studied, as partially dependent on the verbal component of working memory (Kellogg, 1996; McCutchen, 1996; McCutchen, Covill, Hoyne, & Mildes, 1994; Swanson & Berninger, 1996). Following this thread, Chenoweth and Hayes (2003) have shown that articulatory suppression, a procedure widely used to impair the rehearsal of verbal information within working memory (Baddeley, 2007), consistently decreases burst length and writing fluency. They have found an average decrease of 34% in burst length from the control condition to the articulatory suppression one. They concluded that burst length depends on available verbal working memory capacity.

In another study, Hayes and Chenoweth (2006) asked 20 highly proficient typists to transcribe six texts between two word processor windows. Three texts were copied under articulatory suppression and three under a foot tapping control. Congruent with the recruitment of verbal working memory by the transcribing task, they found a decrease in transcription fluency and an increase in mechanical errors in the articulatory suppression but not foot tapping condition. Noticeably, they did not find evidence of bursting while the expert typists were transcribing. Thus, they tentatively suggested that bursting might be dependent on the formulation of new strings of language.

More recently, Hayes and Chenoweth (2007) used a double passive-to-active sentence conversion task to test competing hypotheses regarding the sources of bursting in writing. If bursting depends on generating new ideas, then in the conversion task no bursts should be observed, because beforehand the writers knew the ideas in the sentence. Conversely, if bursting depends on generating a new linguistic structure, then bursting should be observed. They found support for the later hypothesis, yet the evidence is far from definitive. Overall, the reviewed studies have established the bursting phenomenon in writing and have convincingly related it to cognitive translating processes.

In beginning and developing writers, transcription and different levels of written language (word, sentence, and text) support the translation process (Berninger & Swanson, 1994). Text generation expresses ideas in language representations in working memory, and transcription transforms these language representations into visible letters, written spellings, and the sentences and discourse structures of written text (Berninger, Fuller, & Whitaker, 1996; Berninger & Swanson, 1994).

Transcription draws on the programming and execution of motor movements required by the particular writing tool used (e.g., pen, keyboard) to produce the letters and written spellings in the larger units of written language. The fine, automatic integration of the orthographic codes of letters and written spelling with the sequential finger movements is an early requirement for achieving automatic handwriting (for reviews, see Berninger & Amtmann, 2003; also Graham & Harris, 2000). Evidence exists that for child writers in Grades 1 to 6 (ages 6 to 12) transcription constrains fluency and quality of written texts (Bereiter & Scardamalia, 1987; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997). In a large cross-sectional study with children from the primary grades, Berninger et al. (1992) found that transcription accounted for 66% of the variance in writing fluency. Similarly, Jones and Christensen (1999) found that transcription explained 67% of the variance in the quality of texts produced by a sample of second graders. Additionally, in two studies with primary school children, Connelly, Gee, and Walsh (2007) showed that limited keyboarding skill, as opposed to better handwriting skill, had a detrimental impact on text quality. Furthermore, in initial primary grades orally produced texts have been described as of better quality than written ones (Bereiter & Scardamalia, 1987; but see Hidi & Hildyard, 1983). However, a turnaround seems to occur around fourth grade in normally developing children (McCutchen, 1996) and somewhat later for children with disabilities in transcription (Graham, 1990). This change seems not to be a developmental pattern, but rather an issue of achieving relative expertise with a particular mode of composing. For instance, in a study with adult competent writers, Gould and Boies (1978) found no quality differences between commercial letters whether they were dictated or handwritten.

The release from a detrimental impact on text quality caused by poor handwriting skill is noticeably dependent on its relative automatization, which seems to be achieved earlier by girls (Berninger & Fuller, 1992). Given the limited resources of working memory, a tradeoff between formulation of content and transcription is likely to happen during written language production, as suggested by a study by Bourdin and Fayol (1994). They tested children and adults in a serial recall task, in which the response modality was spoken in some blocks and handwritten in others. For adults the response mode did not matter in that they did equally well, but children had consistently smaller spans when the response was written than when it was spoken. This detrimental impact of writing compared to speaking was attributed to the cognitive cost of transcription. Moreover, when Bourdin and Fayol asked adults to recall using an untrained uppercase cursive script, this transcription requirement had a similarly negative impact on their performance in that they did better when speaking than writing. This result has been replicated and expanded in several studies (Bourdin & Fayol, 2000, 2002; Grabowski, 2010). Additionally, Olive and Kellogg (2002) showed that in a composition task, transcription is more effortful for children than for adults, and this cost seems to alter the dynamics of activation of writing processes (see also Alves, Castro, & Olive, 2008; Olive, Alves, & Castro, 2009). Olive and Kellogg measured secondary reaction time to auditory probes while participants were copying their texts or composing them. Arguably, while copying text, writers engage only transcription; but while composing it, other processes, such as planning or revising, need to be concurrently activated. If this is the case, cognitive effort should increase from copying to composing. Indeed, Olive and Kellogg found that to be the case in their adult sample and interpreted the finding as a sign of parallel activation of writing processes. However, in their child sample handwriting was more demanding than for adults, and there was no change in cognitive effort from copying to composing tasks. This finding was interpreted as a sign of a sequential activation of writing processes. That is, when the cost of transcription is high, it might prevent the concurrent activation of other writing processes. Congruently, when adults composed or copied texts using an untrained script, as in Bourdin and Fayol's studies, they exhibited a similar pattern to children. To conclude from the reviewed studies, it is clear that when transcription is not automatized, its cognitive cost is high, which has a negative impact on fluency and text quality.

It follows that automatizing transcription might also have an impact in bursting, because bursts are closely tied to writing fluency. More efficient transcription skills might require less effort in fully capturing the language segment held in the mind and thus determine the ease and speed in which it is produced as written language. Automatic transcription processes seem to overcome some working memory limitations and enable greater support for the higher-level cognitive processes of producing written text (Berninger, 1999; Fayol, 1999; Olive & Kellogg, 2002), which might reflect in larger language bursts.

Two recent studies showed that automatizing transcription leads to larger language bursts. Alves, Castro, Sousa, and Strömqvist (2007) asked two adult groups that differed in typing proficiency to produce written narratives. They found that the highly automatic transcription group composed using larger language bursts, on average three words more. Thus, typing faster seems to allow the usage of lengthier segments while composing (see also Grabowski, 2008). Alves, Castro, and Olive (2011) randomly assigned 84 undergraduate students to one of four experimental conditions, which manipulated output modality and transcription skill. Half the participants composed by handwriting and half by typing. In handwriting, low skill was manipulated by using an uppercase cursive script or the participants' usual calligraphy. In typing, low skill was manipulated by using a scrambled keyboard or a QWERTY layout. In both modalities, handwriting and typing, the low-skill groups showed similar reliable decreases in burst length, about six words less (respectively, three vs. nine words) and received lower ratings of text quality. Alves et al. concluded that, when not well automatized, transcription creates a lower-end toll that hinders the number of words a writer can put in a written language burst.

The reviewed studies highlight the contribution of transcription skill to achieve writing fluency, text quality, and composing using longer bursts, that is, stretches of written language. In the study reported in this chapter, we extended this research to children in fourth grade (9 years old). By Grade 4 most children have relative proficiency in handwriting (Graham & Weintraub, 1996; McCutchen, 1996), but individual differences still occur (Graham et al., 1997). Thus, with initial screening one can identify groups of varying handwriting skill. Here we used the alphabet task (Berninger, Cartwright, Yates, Swanson, & Abbott, 1994) to screen for groups of low, average, and high handwriting skill. The alphabet task has been extensively used as an index of automatic handwriting, in some studies even as a solo measure to screen for children's handwriting skill (e.g., Christensen, 2005).

For this study, we screened 264 fourth graders (9 years old on average) and constituted three handwriting skill groups. The average-skill group was formed by taking the children who fell in the range between half a standard deviation below and half a standard deviation above the mean in the collected sample. The low- and high-skill groups included all children who fell one standard deviation below or above the mean, respectively. The validity of this screening was further expanded by testing if a well-established questionnaire on handwriting proficiency (Rosenblum, 2008), which we adapted to the Portuguese language, would be able to distinguish among the skill groups.

The children in this study were individually tested and asked to write two stories, one by handwriting and another by dictation to a scribe. Dictation has been extensively used to eliminate the transcription demands from written composition (for rationale, see Bereiter & Scardamalia, 1987). In normally achieving children dictating might not have clear benefits over handwriting (McCutchen, 1987; Reece & Cumming, 1996), but in learning-disabled children it is an effective way to circumvent transcription difficulties and improve text quality (De La Paz & Graham, 1997; Graham, 1990; Quinlan, 2004). In this study we were able to test written composition among three groups of differing transcription skills and across two output modalities (handwriting or dictating). Regarding transcription, we predicted that high skill should be associated with larger language bursts and better quality texts. Regarding modality, we predicted an interaction between transcription skill level versus modality (handwriting vs. dictating). Because an advantage in automatic handwriting of girls over boys is commonly reported (Alves, Branco, Pontes, & Castro, 2007; Berninger & Fuller, 1992; Graham & Weintraub, 1996), we also explored possible effects or interactions from gender.

METHOD

Participants

From the initial 264 fourth graders screened, 80 children were selected to participate in this study. On the basis of the described screening procedure, three groups were formed: 32 children of low transcription skill (mean age = 9.38 years; *SD* = 0.75; 10 girls); 27 children of average skill (mean age = 8.89 years; *SD* = 0.32; 14 girls); and 21 children of high skill (mean age = 9.05 years; *SD* = 0.38; 12 girls).

Materials

The alphabet task was adapted from Berninger, Mizokawa, and Bragg (1991). Children wrote the alphabet letters using a pen on an A4 sheet with 1-cm squares, one for each letter.

A Portuguese version of the Handwriting Proficiency Screening Questionnaire (THPQ) (Rosenblum, 2008) was adapted for this study. This 10-item questionnaire addresses issues such as handwriting speed and legibility using a 5-point Likert scale, ranging from "never" to "always." Higher scores in the scale denote less proficiency. The regular teacher of each child completed the questionnaire.

Two sets of cartoonlike pictures were used to elicit the production of written narratives. One of the sets shows a boy going for a walk. He meets a balloon seller and gets a red balloon. He is very pleased and continues strolling. Suddenly, a blast of wind takes the balloon away and the boy breaks into tears. Sadness ends when the balloon seller comes in again and offers the child a new balloon. The other set portrays a boy going to the beach with his family. On the beach, the boy decides to make a sand castle and is very pleased with his constructions. Suddenly, a girl comes running and smashes his castle. The boy gets very sad, but he finally gets through it, as the girl helps him to build a new castle.

The written productions were registered by means of a digitizing tablet (Wacom Intuos 2) connected to a Windows-compatible PC running an E-Prime script (Schneider, Eschman, & Zuccollato, 2002) that logged the handwritten trace. A 15-in screen was used to give written feedback of the orally produced stories.

Procedure

The alphabet task used for screening was administered in groups in the children's classroom during regular class time and required 5 min. The experimenter asked the children to write the lowercase cursive letters of the alphabet as fast as possible, without sacrificing legibility, during 1 min (Berninger et al., 1991). Studies in the United States have commonly asked children for manuscript letters, but here we asked for cursive letters because in Portugal the alphabet is most often taught using that script. One point was attributed for each legible letter written in the proper position within 1 min. Two weeks later, the experimenter returned to the class and asked for the participation of some selected children. One at a time, each child left the class and participated in the study. All children produced two stories, one by handwriting on a digitizing tablet and another by dictating to a typist, with written feedback given through a liquid crystal display (LCD) screen. Providing the child with written feedback while dictating renders the composition mode more similar to the handwriting condition, and it has been shown to have a positive impact on text quality (Reece & Cumming, 1996). The elicitation pictures and production modalities were counterbalanced across the whole group.

On-Line Analyses and Text Quality Measures

The handwritten productions were analyzed by pauses and language bursts. Pauses were defined as periods of handwriting inactivity lasting longer than 2 s, which is a common pause threshold (e.g., Chenoweth & Hayes, 2001; Kaufer et al., 1986; Strömqvist, Holmqvist, Johansson, Karlsson, & Wengelin, 2006). This criterion is sensitive to children's production rates and the involvement of high-level writing processes (Alves et al., 2008; Wengelin, 2006). Language bursts were defined as periods of transcription activity in between two consecutive pauses, in which at least one word was written.

All narratives produced by the children were transcribed into a word processor and then evaluated by two independent judges blind to the objectives and methods of the study. The judges assessed text quality using a 7-point scale on three criteria: formal use of language (compliance with orthographic and grammar rules), creative use of language (expressivity and originality of writing and ideas), and amount of information (detail given on the story characters and situations). A fourth score was computed from the sum of the three scales. Ratings were carried following a procedure used by Levy and Ransdell (1995). Reliable interrater agreements were found for all scales ($r > .70$, all correlations significant at $p < .01$). The two scores provided by the two raters for a text were then averaged.

RESULTS

Screening

As a consequence of the screening procedure the three transcription skill groups reliably differed in the number of alphabet letters they were able to produce per minute [$F(2, 77) = 381.86$, $p < .001$, $\eta_p^2 = .91$] (descriptive measures can be seen in Table 16.1). As expected, the teachers' evaluations of each child's handwriting proficiency (THPQ) were also reliable at the group level [$F(2, 75) = 11.21$, $p < .001$,

TABLE 16.1 Means (and Standard Deviations) of Several On-Line Written Text Production Measures Among Three Handwriting Skill Groups and Across Girls And Boys

	Low Skill		Average Skill		High Skill	
	Girls	Boys	Girls	Boys	Girls	Boys
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Alphabet task	18.70 (5.48)	17.68 (5.47)	38.43 (4.05)	39.46 (4.22)	58.75 (6.51)	59.00 (6.78)
Composition time (min)	7.01 (1.61)	7.55 (2.26)	8.42 (4.18)	7.83 (2.67)	7.86 (1.66)	8.95 (4.15)
Text length (words)	89.50 (23.40)	89.68 (29.80)	112.43 (58.50)	90.38 (27.40)	129.00 (29.40)	119.00 (55.60)
Fluency (wpm)	12.30 (2.31)	11.64 (2.63)	12.79 (2.16)	11.46 (2.50)	16.00 (2.22)	13.33 (3.08)
Number of pauses	21.60 (8.77)	27.36 (8.92)	25.86 (10.14)	26.23 (9.82)	20.83 (6.52)	26.00 (12.33)
Pause duration (seg.)	4.31 (0.77)	4.89 (1.30)	3.96 (0.94)	4.70 (1.55)	4.16 (0.83)	5.80 (3.03)
Burst duration (seg.)	18.70 (7.5)	14.00 (3.75)	17.53 (8.23)	15.86 (6.24)	21.65 (7.83)	16.79 (3.81)
Burst length (words)	5.07 (1.71)	4.00 (1.17)	4.99 (2.39)	4.27 (1.83)	7.34 (3.19)	5.23 (1.45)

wpm, words per minute.

$\eta_p^2 = .23$] and showed a moderate correlation with the alphabet task ($r = .45, p < .01$). Post hoc analyses showed that THPQ was effective in distinguishing the low-skill group ($M = 10.42, SD = 7.77$) from the two others, but did not differentiate between the average- and high-skill groups ($M = 5.11, SD = 3.69$; $M = 3.60, SD = 2.66$, respectively). The screening procedure found some noticeable differences between the groups, namely in age [$F(2, 77) = 6.05, p < .01, \eta_p^2 = .14$] and gender. The low-skill group was slightly older than the average-skill group (Games-Howell, $p < .01$), but not significantly different from the high-skill group (Games-Howell, $p > .05$). The low-skill group had a greater proportion of boys (69%) than would be expected by chance [$\chi^2(1) = 4.5, p < .05$].

Handwritten Production

Table 16.1 shows several on-line text production measures across girls and boys in the three handwriting skill groups. Two-way ANOVAs were conducted, and across groups there were no reliable differences in the amount of time devoted to composition. Even if all groups spent about 8 min composing, the amount of words produced by the three groups differed [$F(2, 74) = 4.68, p < .01, \eta_p^2 = .11$], with the high-skill group producing lengthier texts than the low-skill group (Games-Howell, $p < .01$). It is not only that the children of high handwriting skill wrote longer texts, but also that they were more fluent, as shown by a main effect of skill on compositional fluency [$F(2, 74) = 8.30, p < .001, \eta_p^2 = .18$]. On average, they produced three words per minute (wpm) more than the children of low transcription skill (Scheffé, $p < .01$). This analysis also revealed a main effect of gender [$F(1, 74) = 7.16, p < .01, \eta_p^2 = .09$], showing that girls composed more fluently than boys.

The higher compositional fluency of girls can be further explored by analyzing pauses and bursts. There were no main effects of handwriting skill or gender in the number of pauses. However, boys paused for a significantly longer time than girls [$F(1, 74) = 8.12, p < .01, \eta_p^2 = .10$], and girls had longer [$F(1, 74) = 6.50, p < .01, \eta_p^2 = .08$] and lengthier bursts [$F(1, 74) = 7.74, p < .01, \eta_p^2 = .10$]. On average, girls produced bursts that were 4 s longer and contained one and a half more words than those of the boys.

Although the main effect of handwriting skill on burst duration did not reach significance, there was a main effect of handwriting on burst length [$F(1, 74) = 5.42, p < .01, \eta_p^2 = .13$]. As predicted, Scheffé post hoc analyses showed that children of high handwriting skill had lengthier bursts ($M = 6.44, SD = 2.75$) than children in both the average- ($M = 4.64, SD = 2.13$) and the low-skill handwriting groups ($M = 4.33, SD = 1.42$). No reliable interactions were found in the preceding analyses.

Handwritten Versus Dictated Texts

All children produced two texts (counterbalanced), one by handwriting and the other by dictation. Handwritten texts took longer to produce as evidenced by a main effect of the repeated factor in a 3 (handwriting skill) × 2 (gender) × 2 (dictation vs. handwriting modality) mixed ANOVA [$F(1, 74) = 158.97, p < .001, \eta_p^2 = .68$]. No other effect in this analysis was significant. A similar analysis on text length showed no effect of dictation versus handwriting modality. Only an effect of handwriting skill was reliable [$F(2, 74) = 4.23, p < .05, \eta_p^2 = .10$], indicating that the high handwriting skill group wrote longer texts than the low handwriting skill group (Scheffé, $p < .01$); there were no other significant differences between groups. As expected from the large difference in composition time between dictation and handwriting modalities, composing fluency was far higher in the dictated texts [$F(1, 74) = 296.29, p < .001, \eta_p^2 = .80$]. While dictating, children produced twice as many words per minute than while handwriting ($M = 29.68, SD = 8.36$; $M = 12.74, SD = 2.85$, respectively). No other effect or interaction was observed in this analysis.

All texts were rated by two independent judges, and the means of those evaluations per groups of transcription skill and dictation versus handwriting modality can be seen in Table 16.2. Three-way mixed ANOVAs were computed on the scores of every quality scale and led to similar findings across scales. Thus, only the findings on the overall narrative quality scores are detailed next. There was no significant effect of dictation versus handwriting modality ($F < 1$), the within subjects factor, on quality. Noticeably, the handwritten or dictated texts were judged on similar quality. There was the main effect of handwriting skill [$F(2, 74) = 8.54, p < .001, \eta_p^2 = .19$]. The texts produced by the high-skill group were rated higher than those of the low-skill group (Games-Howell, $p < .001$) and also those of average skill (Games-Howell, $p < .05$). There were no differences in the quality ratings

TABLE 16.2 Means (and Standard Deviations) of Written Text Production Measures and Holistic Ratings of Text Quality Among Three Handwriting Skill Groups and Across Two Dictation and Handwriting Modes

	Low Skill		Average Skill		High Skill	
	Writing	Dictation	Writing	Dictation	Writing	Dictation
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Composition time (min)	7.38 (2.07)	3.46 (2.09)	8.14 (3.48)	3.56 (2.09)	8.33 (2.95)	4.71 (2.86)
Text length (words)	89.62 (27.57)	94.41 (55.26)	101.81 (46.75)	97.59 (56.11)	124.71 (41.67)	127.29 (67.31)
Fluency (wpm)	11.84 (2.52)	29.70 (8.03)	12.15 (2.38)	29.77 (9.74)	14.86 (2.89)	29.52 (7.26)
Formal use of language	1.98 (1.22)	2.27 (0.82)	2.52 (1.51)	2.69 (1.05)	3.31 (1.39)	3.74 (1.41)
Creative use of language	2.14 (1.17)	2.25 (.97)	2.72 (1.64)	2.59 (1.41)	3.57 (1.52)	3.52 (1.81)
Amount of information	2.13 (1.11)	2.38 (1.14)	2.59 (1.54)	2.59 (1.41)	3.52 (1.51)	3.45 (1.84)
Overall quality	6.25 (3.38)	6.89 (2.71)	7.83 (4.54)	7.87 (3.67)	10.40 (4.21)	10.71 (4.99)

wpm, words per minute.

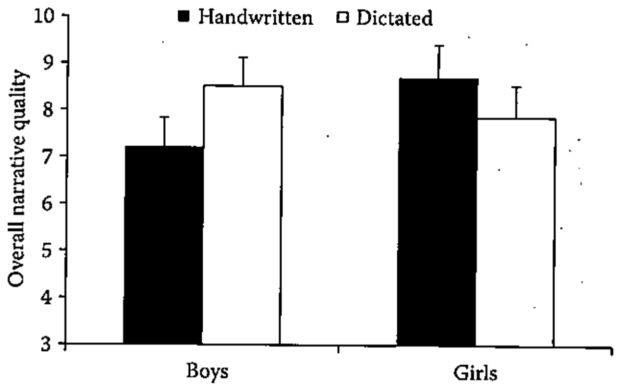

Figure 16.1 Interaction between text production modality and gender found on the overall narrative quality ratings (error bars denote standard errors).

of the low and average handwriting groups (Games-Howell, $p > .05$). This analysis also revealed a significant interaction between gender and dictation-handwriting modality [$F(1, 74) = 4.27$, $p < .05$, $\eta_p^2 = .06$], which can be seen in Figure 16.1. A simple effects analysis of the interaction showed that there were no significant differences between the texts handwritten or dictated by girls ($p > .05$), but when boys dictated the quality of their texts improved [$F(1, 78) = 4.67$, $p < .05$].

DISCUSSION

We assessed fourth graders to test if faster transcription speed would lead to larger language bursts, higher composition fluency, and overall better text quality. Indeed, the results indicate so. It is not new that handwriting speed improves composing fluency and text quality (Berninger, 1999; Graham & Harris, 2000), but, as far as we know, this is the first time that its impact on children's written language burst length is shown. In this study children of high handwriting skill showed larger written language bursts, composed text more fluently, and produced better stories.

That handwriting or typing skills contribute to burst length has also been reported in two studies with undergraduate students (Alves et al., 2007, 2011). Of interest, Hayes and Chenoweth (2006) found that written language bursts were virtually absent when the task required transcription only (typing copy task), whereas we found that when the task required transcription (handwriting) and text generation, handwriting speed was related to written language bursts. Also, the participants in the Hayes and Chenoweth study were selected for their expertise in typing (production rate higher than 40 wpm), whereas we studied good, average, and poor handwriting and not typing. In future research adult and child participants might be selected on the basis of both handwriting and typing skill and given a range of writing tasks from the alphabet (first 15 s, total time, and total legibility), to copying, to sentence writing and sentence combining, and to narrative and essay writing. The manipulation of transcription skill could be achieved experimentally, as in the Alves et al. (2011) study, or assessed for individual differences within a

grade level and developmental differences across grade levels, from elementary to high school to college.

The current results are clear-cut: transcription, as assessed by handwriting skill, contributes to written language burst length in children, just as keyboarding skill did in adults (Alves et al., 2007, 2011). In the current study, the differences in handwriting skill among the groups are reliable, based on the alphabet task, which has been extensively used as an index of transcription efficiency (Christensen, 2005). Furthermore, these differences were validated by the ratings on handwriting proficiency made by the children's teachers. Similar to other studies, children showing lower handwriting proficiency were more likely boys (Graham & Weintraub, 1996) and had consistently lower scores on the Handwriting Proficiency Screening Questionnaire (HPSQ) (Rosenblum, 2008).

We expected that the quality of the texts produced by those with low handwriting skill would benefit from dictation, but this was not the case. Although this interaction was seen in beginning writers and children with learning disabilities (Bereiter & Scardamalia, 1987; MacArthur & Graham, 1987), rarely, as noted by Reece and Cumming (1996), has it been reported in normal-achieving children (see also Hidi & Hildyard, 1983; McCutchen, 1987). In the current study, the low-skill group, as a whole, cannot be described as having severe transcription difficulties, because in most of the relevant measures this group showed similar performances to that of the average group. Clearly in several measures of on-line production and text quality it was the high handwriting skill group that stood apart. We would like to point out that we screened only for handwriting speed, which if very fast and accurate, allows more efficient juggling of writing demands within working memory (McCutchen, 1996; Olive & Kellogg, 2002; Olive, Alves, & Castro, 2009). However, we cannot dismiss the possibility that fast and accurate transcription skill might also be a proxy for other abilities relevant to written composition. Keep in mind that transcription refers to both handwriting or keyboarding and spelling, and this study has not investigated whether automatic handwriting or automatic access to spelling may differentially contribute to the longer language bursts. Future research might explore this issue. Specifically, intervention studies could independently target handwriting (its accuracy or rate) or spelling and measure how each impacts burst length.

In this study, girls were more fluent than boys when using handwriting, but not when dictating. The on-line analysis of their text production revealed how deep this fluency difference runs. Girls showed smaller pauses and larger bursts. Future research could address the source of these larger bursts shown by girls during writing. Although overall girls and boys had similar scores on the alphabet task, boys were overrepresented on the low transcription skill group. Future research should investigate the differences between boys who are low and high in handwriting speed. Low handwriting speed may interfere with integration of transcription and text generation during translation. For example, one could test girls and boys in tasks like lexical decision, speaking span, or writing span (see McCutchen et al., 1994). Girls produced texts of similar quality, irrespective of dictation or handwriting modality, but boys benefited from the removal of transcription demands and produced better texts through dictation than by handwriting. In the absence of a general lower transcription skill in boys, it may be that there are individual differences variables with boys that future research should try to identify. One possibility is that some, but not all, boys have trouble connecting the language by hand system (Berninger, 2000) to their cognitions during translation. Instead of recommending dictation as a preferred way for low-skill boys to compose, they might benefit from appropriate instruction and practice in writing accurate letters automatically. It seems that the more efficient transcription gets, the more resources can readily be devoted to text generation, and the more quickly the hand will fully capture the language briefly held in the mind.

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17

Written Production of Single Words and Simple Sentences

MARK TORRANCE and GUIDO NOTTBUSCH

It is normal practice for authors writing about the writing process to start with introductory remarks about how difficult it is. This perception is, no doubt, partly a reflection of the author's own immediate experience. Writing in general, and writing introductory remarks to academic papers in particular, requires high levels of sustained attention. This processing requirement is captured, for example, in Scardamalia and Bereiter's (1991) argument that, unlike development of expertise in other domains, higher expertise in writing is associated with greater, rather than less, struggle and in the frequent observation that writing makes high demands on cognitive capacity (McCutchen, 1996). Implicit within these "writing-is-difficult" arguments is a contrast with spoken language production, which seems often to proceed automatically and with relatively little need for focused attention.

Where does this writing difficulty come from? There are, broadly, two sets of processes associated with the production of coherent text. First, there is the conceptual processing required in deciding what is to be communicated. This requirement takes the writer from a general communicational goal—an intention to affect the reader's understanding in a particular way—to the intention to communicate a particular proposition in the next clause or sentence. It is these conceptual processes that were the focus of early cognitive accounts of written production (Hayes & Flower, 1980a). Conceptual processing is, at least sometimes, explicit and deliberate. This makes it accessible to the methods used in research examining complex information processing in other domains and particularly the solving of toy problems (Tower of Hanoi, the Water Jug Problem, etc.): Hayes and Flower (1980a, 1980b) explicitly identified writing as analogous to problem solving in other nonlinguistic contexts.

A second set of processes takes the output from conceptual processing—the writer's intended message—and adds the necessary lexical, syntactic, and