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Modeling Writing Development: Contribution of Transcription and Self-Regulation to Portuguese Students' Text Generation Quality

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Abstract

Writing is a complex activity that requires transcription and self-regulation. We used multiple-group structural equation modeling to test the contribution of transcription (handwriting and spelling), planning, revision, and self-efficacy to writing quality at two developmental points (Grades 4-6 vs. 7-9). In Grades 4-6, the model explained 76% of the variance in writing quality, and transcription contributed directly to text generation. This finding suggests that, for younger students, handwriting and spelling were the strongest constraints to text generation. In Grades 7-9, the model explained 82% of the variance in writing quality. Although transcription did not contribute directly to text generation, it contributed indirectly through planning and self-efficacy. The progressive automatization of transcription throughout school years may contribute to the acquisition and development of self-regulatory skills, which, in turn, positively influence the quality of text generation. Explicit instruction and practice in handwriting, spelling, planning, and revising along with nurturing of realistic self-efficacy beliefs may facilitate writing development beyond primary years of schooling.

Keywords: writing development, transcription, planning, revision, self-efficacy

Modeling Writing Development: Contribution of Transcription and Self-Regulation to Portuguese Students' Text Generation Quality

From a cognitive perspective, writing is a complex and costly skill that places multiple demands on the writer (Hayes, 1996). Writing is such a complex and demanding activity that it generally takes more than two decades to achieve writing expertise (Kellogg, 2008). Berninger and colleagues have argued that both the simple view of writing proposed by Juel, Griffith, and Gough (1986; Juel, 1988), and the not-so-simple view of writing (Berninger & Winn, 2006; see also Berninger & Chanquoy, 2012) contribute to better understand the writing processes and how they may change over development. In the not-so-simple model, text generation is supported by the collaboration between transcription (handwriting and spelling) and high-level cognitive skills for self-regulation, such as planning and revising. During writing, the interaction among these processes occurs within working memory constraints. In a notable review, Graham and Harris (2000) also concluded that writing development depends on the automatization of transcription and the acquisition of high levels of self-regulation.

The present study aims to contribute to extant research on writing development by focusing on the role of transcription and self-regulation skills in writing. Although considerable research has shown that these skills influence writing quality, little is known about their relative contribution to text generation throughout schooling. Moreover, studies have been yielding contradictory findings regarding the relationships between transcription and self-regulation and their contribution to written composition from a developmental perspective. The current study was therefore designed to examine the relationships among transcription, self-regulation, and text generation, and to directly compare them at two developmental points (Grades 4-6: age 9-12 vs. Grades 7-9: age 12-15, with about 60 children per grade level). To our knowledge, no such large and comprehensive assessment study, using multiple-group structural equation modeling, has investigated the joint development of these critical writing skills across six years of schooling.

Transcription Predicts Writing Quality

Transcription refers to the transformation of language representations in working memory into written text (Berninger, 1999; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997). This requires the retrieval of orthographic symbols and the execution of fine-motor movements for producing them (Abbott & Berninger, 1993). Thus, transcription involves spelling and handwriting.

This low-level writing skill was under-recognized for years (Medwell & Wray, 2008) because it was assumed that it did not interfere with text quality in typically developing children beyond primary grades (Scardamalia, Bereiter, & Goleman, 1982). Nevertheless, during the last two decades, writing research has been accumulating evidence about the impact of transcription in the quality of texts produced by children and adolescents, with and without disabilities (Connelly, Gee, & Walsh, 2007; De La Paz & Graham, 1995; Graham, 1990; MacArthur & Graham, 1987; Reece & Cumming, 1996). Graham et al. (1997; see also Graham & Harris, 2000) reviewed several correlational studies and concluded that transcription was moderately correlated with text quality. However, this finding should be read carefully as, in the majority of these studies, spelling and handwriting bias were not removed from text quality scoring. This is problematic because it was observed that poor spelling and penmanship have a negative impact on holistic assessments of text quality (Berninger & Swanson, 1994). In the studies reviewed next, this methodological limitation was address by setting apart transcription skills from quality assessments.

Regarding spelling, Juel (1988) found that, in Grade 1, 29% of the variance in writing quality was explained by spelling skills, but in Grade 4 the explained variance dropped to 10%. In a 5-year longitudinal study (Grades 1-7), Abbott, Berninger, and Fayol (2010) found that spelling was the most consistent predictor of composing across adjacent grades ($.25 < \beta < .67$). Using structural equation modeling with multiple measures of each construct, Graham et al. (1997) showed that handwriting fluency contributed to writing quality in Grades 1-3 ($\beta = .53$) as much as in Grades 4-6 ($\beta = .67$). Alves and Jesus (2011) found significant correlations between handwriting fluency and writing quality in Grade 2 ($r = .36$), but not in Grades 1, 3, and 4. Christensen (2004) found moderate correlations with a sample of older students (Grades 8-9; $r = .44$). Generally, these studies

have shown that writing quality is influenced by writers' transcription skills, even though results are mixed concerning the developmental pattern of this relationship. This might be due in part to whether single or multiple measures were used to assess handwriting fluency, spelling, and compositional quality, and also to whether cross-sectional or longitudinal research designs were used.

Berninger and colleagues conducted a comprehensive cross-sectional study collecting multiple transcription and text generation measures from Grade 1 to 9 (for reviews see Berninger & Swanson, 1994; Berninger, 1999). They found that in Grades 1-3 (age 6-9) and Grades 4-6 (age 9-12), respectively, 25% and 42% of the variance in compositional quality was explained by transcription (see also Graham et al., 1997). It is noteworthy that the explained variance in writing quality by transcription dropped to 18% in Grades 7-9 (age 12-15). Although this decrease was not statistically tested, it was suggested that students became more proficient in transcription and these processes may have exerted less constrain on text generation (Berninger, 1999).

Self-Regulation Predicts Writing Quality

Self-regulation is critical in writing as it enables writers to attain their literary goals through the use of strategies employed before, during, and after writing (Zeidner, Boekaerts, & Pintrich, 2000). Zimmerman and Risemberg (1997) proposed three kinds of self-regulatory strategies involved in the deliberate management of the composing process: (a) environmental strategies entail the self-regulation of the physical or social setting where writing takes place; (b) behavioral strategies comprise writing-related motoric activities, and (c) personal strategies encompass cognitive and affective processes that writers use to increase their effectiveness. Two of the most important cognitive self-regulatory strategies for organizing, producing, and transforming written text are planning and revising (Graham & Harris, 2000; Harris, Santangelo, & Graham, 2010; Zimmerman & Risemberg, 1997).

Planning involves setting goals, generating, and organizing ideas (Hayes & Flower, 1980). As it can occur before or during writing, a distinction was made between advanced and online

planning (Berninger & Swanson, 1994). Several correlational studies have analysed how students' ability to generate a plan before writing is related to their writing performance. In the studies reviewed below, preplanning skills were assessed through the complexity of students' written plans. Generally, outlines and graphic organizers are considered as the most sophisticated form of preplanning (see Hayes & Nash, 1996 for a review on planning measures).

In Grades 2 and 4, it was found that students' plans did not predict writing quality (Olinghouse & Graham, 2009). Likewise, in Grades 4-6, preplanning skills were not related to compositional quality (Whitaker, Berninger, Johnston, & Swanson, 1994). Only in Grades 7-9, positive but weak correlations were found between preplanning and writing quality ($r > .17$; Berninger, Whitaker, Feng, Swanson, & Abbott, 1996). As younger students' written plans were very similar to their texts, it was suggested that they were not differentiating planning from translating (Bereiter & Scardamalia, 1987; Berninger & Swanson, 1994; McCutchen, 2006). Moreover, it was found that only 15% of sixth graders engaged in outlining before writing (Torrance, Fidalgo, & García, 2007). This value increased to 33% in a similar study with eight graders (Fidalgo, Torrance, & García, 2008).

Concerning revision, there is general agreement that at least it includes two key-processes: problem detection, which includes schema-guided reading and text evaluation, and problem correction, which involves the selection of a revising strategy and its implementation (Chanquoy, 2009; Fitzgerald, 1987). Whether the revising strategy operates at the surface or meaning level, it can be classified as editing or rewriting (Allal, Chanquoy, & Largy, 2004). In a similar way to preplanning, revision is hardly included in the composition process of novice writers (Fitzgerald & Markham, 1987; McCutchen, 2006). Although ability to revise emerged in Grades 4-6 in a sample studied by Whitaker et al. (1994), it only operated at all levels of language (i.e., word, sentence, and text) in Grades 7-9 (Berninger et al., 1996). Young writers' revisions seem also to have a very limited impact on text quality (Graham, Harris, MacArthur, & Schwartz, 1991) – probably because younger students tended to focus their revisions on surface problems, whereas older writers focused

on meaning problems (Graham, Schwartz, & MacArthur, 1993; Harris et al., 2010; MacArthur & Graham, 1987).

Intervention studies have provided strong support for the association between planning and revision with writing quality. Meta-analyses have shown that students from Grades 2 to 12 wrote better texts after receiving instruction in planning and/or revision (Graham, McKeown, Kiuhara, & Harris, 2012; Graham & Perin, 2007). Importantly, writing quality increased when these strategies were taught in tandem with other self-regulatory strategies (Brunstein & Glaser, 2011; Glaser & Brunstein, 2007; for a review see Harris & Graham, 2009). Examining the underlying mechanisms of a successful self-regulation-based intervention, Brunstein and Glaser (2011) found that it had a positive impact on text quality by promoting planning and revising. Of great import, they showed that the intervention was associated with an increase in students' writing knowledge and self-efficacy.

Writers' beliefs about their writing ability are a main component of self-regulation (Zimmerman, 1995). Self-efficacy depends on the effectiveness of the self-regulatory strategies employed and influences their persistent use in writing (Zimmerman & Risemberg, 1997). For instance, if writers attain their goals by planning or revising, their self-efficacy increases and they continue using these strategies (Schunk & Ertmer, 2000). Consequently, writing performance is enhanced (for reviews see Klassen, 2002a; Pajares, 2003). Indeed, at different school levels, self-efficacy predicted writing quality above and beyond previous performance (effect sizes ranged from .19 to .40; Pajares, Miller, & Johnson, 1999; Pajares & Valiante, 1997, 1999). Analyzing the development of writing self-efficacy, Pajares, Valiante, and Cheong (2007) found a decrease from Grade 4 to 8. Despite the expectation that an increase in competence across schooling would be accompanied by an increase in self-efficacy, this pattern was not verified. Possibly, younger students may overestimate their writing skills, as some students with learning disabilities tend to do (Klassen, 2002a, 2002b).

Transcription Competes with Self-Regulation

Low-level transcription and high-level self-regulation processes impose heavy demands on the limited capacity of working memory. Vanderberg and Swanson (2007) showed that the central executive significantly predicted planning, translating, and revising, as well as vocabulary, punctuation, text structure, and grammar (beta weights ranged from .21 to .32). As transcription and self-regulation compete for the same pool of attentional resources, these processes must be juggled to manage cognitive load (Alamargot, Plane, Lambert, & Chesnet, 2010; Berninger, 1999; Fayol, 1999; Kellogg, 1996; McCutchen, 1996).

Beginning writers, who adopt the so-called knowledge telling strategy for composing, do not show this coordination (Bereiter & Scardamalia, 1987). Bourdin and Fayol (1994, 2000) showed that as transcription is a large resource drain, it constrains the acquisition and use of high-level writing skills (see also Alves, Branco, Castro, & Olive, 2012; Grabowski, 2010; Olive & Kellogg, 2002). This may explain, first, why young writers' barely plan or revise spontaneously and, second, why their planning and revising skills are not sufficiently developed to influence text production. However, in the course of the school years, transcription becomes more efficient, reducing the cognitive effort required (Kellogg, 2008; McCutchen, 1988; Olive, Favart, Beauvais, & Beauvais, 2009). In line with a capacity theory of writing, this gradual automatization enables writers to use their spare attentional resources for high-level processes (Fayol, 1999; McCutchen, 1996). This shift of cognitive resources allocation may set the basis for the more elaborated composing strategy of knowledge-transforming (Bereiter & Scardamalia, 1987). Transcription stops being a major source of constraint, leading to the development and successful employment of planning and revising strategies in writing.

Regarding writing self-efficacy, little is known about how it is influenced by transcription processes, which are crucial in developing writing. Given that young writers consider writing transcription features as the most important ingredients in good writing (Graham et al., 1993; Lin, Monroe, & Troia, 2007; Olinghouse & Graham, 2009), it seems likely that they may use observable information, such as the length of their texts or the number of spelling errors, to appraise their

writing ability. Indeed, one of the most influential sources of self-efficacy is students' interpretation of their own performances (Bandura, 1997).

Overview of the Current Study

Multiple-group structural equation modeling was used to examine the development of writing throughout school years. In particular, we aimed to analyze: (a) the relationship between transcription (handwriting and spelling), planning, revision, self-efficacy, and the quality of text generation (story and opinion essay), and (b) if the strength of this relationship changes over time. For that, we tested the model depicted in Figure 1 at Grades 4-6 (age 9-12) and 7-9 (age 12-15). Although the proposed paths were based on the multiple sources of evidence reviewed above, to the best of our knowledge, no such model was previously tested across development.

Figure 1 about here

In Grades 4-6 we predicted a direct effect of transcription on text generation quality, but in Grades 7-9 we predicted an indirect effect of transcription on text generation via planning and revision. As younger students have not mastered transcription yet, text generation was expected to be largely constrained by it (Graham et al., 1997). A different pattern was expected in older students when transcription becomes automatized and should exert less constraint on text generation (Berninger, 1999; Berninger & Swanson, 1994; Kellogg, 2008). This increased transcription fluency may enable them to develop their planning and revising abilities (Bereiter & Scardamalia, 1987; Fayol, 1999; McCutchen, 1996), which in turn may influence writing quality (Graham & Harris, 2000). As in Grades 7-9 (Berninger et al., 1996), but not in Grades 4-6 (Whitaker et al., 1994), planning and revising were found to be correlated, albeit weakly (*r*s = .25), we expected a stronger effect from planning to revision in older than younger writers.

The hypotheses regarding the paths from transcription, planning, and revising to self-efficacy were as follows. In Grades 4-6, we predicted that self-efficacy would be influenced by transcription. This prediction stems not only from the critical role that transcription has on younger

students' writing (Berninger, 1999) but also from their emphasis on production factors when defining good writing (Olinghouse & Graham, 2009). In Grades 7-9, we predicted that self-efficacy would be influenced by planning and revising because self-efficacy depends on the effectiveness of the self-regulatory strategies (Zimmerman & Risemberg, 1997). Older students not only use them successfully (Berninger et al., 1996) but also acknowledge their importance in writing (Graham et al., 1993). Finally, we hypothesized that self-efficacy would influence text generation at both grade levels. Research findings have shown that self-efficacy predicts writing performance throughout schooling (Pajares, 2003).

Method

Participants

Participants were 419 Portuguese native speakers in Grades 4-9. Forty three students were excluded from the analyses based on one or more of the following criteria: absence in one of the two administration sessions (17 students), task instructions not followed (22 students), special education needs (five students), and incomplete tasks (six students). Subsequent analyses were based on the data from 376 students.

Younger sample. This sample included 171 students in Grades 4-6 (57 fourth graders, M_{age} = 10.0 years, *SD* = 0.3, age range = 9.4–11.0; 49 fifth graders, M_{age} = 11.0 years, *SD* = 0.6, age range = 10.4–13.0; 65 sixth graders, M_{age} = 12.1 years, *SD* = 0.5, age range = 11.4–14.0; for the all sample: M_{age} = 11.1 years, *SD* = 1.0; 92 girls and 79 boys). Students' socioeconomic status was assessed through the educational level of their parents. Respectively, mother and father's educational level was as follows: 18% and 23% completed Grade 4 or less; 45% and 53% completed Grade 9 or less; 19% and 13% completed high school; 16% and 7% completed college or college plus some postgraduate study; and 2% and 4% was unknown. In 2011, Portuguese national statistics regarding females and males' educational level is as follows: 24% and 27% completed Grade 4 or less; 30% and 38% completed Grade 9 or less; 17% and 17% completed high school; 15% and 11% completed college or college plus some postgraduate study, and 14% and 7%

was unknown (Fundação Francisco Manuel dos Santos, 2012). Student's achievement was assessed via their previous marks for Portuguese, Mathematics and History. Their marks are given in a scale ranging from 1 (lowest score) to 5 (highest score). Taken all subjects together, 14% to 19% had marks below 3; 36% to 46% had marks equal 3; and 35% to 50% had marks above 3.

Older sample. This sample included 205 students in Grades 7-9 (69 seventh graders, M_{age} = 13.0 years, SD = 0.4, age range = 11.9–14.4; 61 eighth graders, M_{age} = 13.9 years, SD = 0.4, age range = 12.7–15.3; 75 ninth graders, M_{age} = 15.0 years, SD = 0.5, age range = 14.4–16.8; for the all sample: M_{age} = 14.0 years, SD = 0.9; 97 girls and 108 boys). Respectively, mother and father's educational level was as follows: 13% and 14% completed Grade 4 or less; 45% and 48% completed Grade 9 or less; 20% and 17% completed high school; 20% and 17% completed college or college plus some postgraduate study; and 2% and 4% was unknown. Regarding students' achievement, taken Portuguese, Mathematics and History together, 8% to 26% had marks below 3; 49% to 53% had marks equal 3; and 25% to 39% had marks above 3.

Setting

Students came from 19 classes integrated in a public cluster of schools located in an urban district in Northwest Portugal. In Portugal, Basic Education lasts 9 years and comprises three stages: Grades 1-4 (age 6-10), Grades 5-6 (age 10-12), and Grades 7-9 (age 12-15). Stage 1 is provided in primary schools and only one teacher is responsible for teaching four main courses; Stage 2 is provided in basic schools and children have one teacher for each of the nine courses; finally, Stage 3 is provided in basic or secondary schools and students have eleven courses taught by different teachers.

Regarding the teaching of writing in Portugal, two key shifts occurred in the past two decades (Álvares Pereira, Aleixo, Cardoso, & Graça, 2010). First, writing was assumed as a specific teaching object since its importance in students and professionals' lives was recognized. Second, there was a shift from a product to a process approach to writing, which provides explicit teaching on how planning, translating, and revising processes can be carried out in text production. Although

writing is the preferred learning and assessment tool across courses and schooling, explicit writing instruction only occurs in Portuguese Language classes.

Handwriting Fluency Measures

Alphabet task. Students were asked to write the alphabet in lowercase as quickly as possible without making mistakes (Berninger et al., 1992). The experimenter told them to stop 15 s after they had started writing the alphabet. The final score was the number of correct letters written. A letter was counted when it was legible out-of-context and in the right alphabetical order.

Copy task. Students were asked to copy a 60-word paragraph as quickly as possible without making mistakes. After 90 s copying it, the experimenter told them to stop. The final score was the number of words copied accurately. A word was considered correct when its letters and diacritics were clearly copied without any mistake.

Spelling Measures

Spontaneous spelling. A measure of spelling in a functional communicative context was provided by the percentage of words spelled correctly in the story and in the opinion essay.

Dictated spelling. Forty words were dictated at intervals of 6 s. These words belong to five categories representing some complexities of the Portuguese spelling system: silent letter *h*, contextual effect, position effect, inconsistency, and consonantal group (for greater detail see Carvalhais & Castro, 2012). The final score was the total number of words spelled correctly.

Planning Measures

The experimenter gave students a green sheet and explained to them that before writing the text they would have 3 min to plan it. They were told to use that sheet as their "think pad" and to write down everything that could help them to write the text (for a similar procedure see Berninger et al., 1996). The developmental maturity of students' planning behavior was measured with a scale ranging from 1 (*low*) to 6 (*high*). The scores 1 and 2 were attributed to plans that represent no preplanning and minimal preplanning, respectively. Plans summarizing the text received a score of 3, and plans with topics slightly elaborated in the text received a score of 4. The scores 5 and 6 were

attributed to plans with emergent subordination (i.e., rudimentary macrostructure) and structural relationships (e.g., graphic organizers), respectively. This scoring scale is non-genre dependent and was based on the scales developed by Whitaker et al. (1994), and Olinghouse and Graham (2009). Participants made one plan for the story and another for the opinion essay and both measures were considered.

Revision Measures

To measure students' revising skills, they were asked to revise a narrative text, which had two meaning errors of three kinds created by missing, inconsistent, and out-of-sequence sentences. As younger students seem to have problems in detecting errors (Beal, 1990), which is necessary for their correction, the task was performed in two phases. First, students were asked to mark "anything that it is not right or does not sound good". Second, the experimenter gave them the same text with the target errors marked and asked students to correct them. Respectively, the final scores were the total number of errors accurately detected (revision-detection) and corrected (revision-correction).

Self-Efficacy Measure

To measure self-efficacy beliefs, students filled out the Writing Skills Self-Efficacy scale (Pajares & Valiante, 1999) that we adapted to the Portuguese language. The scale has 10 items, which measure students' confidence about being able to accomplish specific writing skills (e.g., *Correctly spell all words in a one-page story or composition*). The answers were given in a scale ranging from 0 (*no chance*) to 100 (*completely certain*). As suggested by Pajares (2003), the self-efficacy assessment must be matched to and in close temporal proximity with the writing outcome. Accordingly, after the text topic was presented, students were asked to judge their confidence in accomplishing those skills when writing about that topic. Thus, two measures of self-efficacy were collected: story self-efficacy ($\alpha_{4\text{-}6} = .93$; $\alpha_{7\text{-}9} = .94$) and opinion essay self-efficacy ($\alpha_{4\text{-}6} = .94$; $\alpha_{7\text{-}9} = .94$). Because multicollinearity between these two measures ($r_{4\text{-}6} = .81$; $r_{7\text{-}9} = .87$) could create estimation and inference problems, as suggested by Kline (2005), they were averaged to form a composite score (viz., self-efficacy).

Text Generation Measures

Text generation was assessed through the quality of a story (Tell a story about a child who lost his/her pet) and an opinion essay (Do you think teachers should give students homework every day?). To control for potential effects of genre difficulty on subsequent tasks, writing order for genre was counterbalanced. Students had 8 min to write the text and they were notified 4 and 2 min before the end of the time limit. Anytime a student stopped writing he/she was prompted once to continue.

Four graduate students, blind to study purposes, rated the overall text quality using a scale ranging from 1 (*low quality*) to 7 (*high quality*). To control for expected differences between grade levels, one pair of judges rated the texts from Grades 4-6, and the other pair rated the texts from Grades 7-9. Raters were told to consider and give the same weight to the following factors: ideas quality (i.e., originality and relevance of the ideas), organization (i.e., coherence and organization of the text), sentence structure (i.e., syntactic correctness and diversity of the sentences), and vocabulary (i.e., diversity, interest, and proper use of the words). To avoid biased judgments all texts were previously typed and corrected for spelling, punctuation, and capitalization errors. For each text genre, the scores were the average for the two judges.

Measures Reliability

At each grade level, a second judge rescored the written products for 20% of the students. For the alphabet and copy task, story and opinion essay spelling, dictated spelling, story and opinion essay planning, and error detection and correction tasks, inter-rater reliability (Pearson's coefficient) was .98, 1.00, .99, .99, 1.00, .89, .89, 1.00 and 1.00, respectively. For story and opinion essay quality evaluation, inter-rater reliability was, respectively, .79 and .84 for Grades 4-6, and .85 and .83 for Grades 7-9.

Procedure

Classroom groups with 20-25 students performed the tasks that were distributed between two 45-min sessions during the month of May (end of Portuguese academic year). Both sessions

started with the presentation of the text topics. Then, students filled out the self-efficacy scale about the presented genre. After that, they planned and wrote the text. Lastly, students performed the spelling and revision tasks in the first session, and the copy and alphabet tasks in the second one. Two adults were always present in the room to guarantee that experimental procedures were carried out as intended.

Results

Preliminary Data Analysis

Descriptive statistics for the observed variables for Grades 4-6 and 7-9 are displayed in Table 1. The inspection of the skewness and kurtosis of all variables revealed no distributional problems, as the absolute values of these indexes did not exceed 3.0 and 10.0, respectively (Kline, 2005). Table 2 presents the intercorrelations among all study variables by grade group. Generally, correlations were positive and modest in size, with a similar pattern for both samples.

Table 1 and 2 about here

Structural Equation Modeling

Figure 1 depicts the model that was tested against data from two groups: Grades 4-6 vs. Grades 7-9. Multiple-group structural equation modeling was used to evaluate model invariance across both groups. To test the hypotheses that the relationships among latent constructs were different across samples, data analyses encompassed a series of hierarchical steps (Byrne, 2010; Kline, 2005). First, we tested if the model fit the data of both grade groups, separately. For that, single-group analyses were conducted to establish a baseline model for each group (baseline model). Second, we tested if this model fit the data of the two groups, simultaneously. For that, the parameters estimated in the baseline model were estimated in a multiple-group model, with no restrictions on its parameters (configural model). Third, we tested if the path coefficients between latent variables and indicators were equivalent. For that, factor loadings were constrained to be equal across groups (measurement model). Fourth, we examined whether factor structure was

consistent across grade groups. To test structural invariance, equality constrains on structural paths were introduced in a stepwise fashion (structural model).

To evaluate fit of the models we used the chi-square statistic (χ^2), the confirmatory fit index (CFI) and the root-mean-square error of approximation (RMSEA). CFI values greater than .95 and .90, and RMSEA values less than .06 and .10 are considered good and adequate fits, respectively (Hu & Bentler, 1999). As suggested by Byrne (2010), we used the χ^2 and CFI difference tests to test for group invariance. Evidence of noninvariance is claimed when $\Delta\chi^2$ is statistically significant and ΔCFI is greater than or equal to .01 (Chen, 2007; Cheung & Rensvold, 2002).

Before model evaluation, latent variables were scaled by imposing unit of loading identification constraints (Kline, 2005). The unstandardized coefficients of the alphabet task, opinion essay spelling, opinion essay planning, revision-detection, self-efficacy, and opinion essay quality on the respective factors were fixed to 1.0. Only the variance of the Transcription factor was constrained to equal 1.0, so that the second-order factor loadings were freely estimated.

Baseline models. The first evaluation of the model revealed an adequate fit to the data for the younger sample, $\chi^2(43, N = 171) = 79.02$, $p = .001$, CFI = .93, RMSEA = .07, $P(\text{rmsea} \leq .05) = .09$, and a very good fit for the older sample, $\chi^2(43, N = 205) = 43.64$, $p = .44$, CFI = .99, RMSEA = .01, $P(\text{rmsea} \leq .05) = .96$. An analysis of the modification indices (MIs) revealed a problem in the model regarding the dictated spelling indicator. In Grades 4-6, MIs for the regression weights revealed two parameters with MIs greater than 6.0, which represented the cross-loadings of dictated spelling on the Revision and Text Generation factors. Because there was no strong theoretical basis to specify these additional parameters, and given that the Spelling factor already had two other indicators, we decided to remove the dictated spelling indicator. Also, to produce the most parsimonious model, the non-significant paths for both groups were deleted (viz., Planning → Revision, Planning → Self-efficacy, and Revision → Self-Efficacy). As the effect of revision on text generation was marginally significant in both samples (ps > .08), we decided not to remove it. After this respecification, the final model provided a good fit to the data for Grades 4-6, $\chi^2(36, N =$

171) = 52.56, p = .04, CFI = .95, RMSEA = .05, P(rmsea≤.05) = .43, and a very good fit to the data for Grades 7-9, χ^2(36, N = 205) = 29.36, p = .77, CFI = 1.00, RMSEA < .001, P(rmsea≤.05) = .99. Table 3 presents standardized and unstandardized regression coefficients for both samples. Although only story planning in Grades 4-6 had a marginally significant factor loading (p = .06), all standardized factor loadings ranged from moderate to strong ($range_{4\text{-}6}$ = .46–.99; $range_{7\text{-}9}$ = .54–.99) indicating that the observed variables were good indicators of the latent constructs.

Transcription, planning, revision, and self-efficacy accounted for 76% and 82% of the variance in text generation quality, respectively, in Grades 4-6 and 7-9. Considering the structural part of the model, the effects of transcription on planning (T→P), revision (T→R), and self-efficacy (T→SE) were significant in Grades 4-6 ($\beta_{T\rightarrow P}$ = .33, p = .006; $\beta_{T\rightarrow R}$ = .57, p < .001; $\beta_{T\rightarrow SE}$ = .39, p < .001) and in Grades 7-9 ($\beta_{T\rightarrow P}$ = .39, p < .001; $\beta_{T\rightarrow R}$ = .58, p < .001; $\beta_{T\rightarrow SE}$ = .69, p < .001). The effect of transcription on text generation (T→TG) was significant in Grades 4-6 ($\beta_{T\rightarrow TG}$ = .60, p = .01), but it was not in Grades 7-9 ($\beta_{T\rightarrow TG}$ = .26, p = .23). To examine the indirect effects of transcription on text generation via planning (T→P→TG), revision (T→R→TG), and self-efficacy (T→SE→TG), we used modified Sobel tests (Sobel, 1982). The indirect effects mediated by planning and self-efficacy were significant in Grades 7-9 ($\beta_{T\rightarrow P\rightarrow TG}$ = .15, Sobel z = 2.55, p = .01; $\beta_{T\rightarrow SE\rightarrow TG}$ = .21, Sobel z = 2.05, p = .04), but they were not in Grades 4-6 ($\beta_{T\rightarrow P\rightarrow TG}$ = .03, Sobel z = 0.69, p = .49; $\beta_{T\rightarrow SE\rightarrow TG}$ = .03, Sobel z = 0.66, p = .51). The indirect effect of transcription on text generation via revision was significant in neither group (ps > .10). These results suggest that, for younger students, transcription contributes directly to text generation, but, for older students, transcription contributes indirectly to text generation, through planning and self-efficacy. As the baseline model was very good for both groups, invariance evaluation was conducted to analyze grade-group differences (see Table 4 for goodness-of-fit statistics).

Table 3 and 4 about here

Configural model. As the multiple-group model fitted the data very well, $\chi^2(72, N = 376) = 81.93$, $p = .20$, CFI = .99, RMSEA = .02, $P(\text{rmsea} \leq .05) = .99$, we proceeded with invariance testing.

Measurement model. The model with constrained factor loadings showed no decrement in fit, $\chi^2(77, N = 376) = 86.58$, $p < .21$, CFI = .99, RMSEA = .02, $P(\text{rmsea} \leq .05) = 1.00$, with χ^2 and CFI difference tests supporting noninvariance. Thus, there were no differences in factor loadings between Grades 4-6 and 7-9, indicating that the measures had the same meaning for both groups. After establishing measurement invariance, structural differences were examined.

Structural model. There was a decrement in fit when factor loadings and structural paths were constrained to be equal across groups, $\chi^2(86, N = 376) = 102.91$, $p < .10$, CFI = .98, RMSEA = .02, $P(\text{rmsea} \leq .05) = .99$. As the χ^2 difference test was marginally significant, and the CFI difference test supported noninvariance, we went further in the analysis to determine noninvariant paths. A stepwise procedure was used, in which only invariant paths were hold. Firstly, we constrained the paths from transcription to handwriting and spelling. Secondly, we constrained the significant paths in both samples, namely, those from transcription to planning, revision, and self-efficacy. Thirdly, we constrained the path from revision to text generation. In all of these three steps, difference tests supported noninvariance. Finally, when we constrained the paths from planning, self-efficacy, or transcription on text generation, the fit of the model declined significantly, $\Delta\chi^2(1) > 4.36$, ps $< .05$; ΔCFI = .01. These analyses indicated that these three paths differed significantly between grade groups. Transcription contributed more to text generation quality in Grades 4-6, while planning and self-efficacy contributed more to text generation quality in Grades 7-9.

Discussion

Significance of Findings

The findings of the present study are in line with the not-so-simple view of writing (Berninger & Winn, 2006) by showing that transcription and self-regulation, specifically, planning, revision, and self-efficacy are crucial for text generation in developing writing. The analyses indicated that the model under test was a very good description of the data for both Grades 4-6 and

7-9. Moreover, the measurement part of the model was similar across grade groups showing that the constructs had the same meaning for both groups. Notably, we showed that these skills explained 76% and 82% of the variance in writing quality in Grades 4-6 and 7-9, respectively. Of interest, we found some differences between these two groups regarding the relationship between transcription, planning, revision, self-efficacy, and text generation.

In line with our hypothesis, transcription constrained text generation in Grades 4-6 but not in Grades 7-9. This result agrees with Berninger (1999) who showed that the explained variance in writing quality by transcription decreased from Grades 4-6 to 7-9. The direct contribution of low-level skills to writing quality in younger students might reflect a lack of automaticity in transcription (Graham et al., 1997). Because developing writers struggle with the orthographic-motor and orthographic-linguistic components of writing, these components are likely to interfere with the quality of their written texts (Berninger, 1999; Bourdin & Fayol, 1994; Olive & Kellogg, 2002). This was not the case for the older sample, in which transcription had no direct effect on writing quality. A reasonable explanation is that older students' handwriting and spelling skills were sufficiently automatized to directly constrain text generation. This is not to say that these low-level skills are no longer important. On the contrary, a main result from the present study was that transcription continued to exert its influence on writing quality after Grades 4-6, but indirectly, through its impact on planning and self-efficacy.

Consistent with our predictions, older students' transcription skills contributed indirectly to text generation via planning. Still, when we scrutinized this effect, the hypothesis was only partially confirmed because transcription contributed to text generation in Grades 7-9 as much as in Grades 4-6. Thus, in both groups, the greater the transcription fluency, the better their planning skills were. Nevertheless, while these more developed planning skills were associated to better texts in Grades 7-9, they were not in Grades 4-6. Possibly, younger students lack either sufficient planning abilities or the knowledge to appropriately use them in writing (Englert, Raphael, Fear, & Anderson, 1988;

Lin et al., 2007). All in all, whereas preplanning might emerge in Grades 4-6, it only seems to be sufficiently developed to be used for the benefit of text production in Grades 7-9.

Regarding self-efficacy, we found that it was influenced by transcription not only in Grades 4-6 but also in Grades 7-9. This indicates that even older students may rely on their handwriting and spelling abilities to gauge their own sense of confidence. Nonetheless, while self-efficacy influenced older students' writing quality, it did not in the younger sample. It is possible that young writers were not able to translate their perceived self-efficacy into corresponding performance. Students might have lacked the necessary knowledge and skills to proactively adjust their writing behavior to their appraisals of personal capabilities (Bandura, 1997). Although this explanation assumes that students' self-efficacy judgments were accurate, this could have not been the case. Indeed, given that self-efficacy influence task choice, expended effort, perseverance, and emotional reactions, faulty self-judgments could also explain why novice writers' writing performance was unrelated to self-efficacy.

Of concern were the results about revision, which were similar across grade groups. Although students' transcription fluency predicted students' skills to revise meaning errors, these skills were not related to writing quality. This latter result might be explained differently according to grade group. It is possible that younger students lacked sufficient revising skills. By contrast, it might be that older students, albeit being in the possession of those skills, did not use them to increase the quality of their writing. It could be argued that students did not have enough time to employ their revising skills in an 8-min writing task. This was probably not the case because, in a writing task without time limits, eighth graders only spent 10% of their writing time revising their texts (Fidalgo et al., 2008). As revision places large demands on working memory, it is possible that older students were not able to write their texts and, simultaneously, revise them for meaning (Hacker, 1994). Probably, postponing revision would have improved text quality (Chanquoy, 2001).

Finally, the predicted relationship between the self-regulation variables in Grades 7-9 was not found. In the sample studied, writers' ability to generate written plans before writing was not

linked to their ability to revise meaning errors, suggesting that these skills did not develop in tandem. This result might be explained by the different nature of these strategies: Writers plan what they are going to write, but they revise what they have already written. In addition, the lack of relationship between planning and revising is possibly related to the finding that while some students tend to adopt planning strategies, others tend to prefer revising strategies (Kieft, Rijlaarsdam, Galbraith, & van der Bergh, 2007). Unexpectedly, the paths from planning and revising to self-efficacy were also non-significant. This result might be related to the use of a general self-efficacy measure, not explicitly tied to the use of writing self-regulatory strategies. Bruning, Dempsey, Kauffman, McKim, and Zumbrunn (2012) found empirical support for a 3-factor model of writing self-efficacy comprising self-efficacy for writing ideation, writing conventions, and writing self-regulation. The assessment of specific dimensions of self-efficacy, such as *self-efficacy for self-regulated learning* (Zimmerman & Martinez-Pons, 1990), can inform us better about how students' beliefs are influenced by their planning and revising skills.

Limitations and Future Research Directions

Some limitations in the present study need to be considered, as well as possible ways to further explore the development of writing. First, the data came from a single group of schools. However, the sample included a full-range of backgrounds and the main results confirmed the literature reviewed.

Second, by asking students' to plan and revise, we do not know if they were able to do it spontaneously in their texts. Indeed, it is as important to have the appropriate skills to use a strategy, as to autonomously decide when to employ that strategy. Future research should therefore focus on the extent to which students can deliberately plan and revise and how this impacts writing performance.

A third limitation, which is related to the previous one, is that online planning and online revision were not examined. By analysing the online management of these processes we could

deepen our understanding about their interaction and temporal distribution as a function of transcription.

Fourth, working memory and writing knowledge were not included in the model. Working memory is a pivotal system in the relationship between low- and high-level writing processes (Kellogg, 1996; McCutchen, 1996). The inclusion of a working memory factor could have provided valuable information about the evolution of this relationship during school years. Also, the students' writing knowledge and its impact on writing has been widely discussed in the literature (Englert et al., 1988; Graham et al., 1993; Lin et al., 2007; McCutchen, 2011). Very early on, knowledge about writing predicted writing quality, above and beyond transcription and self-regulation (Olinghouse & Graham, 2009). The relationship of writing knowledge with these processes deserves further attention.

Finally, any conclusion drawn from our results is limited to the indicators used and to writing assessment, as writing instruction was not studied in this project. Additional self-regulatory strategies, such as goal-setting, self-monitoring, or self-instructions (Graham & Harris, 2000; Harris et al., 2010; Zimmerman & Risemberg, 1997) should be examined. Likewise, as intraindividual differences at the text, sentence, and word levels were found (Wagner et al., 2011; Whitaker et al., 1994), other text generation measures should be considered in future research.

Educational Implications

This study confirmed that transcription contributes to developing writing (Berninger & Swanson, 1994; Graham et al., 1997), and is likely to hamper the acquisition and development of high-level writing processes, which characterizes mature writing (Alamargot et al., 2010). For that reason, transcription should be taught and practiced until a proficient level of automaticity is achieved. Indeed, through its influence on planning maturity and self-efficacy beliefs, transcription stills constraining older students' writing. Educational research has already shown the positive effects of interventions targeting handwriting (e.g., Christensen, 2004; Jones & Christensen, 1999) and spelling (e.g., Berninger et al., 2002; Berninger et al., 1998; Graham, Harris, & Fink-

Chorzempa, 2002). In spite of that, these skills tend to be neglected by teachers beyond the initial years of learning to write.

The findings that in Grades 4-6 self-regulation variables were influenced by transcription, but did not influence text quality, suggest that this developmental age may be a sensitive period to promote planning and revising as well as to nurture self-efficacy beliefs. Particular attention should be given to the development of revising skills because even older students do not seem to use them as an aid to write better texts. It has been widely demonstrated that teaching self-regulatory strategies builds self-efficacy and enhances writing quality (see Harris & Graham, 2009, for further discussion). Even though it is not desirable that these skills become fully automatized (McCutchen, 1988), through teaching, they can become fluent and increase writing efficiency. To fulfill students writing needs, the design of intervention programs tapping low- and high-level skills is clearly warranted (for successful programs see Berninger et al., 2006; Berninger et al., 2002).

In conclusion, the present study analyzed the role of transcription and self-regulation in text generation quality throughout development. Transcription proved to be the most restrictive factor to writing quality, directly, in Grades 4-6, and, indirectly via planning and self-efficacy, in Grades 7-9. Our study adds to a growing body of research showing that writing development is heavily based on transcription and self-regulation. If we want to enhance students' written composition across school years, none of these sets of skills should be left behind.

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Table 1

Descriptive statistics for all measures by grade group

	Grades 4-6 (n = 171)				Grades 7-9 (n = 205)			
Measure	*M*	*SD*	*Sk*	*Ku*	*M*	*SD*	*Sk*	*Ku*
Alphabet task	14.69	5.10	0.62	0.27	20.93	5.43	-0.02	0.49
Copy task	29.99	5.60	-0.16	-0.11	40.16	5.88	-0.39	0.44
Story spelling	95.71	4.18	-1.81	4.13	98.03	2.13	-1.70	3.39
Opinion essay spelling	95.11	4.98	-2.41	8.40	97.87	2.56	-2.43	8.19
Dictated spelling	30.71	4.44	-1.02	1.05	35.16	2.84	-1.36	2.59
Story planning	2.38	1.28	0.23	-1.64	3.10	1.39	-0.22	-1.01
Opinion essay planning	1.92	1.14	1.03	-0.25	3.06	1.39	-0.17	-1.35
Revision-detection	1.07	1.03	0.64	0.04	1.55	1.23	0.67	0.20
Revision-correction	1.32	0.94	0.23	0.14	1.75	1.03	-0.01	-0.02
Self-efficacy	73.58	17.72	-0.75	0.24	71.88	13.76	-0.34	0.10
Story quality	4.35	1.22	-0.49	0.55	3.84	1.44	-0.05	-0.34
Opinion essay quality	3.70	1.28	-0.18	-0.26	3.73	1.35	0.03	-0.36

Note. Metric and possible range for reported measures are as follows: alphabet task = number of correct letters, copy task = number of correct words, story and opinion essay spelling = percentage of correct words; dictated spelling = number of correct words (0-40); self-efficacy = scale ranging from 0 (*no chance*) to 100 (*completely certain*); story and opinion essay planning = scale ranging from 1 (*low*) to 6 (*high*); revision-detection = number of accurately detected errors (0-6); revision-correction = number of accurately corrected errors (0-6); story and opinion essay quality = scale ranging from 1 (*low*) to 7 (*high*).

Table 2

Correlations between all measures by grade group

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. Alphabet task	–	.51***	.32***	.28***	.27***	.13	.16	.14*	.21**	.38***	.31***	.23**
2. Copy task	.55***	–	.25***	.24***	.33***	.10	.09	.11	.21**	.35***	.34***	.26***
3. Story spelling	.26**	.16*	–	.56***	.43***	.12	.20**	.11	.18*	.32***	.20**	.25***
4. Opinion essay spelling	.22**	.23**	.66***	–	.55***	.18*	.19**	.14*	.18**	.32***	.26***	.23***
5. Dictated spelling	.36***	.29***	.62***	.55***	–	.16*	.18**	.26***	.19**	.35***	.34***	.29***
6. Story planning	.16*	.03	-.01	-.08	.16*	–	.52***	.15*	.16*	.14*	.28***	.31***
7. Opinion essay planning	.11	.06	.19*	.12	.19*	.39***	–	.13	.08	.23**	.31***	.34***
8. Revision-detection	.12	.05	.20**	.19*	.30***	.13	.14	–	.36***	.22**	.19**	.33***
9. Revision-correction	.28***	.17*	.17*	.18*	.35***	.08	.18*	.43***	–	.29***	.32***	.21**
10. Self-efficacy	.15**	.13	.34***	.26**	.40***	.11	.08	.12	.10	–	.50***	.41***
11. Story quality	.34***	.35***	.11	.16*	.27***	.08	.11	.23**	.27***	.18*	–	.44***
12. Opinion essay quality	.35***	.23**	.17*	.23**	.33***	.12	.25**	.28***	.35***	.29***	.39***	–

Note. Correlations for Grades 4-6 (n = 171) are below the diagonal and correlations for Grades 7-9 (n = 205) are above the diagonal.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 3

Unstandardized and standardized path coefficients by grade group

Path	Grades 4-6 (*n* = 171)		Grades 7-9 (*n* = 205)	
	Unstandardized	Standardized	Unstandardized	Standardized
Transcription				
Transcription → Handwriting	2.90	.67***	3.03	.76***
Alphabet task[a]	1.00	.85	1.00	.74
Copy task	0.83	.64***	1.00	.69***
Transcription → Spelling	2.15	.53***	1.23	.64***
Story spelling	0.84	.81***	0.82	.75***
Opinion essay spelling[a]	1.00	.82	1.00	.75
Planning				
Story planning	0.61	.46 ns	.90***	.68***
Opinion essay planning[a]	1.00	.85	1.00	.76
Revision				
Detection[a]	1.00	.59	1.00	.54
Correction	1.15	.74***	1.03	.67***
Self-efficacy				
Self-efficacy[b]	1.00	1.00	1.00	1.00
Text generation				
Story quality	0.75	.56***	1.17	.75***
Opinion essay quality[a]	1.00	.71	1.00	.74
Transcription → Planning	0.31	.33**	0.41	.39***
Transcription → Revision	0.34	.57***	0.38	.58***
Transcription → Self-efficacy	6.83	.39***	9.38	.69***
Transcription → Text generation	0.54	.60*	0.23	.26 *ns*
Planning → Text generation	0.08	.09 *ns*	0.32	.39***
Revision → Text generation	0.44	.30 *ns*	0.33	.25 *ns*
Self-efficacy → Text generation	0.004	.09 *ns*	0.02	.31*

Note. For between-sample comparisons see unstandardized coefficients, but for within-sample comparisons see standardized coefficients.

[a]Reference variable. [b]Single indicator of factor.

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 4

Summary of the goodness-of-fit statistics for tests of multiple-group invariance

Model	χ^2	*df*	$\Delta\chi^2$	Δdf	*p*	CFI	ΔCFI
Configural Model	81.93	72	–	–	–	.99	–
Measurement Model	86.58	77	4.65	5	.46	.99	.00
Structural Model	102.91	86	16.33	9	.06	.98	.01
H → T and S → T equal	89.85	79	3.27	2	.20	.99	.00
T → P, T → R, and T → SE equal	92.70	82	2.84	3	.42	.99	.00
R → TG equal	92.85	83	0.16	1	.69	.99	.00
T → TG equal	97.22	84	4.37	1	.04	.98	.01
P → TG equal	98.31	84	5.46	1	.02	.98	.01
SE → TG equal	98.41	84	5.56	1	.02	.98	.01

Note. CFI = comparative fit index; H = handwriting; T = transcription; S = spelling; P = planning; R = revision; SE = self-efficacy; TG = text generation.

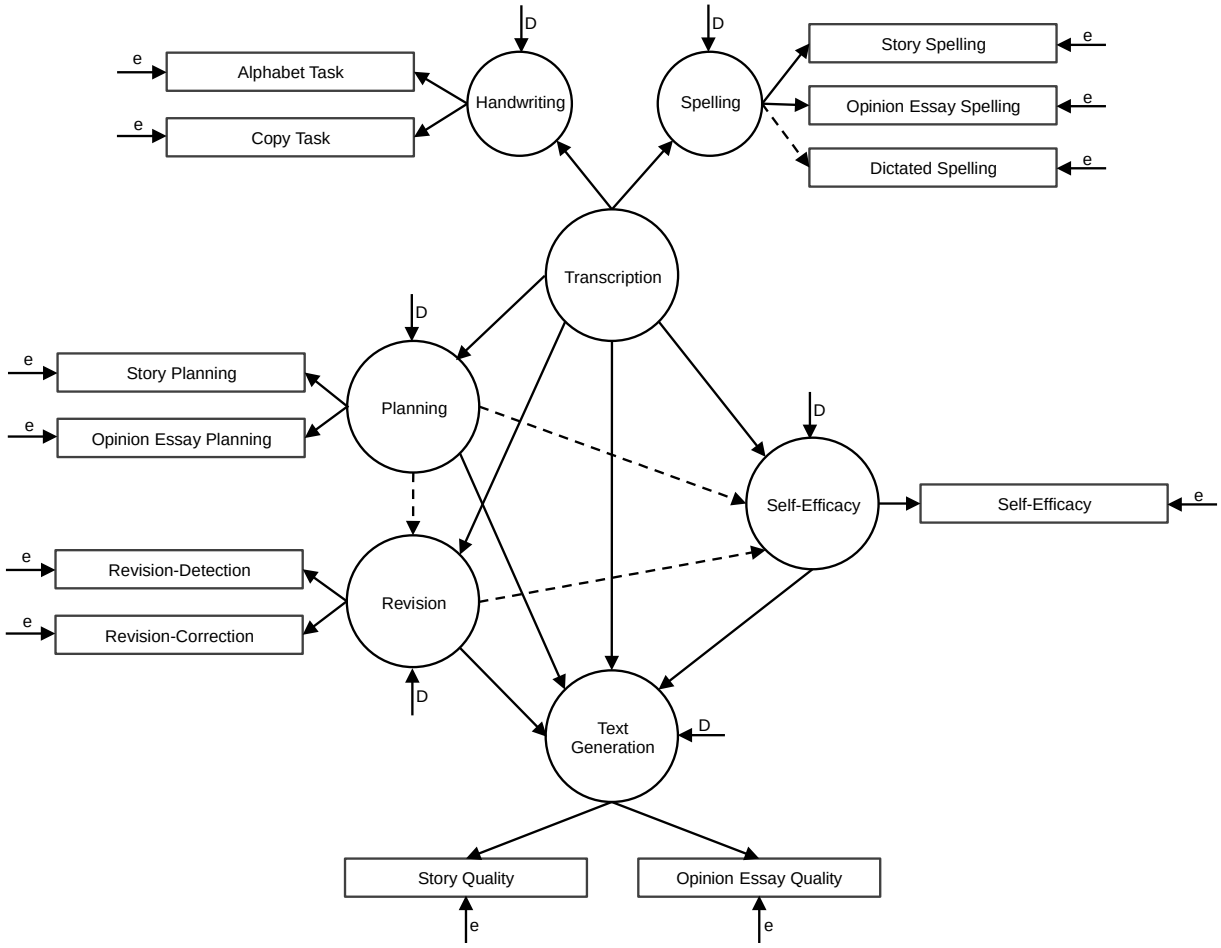

Figure 1. Structural model of the relationship between transcription, planning, revision, self-efficacy, and text generation. Circles represent factors (i.e., latent variables), rectangles represent indicators (i.e., observed variables), and arrows represent direct paths (dashed lines represent paths that were removed from the final model). e = measurement error; D = structural error.