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Writing performance in primary grade: exploring the links between cognitive and motivational variables

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Current theoretical models of writing suggest that cognitive and motivational processes interact with each other during written production. However, despite the growing interest in motivational variables in writing, there are still few efforts to study them together with cognitive variables. Therefore, this study aimed to test the possibility that the cognitive processes of transcription and executive functions may be related to writing performance, through their link with the writing-motivational variables of self-efficacy and attitudes. For that, 157 Portuguese third and fourth graders planned and completed one opinion essay, performed transcription tasks, and completed motivation-related questionnaires. Furthermore, schoolteachers completed an executive function questionnaire about each student and provided their school grades. Results showed that motivation, specifically self-efficacy, did not predict Grade 3 and 4 writing performance. However, attitudes were predictors of written planning and text length. More specifically, attitudes and handwriting fluency contributed to text length just as attitudes and spelling accuracy contributed to written planning. There was no evidence of indirect effects from cognitive variables on writing performance via motivation variables. These findings provide original information on the links between cognition and motivation in writing, which may be useful to guide the teaching of writing. In line with effective instructional approaches to writing, current findings further support the importance of jointly targeting the cognitive and affective dimensions of writing.

KEYWORDS

transcription, executive functions, attitudes, self-efficacy, writing performance

1 Introduction

Given the importance of writing throughout schooling, researchers have made efforts to understand the processes involved in this demanding task. Although early studies focused primarily on cognitive processes (Bereiter and Scardamalia, 1987), there has been a growing interest in investigating motivational ones (Graham et al., 2018; Camacho et al., 2020). However, few studies have been conducted to investigate their inter-relationships. The present study aimed to fill in this gap, by exploring the links between writing-relevant cognitive and motivational variables and writing performance among Portuguese primary graders.

1.1 Cognitive variables in writing

To account for the specificities of writing, Berninger and colleagues proposed the Not-So-Simple View of Writing (Berninger and Winn, 2006; Berninger and Chanquoy, 2012). According to this model, text generation requires the interaction between transcription and executive functions (EFs). Transcription is the process of transforming oral language into written text and involves handwriting/typing and spelling (Limpo et al., 2020). Correlational and experimental studies showed that handwriting fluency and spelling accuracy are positively associated with writing performance in primary and secondary school students (Limpo et al., 2017; Hurschler Lichtsteiner et al., 2018; Limpo et al., 2020; Skar et al., 2021). Besides transcription, EFs are important contributors to the development of written language (Limpo and Olive, 2021). EFs encompass a diversity of cognitive processes for engaging in goal-directed behavior and effectively addressing problems (Alves, 2019; Willoughby and Hudson, 2021). The EFs components of inhibitory control, planning, and working memory have been linked to writing (Hooper et al., 2011). Empirical findings also showed relationships between transcription and EFs. For example, Vieira et al. (2023) showed that transcription skills and EFs were related with each other in Grade 2 and 1 year later in Grade 3, but prior performance on these skills did not predict later text quality. Despite emphasizing the importance of cognitive processes, these studies did not consider the role of motivation, specifically, self-efficacy and attitudes, which seem to be the most relevant ones for writing (Camacho et al., 2021).

1.2 Motivational variables in writing

Writing self-efficacy refers to individuals' opinions regarding their ability to learn and perform writing tasks (Bruning et al., 2013). According to Bandura's socio-cognitive theory (Bandura, 1997), the level of effort and persistence that students invest in achieving their goals are influenced by these self-perceptions. Those who doubt their abilities tend to show low commitment, frustration, anxiety, and, ultimately, passiveness and avoidance. Conversely, those who believe in their abilities tend to try harder, persist, and engage in adaptive behaviors. Self-efficacy is one of the strongest motivational predictors of writing performance (Zumbrunn et al., 2020; Camacho et al., 2021). Attitudes toward writing are generally regarded as the pleasure or satisfaction writers derive from engaging in writing activities (Ekholm et al., 2018). Specifically, they are characterized by a range of emotional reactions toward writing, encompassing positive and negative emotions (Graham et al., 2007). In line with WWC model, students with positive attitudes toward writing were found to write longer and better texts (Ekholm et al., 2018; Graham et al., 2019; Camacho et al., 2021). This seems to happen because positive affect may facilitate the learning process, and liking writing may translate into more time and energy spent in this activity (Graham et al., 2007). Given the well-documented role of self-efficacy and attitudes in writing, we targeted these two constructs to examine the underexplored link between cognitive and motivational processes.

1.3 The link between cognitive and motivational variables

As described above, there is now substantial theoretical and empirical support for the claim that children with higher levels of cognition and motivation produce better written outcomes. However, little is known about the joint contribution of these cognitive and motivational variables to children's writing. Two recent theoretical models included both cognition and motivation as central processes in writing.

Under the component of writers' resources and capabilities, the Writer(s)-Within-Community (WWC) model (Graham, 2018) included not only mental and physical operations (such as transcription) but also control mechanisms (such as executive control) and motivational beliefs (such as attitudes and self-efficacy). These variables are expected to be related to each other. Students who are more motivated to write seem more likely to be attentive and adopt strategic behavior to accomplish writing processes, like putting words onto paper (Graham et al., 2019). Yet, this model did not provide further detail on the link between cognitive and motivational variables. The specification of such a link was advanced by Kim and colleagues in the Direct and Indirect Effects model of writing (DIEW; Kim and Schatschneider, 2017).

The DIEW postulates hierarchical relationships between component skills, namely, transcription skills, higher-order cognitive skills, oral language, motivation, prior knowledge, and EFs (Kim and Park, 2019). Authors hypothesized that EFs and transcription could make direct contributions to writing, as well as indirect, via motivation. Limpo and Alves (2013) found partial support for this claim in middle graders, by showing that self-efficacy mediated the link between transcription and writing. Though similar findings were not found concerning EFs or attitudes, the DIEW model and these results seem to provide sufficient ground to hypothesize that children with better writing-related cognitive skills may have better writing proficiency due to higher motivation. Research into the cognition-emotion link may also help to support this yet-to-be-tested hypothesis. Because a positive emotion may require fewer cognitive resources than a negative one (Pekrun et al., 2002; Coffey, 2020), greater motivation in writing may free up cognitive resources for the task, resulting in better products (Rocha et al., 2019). As positive emotions have been associated with more adaptive forms of cognitive engagement (Isen, 1999), more motivation may also benefit the enactment of cognitive writing processes.

2 Present study

We conducted the present study to answer the following research question: Are cognitive and motivational processes predictors of written performance? Being writing a multidimensional construct (Kim et al., 2014), to provide a comprehensive measurement of students' performance, we combined a process (*viz.*, planning) and a product measure (*viz.*, text length). We targeted a process measure because, despite its impact on writing quality (Ferretti et al., 2009), it is typically ignored in writing studies as an indicator of writing proficiency. However, process measures and, specifically, planning are essential to produce coherent, cohesive, and organized texts. As a product measure, instead of

subjectively evaluating quality as a whole, we used an objective productivity indicator, considered the strongest predictor of writing development and quality (Crossley, 2020). Actually, in argumentative texts, text length has been proposed as a more relevant indicator of performance, as a minimum length of words and sentences is necessary for students to be able to develop a line of thought (Aparici et al., 2021). Based on the previously reviewed literature, we expected that greater cognitive and motivational processes would be associated with better writing performance; and that the link between cognitive processes and writing performance would be mediated by motivational processes.

3 Methods

3.1 Participants

In this study, 157 Portuguese students participated, 92 from grade 3 and 65 from grade 4 (80 boys, 77 girls) with an average age of 8.73 years ($SD = 0.61$; range from 7.83 to 10.17 years). We used a convenience sample comprised of students from five classes from a public group of schools in the North of Portugal, with which our team has cooperation protocols. The socioeconomic status of the children was determined through their mothers' education level, which was as follows: 1.3% completed Grade 4, 8.3% completed Grade 5–6, 21% completed Grade 9, 24.8% completed high school, and 37.6% completed college or attained a higher level of education and 7% was unknown.

3.2 Procedure

All students were evaluated in a 60-min group session. Firstly, students were presented with the essay writing topic: "Do you think teachers should give students homework every day?." Afterward, students had 10 min to plan the essay followed by 15 min to compose it. Secondly, students performed two transcription tasks, in which they were asked to copy a 9-word sentence as quickly as possible during 90 s (Limpo and Alves, 2018), and spell 16 words dictated at intervals of 6-to-10 s (Limpo and Alves, 2018). Thirdly, students filled in the attitudes and self-efficacy questionnaires. The experimenter indicated that, for both questionnaires, there were no right or wrong answers and explained the overall procedure. Items were read aloud, each item at a time, and students were asked to mark their answers individually. Moreover, schoolteachers completed an EF questionnaire about each student.

3.3 Measures

An overview of all measures is presented on Table 1, including validity and reliability data.

3.3.1 Transcription skills

In the copy task, the final score was the number of words accurately copied, with higher scores indicating enhanced handwriting fluency. In the spelling task, we counted the number of words correctly spelled, thus higher scores indicate better spelling skills.

3.3.2 Executive functions

We used the Children's Executive Functioning Inventory (CHEXI), validated to Portuguese by Moura et al. (2019). This is a 24-item instrument through which teachers assess children's EFs (Thorell and Nyberg, 2008). According to Thorell and Nyberg (2008) we used a two-factor model that distinguishes inhibition (11 items) and working memory (13 items). For each student, teachers were requested to indicate their level of agreement with a set of statements using a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). As the items are phrased, higher scores indicate poorer EFs.

3.3.3 Motivation

We used a self-report instrument evaluating students' attitudes toward writing in and out of school (Graham et al., 2017), adapted to Portuguese by Rocha et al. (2019). Students indicated their level of agreement with a set of five statements, using a 5-point Likert scale (1 = *strongly disagree*; 5 = *strongly agree*), with higher scores indicating more positive attitudes.

Moreover, we used the 9-item version of the Self-Efficacy for Writing Scale (SEWS; Bruning et al., 2013), whose long Portuguese version was validated to Portuguese by Limpo and Alves (2017). This scale measures students' perceived confidence in their ability concerning three dimensions: ideation, conventions, and self-regulation. Participants rated their self-efficacy on each item on a scale ranging from 0 (*no confidence*) to 100 (*complete confidence*).

3.3.4 Writing performance

We assessed planning complexity using a scale ranging from 1 (*no planning*) to 7 (*structural relationships*) following Rocha et al. (2023). To measure text length, we calculated the number of words of each text, using the word count function of Microsoft Word.

4 Data analyses

IBM SPSS Statistics (version 26) was used to conduct preliminary analyses. First, we examined the descriptive statistics for all variables and correlations among them. Variables with skewness and kurtosis values above |3| and |10|, respectively, indicated distributional problems (Kline, 2016). Correlations near 0.20, 0.50, and 0.80 were considered weak, moderate, and strong, respectively (Cohen, 1988). Second, because our sample included third and fourth graders, we conducted independent sample t-tests to compare all variables between grades. Variables that differed between Grades 3 and 4 ($\alpha \leq 0.05$) were controlled in the path-analytic model. This model was tested using the R system for statistical computing using the lavaan. survey package (R Development Core Team, 2005). It included direct paths from cognitive variables (*viz.*, working memory, inhibition, handwriting fluency, and spelling accuracy) to motivational variables (*viz.*, self-efficacy for conventions, ideation, self-regulation, and attitudes toward writing); and from these latter to writing performance (*viz.*, written planning and text length). To control for grade, we specified direct paths from grade to the variables that differed between Grades 3 and 4. Model fit was evaluated using the following indices and cutoff points (Kline, 2016): chi square statistic (χ^2), χ^2/df values <2 and 3, confirmatory fit index (CFI) > 0.95 and 0.90, root-mean-square error of approximation (RMSEA) < 0.06 and 0.10, and standardized root mean residual (SRMR) < 0.06 and 0.09.

TABLE 1 Description of all the measures, reliability, and validity.

Measure	Description	Reliability and validity
Transcription skills		
Handwriting fluency	Copy task to assess handwriting fluency, by counting the number of words accurately copied in 90 s.	Validated by Limpo et al. (2017). ICC = 1.00
Spelling accuracy	Spelling task to assess spelling accuracy, by counting the number of words correctly spelled.	Validated by Limpo and Alves (2018). ICC = 0.994
Executive functions		
Inhibition	Assesses ability to inhibit automatic responses control attention, behavior, thoughts, or emotions trough 11 teacher-report items (e.g., *Has a tendency to do things without first thinking about what could happen*).	Moura et al. (2019) α = 0.96
Working memory	Assesses ability to store, relate and manipulate information in a short period of time through 13 teacher-report items (e.g., *Easily forgets what he/she is asked to fetch*).	Moura et al. (2019) α = 0.98
Motivation		
Attitudes	Assesses attitudes toward writing in and out of school through 5 self-report items (e.g., *I enjoy writing*).	Rocha et al. (2019) α = 0.83
Self-efficacy for ideation	Assesses writers' confidence in their ability to generate content and order their thoughts through 3 self-report items (e.g., *I can put my ideas into writing*).	Limpo and Alves (2017) α = 0.81
Self-efficacy for conventions	Assesses writers' ability to express ideas in writing in a given language through 3 self-report items (e.g., *I can write complete sentences*).	Limpo and Alves (2017) α = 0.73
Self-efficacy for self-regulation	Assesses writers' ability to trust their competence to generate productive ideas and writing strategies as well as to manage the anxiety and emotions that can accompany writing through 3 self-report items (e.g., *I can avoid distractions while I write*).	Limpo and Alves (2017) α = 0.68
Writing		
Written planning	Assesses the complexity of the plan made ahead of writing.	Rocha et al. (2023) ICC = 0.89
Text length	Assesses text productivity through the total number of words written.	

5 Results

As depicted in Table 2, we found no distributional problems and observed the expected pattern of correlations between variables. Except for working memory and handwriting, cognitive variables were related with each other ($0.19 < rs < 0.79$) as well motivational variables ($0.44 < rs < 0.57$). Written planning was correlated with text length ($r = 0.48$). Independent-sample t tests showed grade differences for working memory ($t = -1.97$, $p = 0.05$), spelling ($t = 3.25$, $p < 0.001$), and handwriting ($t = -2.98$, $p < 0.001$). Thus, we introduced direct paths from grade to these three variables.

The path-analytic model fitted the data very well, χ^2 (57, $N = 157$) = 7.73, $p = 0.56$, χ^2/df = 0.86; CFI = 1.00; RMSEA <0.001, RMSEA 90% CI [0.00, 0.08], $p = 0.80$; SRMR = 0.03. We found significant paths from working memory to self-efficacy for conventions ($b = -0.35$) and ideation ($b = -0.34$); from inhibition to attitudes ($b = -0.27$); from spelling to self-efficacy for conventions ($b = -0.32$) and self-regulation ($b = -0.28$), as well as to attitudes ($b = -0.17$) and written planning ($b = -0.28$); and from handwriting to self-efficacy for conventions ($b = 0.15$) and text length ($b = 0.22$). Among the motivational variables, only attitudes were related to written planning ($b = 0.22$) and text length ($b = 0.16$).

The amount of variance explained by cognitive variables was 27% for self-efficacy for conventions, 9% for self-efficacy for ideation, 14%

for self-efficacy for self-regulation, and 5% for attitudes. As whole, the model explained 14% of the variance of written planning and 18% of the variance of text length. The examination of indirect effects (i.e., from cognitive variables on writing performance via motivational variables) revealed no significant links. Complete results appear in Table 3 and the pattern of significant relationships is depicted in Figure 1.

6 Discussion

This study aimed to explore the joint contribution of cognitive and motivational variables to writing performance at the end of primary school.

6.1 Predictors of self-efficacy

Self-efficacy for conventions refers to writers' confidence in relying on the use of tools related to the language of writing to express one's ideas (Bruning et al., 2013). Results showed that about one third of the variability in this dimension was explained by cognitive variables, namely, working memory, handwriting fluency, and spelling accuracy. One of the factors contributing to students' greater perceived

TABLE 2 Descriptive statistics and bivariate correlations between all variables.

	Descriptive statistics				Bivariate correlations								
	M	SD	Sk	Ku	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Working memory	1.99	0.91	0.72	−0.36									
2. Inhibition	2.07	0.95	0.64	−0.53	0.79**								
3. Spelling accuracy	3.11	2.88	0.94	0.35	−0.19*	0.01							
4. Handwriting fluency	18.77	4.68	0.58	2.44	−0.09	−0.04	−0.24**						
5. SE for conventions	81.32	18.66	−1.42	2.15	−0.34**	−0.17*	−0.43**	0.26**					
6. SE for ideation	79.90	21.34	−1.53	2.36	−0.19	−0.04	−0.20*	0.11	0.54**				
7. SE for self-regulation	74.96	23.24	−1.05	0.61	−0.24**	−0.19*	−0.31**	0.13	0.57**	0.44**			
8. Attitudes	3.91	0.92	−1.07	0.57	−0.07	−0.13	−0.14	0.04	0.28**	0.26**	0.45**		
9. Writing planning	2.70	1.00	0.99	1.08	−0.10	−0.13	−0.25**	0.15	0.09	0.09	0.05	0.21**	
10. Text length	58.38	30.72	1.21	1.66	−0.25**	−0.22**	−0.22**	0.26**	0.18*	0.19*	0.21**	0.23**	0.48**

SE, Self-efficacy. *$p < 0.05$. **$p < 0.01$.

self-efficacy for conventions was working memory. There is a consensus that working memory is fundamental for the production of a good text, including language production. Verhagen and Leseman (2016) showed that, in the first grades, students with greater working memory capacity exhibited greater grammatical and vocabulary skills. Given this association between working memory and language skills, it is not surprising that students with higher levels of working memory may feel more capable of successfully using those skills (Vellutino et al., 2007). Along with working memory, transcription also predicted self-efficacy for conventions. This result aligns with previous findings (Limpo and Alves, 2013), showing that transcription predicted general self-efficacy. Together these findings reinforce the role of students' handwriting and spelling abilities as a fundamental source of self-efficacy.

Self-efficacy for ideation refers to writers' confidence in generating ideas for writing (Bruning et al., 2013). Our findings demonstrated that, besides predicting self-efficacy for conventions, working memory also predicted self-efficacy for ideation. This link between higher working memory resources and stronger beliefs on own's ability to generate ideas reinforces the key role of working memory in writing. Working memory allows students to group active thoughts in memory and link them with information stored in long-term memory (McCutchen, 2000). Thus, students who have greater working memory may perceive it to be easier to remember the objectives of the task, while composing and organizing ideas. Given the importance of working memory to generate ideas (Cordeiro et al., 2019) and formulate language (Verhagen and Leseman, 2016), students with greater working memory resources may feel more competent in producing relevant ideas and choosing appropriate linguistic forms to express them accurately (Martinussen and Major, 2011).

Self-efficacy for self-regulation refers to writers' confidence to manage their writing behavior and affect (Bruning et al., 2013). Our results revealed that this dimension of self-efficacy was predicted by spelling, suggesting that the more automated children's spelling is, the greater their perception of behavioral and affective control in writing. When spelling skills become sufficiently accurate, writers may use spare attentional resources for higher-level processes, including self-regulation (Berninger and Winn, 2006; Limpo and Alves, 2013). This

may explain why students with better spelling skills may feel more competent to manage writing. The fact that this link only involved spelling and none of the other cognitive variables assessed was unexpected, given past findings showing the importance of EFs for self-regulation (Lyons and Zelazo, 2011). It should, however, be noted that, we measured students' self-perceived self-regulation skills, which may explain the absence of links. Yet, because our study does not allow us to test this or other hypotheses, more research relating EFs and students' real and perceived ability to self-regulate writing seems needed.

6.2 Predictors of attitudes

Although the percentage of explained variance was low (5%), the results demonstrated a relationship between cognitive variables and attitudes. We found that only inhibition and spelling predicted attitudes. It seems that by having stronger abilities to ignore distractions and adopt more thoughtful, less impulsive approaches to writing, children may experience writing as a more pleasant experience. The same relationship was, however, not found for working memory, contradicting theoretical models, such as the WWC or the DIEW, and past findings relating middle graders' working memory with attitudes toward learning (Jung and Reid, 2009). Despite no prior writing study has explored the link between working memory and attitudes, these later are multifaceted and shaped by a range of factors, including cognitive ones (Camacho et al., 2020). Whether working memory is one of them deserves further attention.

The link between spelling and attitudes may be related to the key role that the transcription has in primary education. Portuguese students struggle to learn spelling and produce several misspellings, which receive repeated corrective feedback from teachers and foster an attitude of demotivation and avoidance toward writing. Therefore, it is essential that teachers adopt a procedural correction approach to writing, in which they value intermediate work, correct multiple drafts, emphasize content and form, and praise writers' efforts (Cassany, 2000). In this way, teachers will be contributing to the development of students' positive attitudes toward writing.

TABLE 3 Parameter estimates of the path-analytic model (significant paths are signaled in Bold).

| Paths	B	SE	p	β
Direct paths				
Grade→Working memory	0.16	0.09	0.07	0.09
Grade→Spelling	**−1.47**	**0.45**	**0.001**	**−0.25**
Grade→Handwriting	**2.20**	**0.74**	**0.003**	**0.23**
Working memory→Attitudes	0.18	0.14	0.18	0.18
Working memory→Planning	0.12	0.15	0.43	0.11
Working memory→Text length	−4.08	4.43	0.36	−0.12
Inhibition→SE for conventions	2.36	2.22	0.29	0.12
Inhibition→SE for ideation	5.19	2.85	0.07	0.23
Inhibition→SE for self-regulation	−2.62	3.01	0.39	−0.11
Inhibition→Attitudes	**−0.26**	**0.13**	**0.04**	**−0.27**
Inhibition→Planning	−0.23	0.13	0.08	−0.22
Inhibition→Text length	−3.40	4.03	0.40	−0.11
Spelling→SE for conventions	**−2.07**	**0.48**	**< 0.001**	**−0.32**
Spelling→SE for ideation	−0.91	0.61	0.14	−0.12
Spelling→SE for self-regulation	**−2.28**	**0.64**	**< 0.001**	**−0.28**
Spelling→Attitudes	**−0.05**	**0.03**	**0.05**	**−0.17**
Spelling→Planning	**−0.10**	**0.03**	**0.001**	**−0.28**
Spelling→Text length	−1.49	0.89	0.09	−0.14
Handwriting→SE for conventions	**0.61**	**0.28**	**0.03**	**0.15**
Handwriting→SE for ideation	0.24	0.36	0.50	0.05
Handwriting→SE for self-regulation	0.24	0.38	0.53	0.05
Handwriting→Attitudes	0.001	0.02	0.95	0.01
Handwriting→Planning	0.02	0.02	0.15	0.11
Handwriting→Text length	**1.41**	**0.50**	**0.01**	**0.22**
SE for conventions→Planning	−0.01	0.01	0.41	−0.09
SE for conventions→Text length	−0.20	0.17	0.25	−0.12
SE for ideation→Planning	0.004	0.004	0.31	0.09
SE for ideation→Text length	0.17	0.13	0.19	0.12
SE for self-regulation→Planning	−0.01	0.004	0.11	−0.16
SE for self-regulation→Text length	0.05	0.13	0.71	0.04
Attitudes→Planning	**0.24**	**0.09**	**0.01**	**0.22**
Attitudes→Text length	**5.50**	**2.75**	**0.05**	**0.16**
Correlations				
Working memory↔Inhibition	0.67	0.08	< 0.001	0.79
Working memory↔Spelling	0.55	0.13	< 0.001	0.22
Working memory↔Handwriting	−0.35	0.20	0.07	−0.09
Spelling↔Handwriting	−2.45	1.03	0.02	−0.19
SE for conventions↔SE for ideation	159.03	28.67	< 0.001	0.49
SE for conventions↔SE for self-regulation	164.34	30.18	< 0.001	0.48
SE for conventions↔Attitudes	3.78	1.17	0.001	0.27
SE for ideation↔SE for self-regulation	174.00	37.55	< 0.001	0.40
SE for ideation↔Attitudes	4.74	1.50	0.002	0.26
SE for self-regulation↔Attitudes	8.13	1.66	< 0.001	0.42
Planning↔Text length	10.73	2.20	< 0.001	0.42

SE, Self-efficacy.
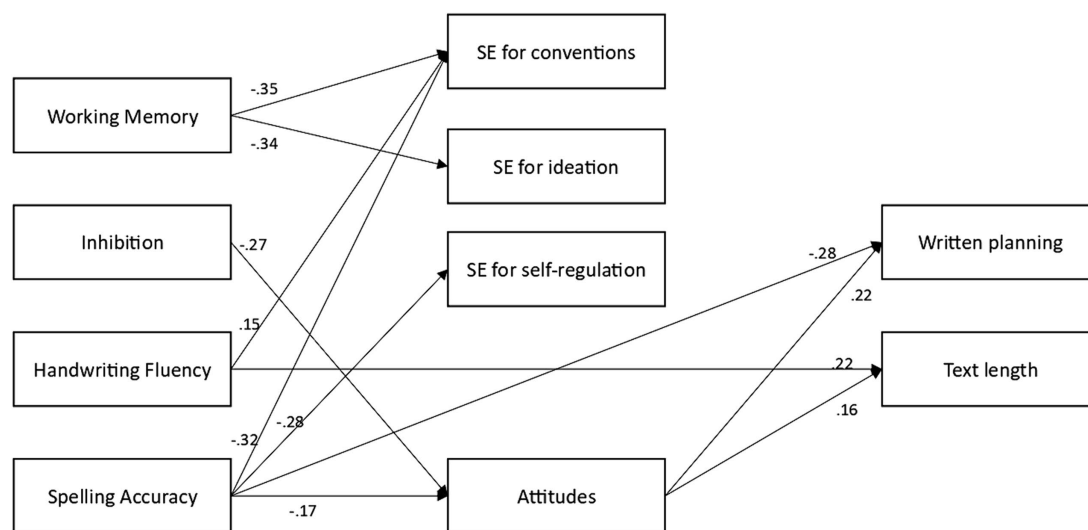
FIGURE 1
Path-analytic model tested with the links between cognitive variables, motivational variables, and writing performance. SE, Self-efficacy. To control for grade differences, direct paths from grade to working memory, handwriting fluency, and spelling accuracy were introduced, though not depicted for clarity.

6.3 Predictors of writing performance

We found partial support to the hypothesis that transcription, self-efficacy, and attitudes would predict writing performance, assessed through the amount of writing and the complexity of plans. Concerning text length, results indicated that students with higher handwriting fluency and more positive attitudes toward writing wrote longer texts. These findings reinforce the importance of handwriting for writing performance (Santangelo and Graham, 2016; Limpo and Graham, 2020). Students' attitudes also influenced the amount of their writing output. Therefore, the more positive the students' attitudes toward writing, the longer their written productions. In line with the WWC model, studies indicate that the more students enjoy writing, the more often they write and the more energy they dedicate to the task, which is fundamental to producing good writing (Graham and Harris, 2016).

Concerning planning, our findings showed that spelling accuracy and attitudes were significant predictors. Given the multiplicity of simultaneous processes that compete for the focus of writers' attention during composition, being able to write accurately emerges as a significant advantage for young students (Graham et al., 2002). The present study reinforced the importance of spelling in writing, by showing that these skills not only seem to impact the final product, but also a key processual component of it. This is an important finding because planning is critical for the production of high-quality texts throughout schooling (Graham and Perin, 2007; Graham et al., 2012).

Besides spelling, students' attitudes also predicted planning. Previous studies already showed that students with more positive attitudes toward writing wrote longer and better texts (Graham et al., 2017; Ekholm et al., 2018). To our knowledge, this is the first study showing a link between attitudes and written planning. In line with the claim that that positive (vs. negative) emotions require fewer

cognitive resources (Coffey, 2020) and stimulate more adaptive cognitive engagement (Isen, 1999), this finding suggests that favorable writing attitudes may foster planning by freeing up cognitive resources for relevant processes, such as the generation and organization of ideas.

Contrary to past findings (Pajares, 2003), self-efficacy belief did not predict writing performance. This was a surprising result, which can be explained by the indicators of writing performance we used, planning and text length, whose link with self-efficacy has been barely explored. Typically, self-efficacy has been shown to predict writing performance indexed through text quality. Together, past findings and ours suggest that attitudes, rather than self-efficacy, may have a stronger role in shaping processual measures, such as planning. Further research is needed to support this claim by comparing the differential effects of self-efficacy and attitudes on process and product measures.

Despite the associations between cognitive and motivational processes, as well as between these latter and writing performance, our hypothesis that cognitive processes would be associated with writing performance via motivation was not confirmed. This was the first study testing this claim, making it harder to interpret this lack of mediation. Though it may mean that the link between cognitive processes and writing performance is not mediated by motivation, but by other variables, it may also be a reflex of the variables assessed. Our model left out cognitive processes such as attention, cognitive planning, cognitive flexibility as well as motivational beliefs such as intrinsic and extrinsic motivation derived from Self-Determination Theory (Ryan and Deci, 2000), which have been shown to have a key role in writing. We do not know if targeting other cognitive and motivational variables would have uncovered the motivational mechanisms expected to mediate the link between cognition and performance in writing.

7 Limitations and future directions

The above-discussed findings should be considered take into account the following limitations. First, we adopted a cross-sectional design, which prevents us from drawing conclusions about causality. Future studies should consider the use of longitudinal designs to follow the trajectory of children's writing-related cognition and motivation throughout schooling and scrutinize their interaction over time (Camacho et al., 2020). Second, due to the lack of sound evidence suggesting the directionally of the link between transcription and executive functions (Vieira et al., 2023), our model specified correlations rather than regressive paths between these variables. Additionally, besides grade, no other variables were controlled in the model, because the inclusion of additional paths could produce unreliable estimates, given our sample size. Further research using larger samples and employing cross-lagged panel analysis seems needed to test more complex models and compare different relationships between the variables under study. Fourth, the limited representativeness of the sample derived from the sampling procedure does not allow the generalization of the results to other contexts. To that end, it would be important to replicate this study with more primary schools from different regions of the country (Camacho et al., 2020).

8 Educational implications

Worldwide, the teaching of writing in schools is still very focused on developing cognitive aspects of writing without considering motivational ones. A more informed and effective approach seems to target both aspects jointly. This claim is supported by past studies (Graham et al., 2017; Limpo et al., 2020), and the current one, whose findings showed the interaction between cognition and motivation in writing, and their joint contribution to key indicators of writing performance. Since the development of writing is a critical goal to achieve in school, these findings confirm the need for teachers to approach the teaching of writing by targeting cognitive and motivational aspects. To that end, one of the instructional models that has stood out for its effectiveness is the self-regulated strategy development model (SRSD; Harris and Graham, 2009). Through this approach, students receive explicit teaching and systematic practice to carry out writing-specific and general cognitive processes, including those related with executive control, which allow the optimization of writing performance (Rocha et al., 2023). Furthermore, SRSD enhances students' motivation and commitment to writing tasks. Through the teaching of self-regulation strategies combined with the teaching of writing strategies, students acquire skills that allow them to establish objectives before starting the writing task (which facilitates planning) and to monitor progress their own progress (Graham et al., 2005). Consequently, they are more likely to show greater involvement, persistence, and enjoyment in writing tasks (Graham and Harris, 1996; Schunk, 2001). The benefits of SRSD interventions are well documented not only in what concerns the quality and amount of the written product (Graham and Harris, 2003; Limpo and Alves, 2013), but also on other cognitive and motivational variables, mainly when these variables were specifically and explicitly targeted in instruction. For example, Limpo and Alves (2018) showed that SRSD intervention with transcription training increased transcription and writing quality in Grade 2. Rocha et al. (2023) extended these findings by showing the benefits of this intervention on executive functions. Zumbrunn (2010) additionally

showed the benefits of SRSD on first-graders' self-efficacy for story writing. Despite the need for more research, the findings of this study do support the use of multicomponent programs such as SRSD to foster the backbones of writing, namely, cognition and motivation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of the Faculty of Psychology and Education Sciences of the University of Porto. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s), and minor(s)' legal guardian/next of kin, for the publication of any potentially identifiable images or data included in this article.

Author contributions

RR: Writing – original draft. SM: Data curation, Writing – original draft. SC: Writing – review & editing. TL: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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