



HAL
open science

Spelling Errors in French Elementary School Students: A Linguistic Analysis

Nelly Joye, Lucie Broc, Chloë Ruth Marshall, Julie Elizabeth Dockrell

► **To cite this version:**

Nelly Joye, Lucie Broc, Chloë Ruth Marshall, Julie Elizabeth Dockrell. Spelling Errors in French Elementary School Students: A Linguistic Analysis. *Journal of Speech, Language, and Hearing Research*, 2022, pp.1-15. 10.1044/2022_JSLHR-21-00507. hal-03775179

HAL Id: hal-03775179

<https://hal.science/hal-03775179>

Submitted on 12 Sep 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

1

2

Spelling Errors in French Elementary School Students: A Linguistic Analysis

3

Joye, Nelly^{1*}; Broc, Lucie²; Marshall, Chloë Ruth¹; Dockrell, Julie Elizabeth¹

4

¹Centre for Language, Literacy and Numeracy, Department of Psychology and Human

5

Development, UCL Institute of Education, London (UK),

6

²University of Poitiers & CNRS (FR)

7

*Corresponding author

8

9

Conflict of interest statement. There is no conflict of interest to report.

10

11

Funding statement. This study was designed and planned with support from a UCL

12

Institute of Education PhD scholarship to the first author, and written with support from the

13

Heather van der Lely Foundation awarded to the third author.

14 **Abstract**

15 **Purpose.** The present study offers the first description of misspellings across elementary
16 school using the Phonological, Orthographic and Morphological Assessment of Spelling
17 (POMAS), a linguistic framework based on Triple Word Form Theory (Bahr et al., 2012),
18 adapted for French (POMAS-FR). It aims to test the ‘universality’ of POMAS, and its
19 suitability to track development in French spelling.

20 **Method.** One hundred and ninety-four typically-developing French children (Grade 1-5)
21 produced a written narrative and words-to-dictation. These were analyzed for productivity
22 and accuracy. Misspellings were then analyzed, using POMAS-FR.

23 **Results.** Productivity and accuracy were better in the later grades. POMAS-FR provided a
24 novel framework for tracking error types in our French sample. The data showed a linear
25 trend for text production, whereby the proportion of phonological errors decreased rapidly in
26 the early grades, whilst orthographic errors decreased and morphological errors increased
27 throughout elementary school. Words-to-dictation showed a more stable pattern, with a
28 steady decrease in phonological errors, and a stable proportion of orthographic and
29 morphological errors. The specific error types found within each linguistic category are
30 described for both tasks.

31 **Conclusions.** The POMAS-FR allowed for the characterization of linguistic knowledge
32 involved in learning to spell French across elementary school. Interplays between different
33 types of linguistic knowledge were evident at all grades. In comparison with other writing
34 systems, French text spelling competence relied heavily on morphological knowledge. These
35 results suggest POMAS may be applied to other orthographic systems. It also highlights the
36 importance of task and word selection for the qualitative evaluation of spelling.

37 *Keywords:* French, Triple Word Form Theory, Spelling, Qualitative analysis, POMAS

38

Introduction

39

40

41

42

43

44

45

46

47

48

49

50

51

52

53

54

55

56

57

58

59

60

61

62

Despite a growing research base in spelling development, English remains the predominant focus of investigations and the basis for current theories of spelling development. If we are to develop *universal* theories of spelling development and disorders, models have to be tested in a range of languages of varying characteristics, and not only in the exceptionally opaque English orthography (Seymour et al., 2003). Reading researchers have already contested the ‘anglocentricity’ of reading research and the need for evidence and theories stemming from less opaque orthographies (Share, 2008). Spelling research would similarly benefit from evidence in a broader range of orthographies, and from cross-language theory testing to identify different patterns in development. The present paper contributes to this endeavor by testing the relevance of the Phonological, Orthographic and Morphological Assessment of Spelling (POMAS) framework. The framework was initially developed in English and based on the Triple Word Form theory (Bahr et al., 2012). Here we examine whether the framework is sensitive to the nature and development of spelling errors in French elementary school students.

Triple Word Form theory posits that spelling is a linguistic activity, relying on phonological, but also orthographic and morphological, knowledge of words (Bahr et al., 2009). These different types of knowledge develop and interact early on, to build spelling knowledge and accuracy. The role of phonology in starting to spell is well-documented: we know that phonological awareness is an important predictor of spelling in a range of languages (Caravolas et al., 2012, 2013; Moll et al., 2014), and that learning to parse phonemes and map them to graphemes is an essential step in learning to spell (Castles et al., 2018). Importantly, phonology is not the only skill young spellers rely on. Sensitivity to both morphological parsing (Pacton & Deacon, 2008) and orthographic conventions (Cassar & Treiman, 1997; Pacton et al., 2001; Treiman, 1993) for spelling have been demonstrated in

63 both French and English. Morphological parsing strategies have also been observed early on
64 in children's spelling of word endings. For example, American first graders were more likely
65 to represent two morphemes in their spelling of the final consonant cluster /nd/ if the word
66 could be parsed morphologically (e.g., *tuned*) than if it could not (e.g., *brand*) (Treiman &
67 Cassar, 1996). In French, Sénéchal (2000) showed that children's spelling of silent letter
68 endings was better when the silent letter could be predicted by morphologically-related words
69 (e.g., *chant* (song)– *chanter* (to sing)) than when it could not (e.g., *tabac* (tobacco)). This
70 sensitivity to morphological information was present as early as age seven, but was more
71 prominent in older children (Sénéchal et al., 2006). Orthographic sensitivity is also present
72 early on in children's spelling choices. Cassar and Treiman (1997) showed a preference for
73 doublets in legal (final - *ppes*), rather than in illegal (initial – *ppes*), position in American first
74 graders). Similarly, Pacton et al. (2001), in French, showed a preference for consonants
75 which could legally be doubled (*l*, *m* and *s*), over consonants that could not (*c*, *d* and *v*), as
76 early as the first year of formal literacy instruction. Altogether, this body of work suggests an
77 early and growing sensitivity to morphological and orthographic knowledge in learning to
78 spell both French and English throughout elementary school. However, how this knowledge
79 develops across the school grades is not fully understood in different languages.

80 French orthography differs in a number of ways from English orthography. The Triple
81 Word Form Theory can be used as a base for this comparison. Phonologically, French words
82 are typically made of open syllables (e.g., CV [Consonant + Vowel], CCV), which are
83 roughly equally stressed. English, by comparison, has a majority of closed syllables, with
84 word-specific stress patterns (McLeod, 2007). The few available direct comparisons of
85 French and English spelling have suggested this might have an impact on the nature of
86 spelling errors produced by children in the two languages. Caravolas et al. (2003) showed
87 that 8-9-year-old English poor spellers were less likely than their French poor-speller

88 counterparts to produce a correct word skeleton, that is, to represent all consonants and
89 vowels within a word, an idiosyncrasy attributed to English stress patterns. Orthographically,
90 French and English are both considered to be on the opaque end of the orthographic
91 consistency spectrum (Seymour et al., 2003; Ziegler et al., 1996, 1997). However, the nature
92 of the rules and regularities which affect this orthographic opacity may differ.

93 Kessler and Treiman (2001) analyzed vowel spelling consistency in a set of 914
94 English monosyllabic words, either independent of the syllabic context (preceding and
95 succeeding sounds) or depending on the context. Within this set of monosyllables, they found
96 that vowel sound-to-spelling consistency was 52.9% when context was ignored. However,
97 knowing the end of the word increased consistency to 69.7%. For example, knowing that the
98 sound /e/ is followed by /d/ makes it much more likely to be spelt *ea* (as in *bread*, *spread*,
99 *head*, *dead* or *instead*). Similarly, Peereman et al. (2007) analyzed a set of 1.9 million French
100 words, including complex words with derived and inflected forms. With this set of longer
101 words, they found that sound-to-spelling consistency in French was higher for graphemes in
102 initial (91%) and middle position (75%) than in final position (46%). In a later study, the
103 same research team re-analyzed a subset of these inconsistent endings after sorting them by
104 grammatical category. By doing so, Peereman et al. (2013) increased consistency counts of
105 these word final graphemes. For example, the final phoneme /ã/ had an overall consistency of
106 43%. However, its consistency increased to 100% as a present participle (always spelt *ant*).
107 Together, these studies suggest that sources of orthographic regularities differ across
108 languages. For example, in French, *morphosyntactic* rules (i.e., grammatical rules that affect
109 morphological segments in words) may play an important role in determining spelling of
110 word endings. By contrast, in English, *orthotactic* regularities (i.e., the regularities in the way
111 letters are arranged together in words) may play a major role in spelling English vowels.

112 Spelling error analysis presents an opportunity to assess how these linguistic
113 constraints affect spelling across development. There have been a range of different coding
114 systems characterizing spelling attempts in several languages (see Treiman et al., 2019 for a
115 recent review and systematic comparison of some of those). Spelling error coding schemes
116 vary in nature and focus, from the characterization of the phonological or orthographic
117 plausibility/legality or visual similarity of early or atypical spellings (see, for examples,
118 Bishop & Clarkson, 2003; Bruck & Waters, 1988; Masterson & Apel, 2010; Protopapas et
119 al., 2013; Treiman, 1993), to more comprehensive schemes also considering the
120 representation of morphological components in spelling (Apel & Masterson, 2001; Bahr et
121 al., 2012; Daffern & Ramful, 2020; Salas, 2020). Because of the developmental focus of the
122 current study, a comprehensive scheme based on the Triple Word Form theory was chosen,
123 based on the seminal work of Bahr et al. (2012). Bahr et al. (2012) provided a comprehensive
124 description of the spelling errors produced by American English typically-developing spellers
125 in grades 1-9, using the framework of the Triple Word Form theory to describe spelling
126 attempts. They used a cross-sectional design and a short free writing task (following the
127 prompt ‘One day, ... had the best day at school.’), to identify the nature of spelling errors
128 produced by children across the school years. Errors were analyzed as either phonological,
129 orthographic or morphological in nature, depending on whether they violated primarily
130 phonological (e.g., *bet* for *belt*), orthographic (e.g., *wat* for *what*) or morphological (e.g.,
131 *wantid* for *wanted*) rules and regularities. Using this Phonological, Orthographic and
132 Morphological Assessment of Spelling (hereafter referred to as POMAS), they found that the
133 majority of errors across all grades were orthographic in nature, with orthographic errors
134 constituting 36%-59% of the total number of errors. They also found that the proportion of
135 each spelling error type followed a linear trend, whereby phonological and orthographic
136 errors reduced in proportion across the years (from 26% to 12% and from 52% to 36%,

137 respectively), whilst the proportion of morphological errors increased, from 7% to 22%,
138 reaching a plateau of around 20% of all errors from grade 5. These data suggest an early
139 reliance on all knowledge types from grade 1, with errors found in all categories, but with a
140 sharp decline in the production of phonological errors between grade 1 and 2, and the
141 emergence of orthographic and morphological knowledge throughout elementary school.
142 More specifically, the errors highlighted difficulties with representing long and unstressed
143 vowels, as well as inflections, throughout the elementary school years. However, errors
144 evolved in the sense that they tended to apply to more complex words in the later grades
145 compared to the early grades (e.g., children might omit the final *e* in *pal* for *pale* in grade 1-4,
146 whereas an older student might only omit it at the junction between morphemes, e.g., *lonly*
147 for *lonely*). Bahr et al. (2012) also showed that children wrote more as they got older. So,
148 despite longer texts, older children produced fewer spelling errors: on average, Grade 1
149 students produced eight misspelling per sample (representing 24% of the words in the
150 sample), whereas Grade 5 students produced four misspellings per sample (representing just
151 3% of the words in the sample).

152 Whilst naturalistic samples of writing provide a window into the type of misspellings
153 children produce as their writing ability grows, more constrained spelling tasks might also
154 provide a different insight. It can be argued that, ultimately, children choose the words they
155 spell when they are given a free writing task, whereas dictation tasks allow researchers to
156 control the spelling targets more carefully. On the other hand, it can also be argued that
157 higher-level processes in free writing tasks (e.g., planning, revising, Flower & Hayes, 1981)
158 and the attention required for those processes may interfere with the spelling process (Fayol
159 et al., 1994). Although it is not the purpose of the present paper to directly compare
160 constrained and unconstrained spelling tasks (this is assessed systematically in other studies –
161 see for example Bigozzi et al., 2017; Magalhães et al., 2020), we included both a free writing

162 and a controlled word dictation task in the present qualitative analysis, so as to account for
163 the kind of spelling errors that may be found for both these tasks.

164 The time course for the development of phonological, orthographic and
165 morphological errors in languages other than English still needs to be investigated. The
166 POMAS represents a promising tool for tracking these developmental changes. A Spanish
167 adaptation of this scheme was used in one study, where it allowed the authors to highlight
168 cross-language similarities and differences in the linguistic knowledge of bilingual students
169 learning to spell both Spanish and English (Bahr et al., 2015). The study revealed that
170 orthographic errors were the most frequent error type in both Spanish and English, despite the
171 transparency of Spanish as compared to English, and specifically that errors with word
172 boundaries, capitalization of proper nouns and silent letters occurred at a high rate in both
173 languages. However, there were also language-specific errors, such as ambiguous letters
174 (e.g., the letter *c*, which may be pronounced as either /k/ or /s/) or syllable synthesis in
175 Spanish (e.g., *te nia* for *tenía*), and unstressed vowels or consonant doubling in English (Bahr
176 et al., 2015). Similarly, Llauro and Tolchinsky (2016) conducted a linguistic analysis of
177 spelling errors in Catalan, a semi-transparent writing system with a rich and transparent
178 morphology. They highlighted the weight of orthographic and word-specific spelling
179 knowledge on spelling performance across elementary grades, whilst morphological and
180 phonological errors represented only a small proportion of errors in their corpus. For French,
181 typological work on the French spelling system was conducted by Catach et al. (1995),
182 providing a repertoire of orthographic patterns and their relationships to corresponding
183 sounds and morphemes. A large corpus of words correctly spelled by most French elementary
184 school students is also recorded in the EOLE database by Pothier and Pothier (2004),
185 providing useful benchmarks for teaching typically-developing students age-appropriate
186 words. This body of work recognizes the importance of all three linguistic knowledge sources

187 in spelling French. However, to our knowledge, the respective weight of phonological,
188 orthographic and morphological errors in the elementary grades has not yet been
189 systematically assessed in French. This is a significant omission for several reasons: 1) for
190 practical reasons, it is important that teachers recognize errors that are typical of a
191 developmental stage of learning to spell French, and those that may be indicative of
192 difficulties in particular areas of the curriculum (e.g. the application of specific phonological,
193 orthographic or morphological knowledge), 2) for clinical reasons, it is important that
194 qualitative spelling error analysis frameworks and benchmarks are available in a range of
195 languages, to serve the assessment of clinical populations (see Broc et al., 2021 for a recent
196 review), and 3) for theoretical reasons, it is important that frameworks and theories are tested
197 in a range of languages, to test their universality and specificities – in our case, to test
198 whether the POMAS and Triple Word Form Theory are applicable to describe spelling errors
199 and track changes in French spelling development.

200 **Aims of the present study.** The present study aims to address this gap, by providing
201 developmental benchmarks for the qualitative analysis of spelling errors in French-speaking
202 elementary school students. It extends previous typological work on the French spelling
203 system, as well as previous work on Triple Word Form Theory, and contributes to recent
204 efforts in characterizing spelling mechanisms in a range of orthographies (Desoete & Van
205 Vreckem, 2018; Limpo et al., 2020). Specifically, we aimed to address the following research
206 questions:

207 1) Does the POMAS lend itself to a French adaptation (POMAS-FR), which
208 would reflect the linguistic sources of misspellings in elementary students'
209 written text production and words-to-dictation? More specifically, do the
210 linguistic sources of misspellings occur in French at similar rates and ages as
211 observed in English (Bahr et al., 2012)?

237 initially tested as part of a wider project on the spelling of French and English children with
238 DLD (blinded for review). Data from all monolingual French participants who were
239 performing within average range on measures of spelling and non-verbal ability, and for
240 whom no educational or developmental concerns were reported by the school and parents,
241 were included in the present study. This sampling resulted in a pool of 194 participants. Table
242 1. presents the characteristics of the participants.

243 Please insert Table 1. here.

244 **Measures.**

245 **Non-verbal ability.** Raven's colored progressive matrices was used to check non-
246 verbal reasoning (Raven et al., 1998) as a background measure. This test has a reliability
247 of .80 and a concurrent validity of .91. Children were presented with a pattern to complete,
248 and they had to choose one out of six options to complete it. Patterns and response options
249 were presented in a colored booklet, and children recorded their response with a pencil on the
250 response sheet.

251 **Word spelling.** Single word spelling was tested using the standardized 'Orthographe'
252 subtest of the Wechsler Individual Achievement Test – Second Canadian French version
253 (WIAT-II CDN F, Wechsler, 2005). This test has a reliability of .91. Children were provided
254 with a word within a sentence, which they had to spell on a lined response sheet. The word
255 list increased in difficulty and the task was discontinued after six consecutive word errors, as
256 per the test manual instructions. For this reason, only the first 17 words of this task were
257 analyzed qualitatively here, as they were spelled by all children who performed this task. The
258 list of 17 words and their characteristics is provided in supplementary material S1. They were
259 representative of a range of phonological, orthographic and morphological challenges of the
260 French spelling system. Cronbach's alpha the 17 words was 0.98, indicating strong internal
261 consistency for this short list. Children's raw score on the full list of words correlated poorly

262 with their raw score on the 17 words ($r = -0.07$, $p = .37$) but moderately with the number of
263 spelling errors coded on the 17 words (see data coding procedure below - $r = -0.41$, $p < .001$).
264 The spelling standard scores obtained from the full list of words attempted is reported in
265 Table 1.

266 **Text sampling.** Personal narrative texts were collected using a French adaptation of
267 the prompt from the study by Bahr et al. (2012). Children had half a minute to choose one of
268 the following prompts: “Un jour à l’école, j’ai eu la pire des journées. ...” (“One day, at
269 school, I had the worst day ever.”) or “Un jour, à l’école, j’ai eu la meilleure des journées. ...”
270 (“One day, at school, I had the best day ever.”). They then wrote for five minutes to the
271 chosen prompt. At the end of the five minutes, they were asked to finish their sentence and
272 put their pens down. They were able to make corrections by crossing out only, within the five
273 given minutes. Only the final (uncrossed) words were analyzed.

274 **Procedures.**

275 **Administration.** All children were administered the tasks in small groups of up to
276 eight students, in a quiet room within their school. They were administered the word spelling
277 task, followed by the Raven’s matrices, and the narrative writing task. Altogether, the session
278 lasted 25-35 minutes.

279 **Data coding.** All words produced within the dictation and narrative tasks were
280 transcribed into a spreadsheet, one line per word. Each word spelling was coded as either
281 correct or incorrect, as a first step, before qualitative analysis. The Phonological,
282 Orthographic and Morphological Assessment of Spelling (POMAS) coding scheme was
283 adapted from Bahr et al. (2012) in a three-step iterative process. An initial adaptation of the
284 coding scheme was produced inductively for French, using a subsample of 10 texts per year
285 group, and with reference to previous typological work from Catach et al. (1995), and to the
286 coding scheme from Bahr et al. (2012). Each spelling error from the words identified as

287 incorrect was assigned to one of the three categories from POMAS, depending on whether it
288 affected primarily the phonological, orthographic or morphological form of the word. There
289 could be more than one spelling error per word, and thus more than one error type coded for a
290 given word. Spelling errors were also given a subcategory relevant to the French spelling
291 system (e.g., cluster reduction within the phonological category, or word boundary error
292 within the morphological category), which allowed for a fine-grained description of the
293 common errors found in our French sample. These subcategories also stemmed from previous
294 typologies in both French and English, and aimed to capture the specific sources of potential
295 difficulties for French spelling, and errors that might be language-specific (e.g., accent-based
296 errors) and errors that might be found in other languages (e.g., phonological cluster errors).
297 This was done jointly by two French Speech and Language Pathology (SLP) masters
298 students, with regular input from the first author, leading to discussions, coding decisions and
299 adaptations to the coding scheme. Another 10 samples per year group were then further
300 coded blindly by each of the SLP students using this adapted French POMAS. This second
301 round of coding was then discussed with the first author, disagreements resolved, and further
302 adjustments made to the coding scheme. Interrater agreement on this subsample, which
303 represented over 25% of the total sample, was .79 (Cohen's Kappa). The remaining texts
304 were randomly assigned to the two students to code following the agreed coding scheme,
305 with any remaining problematic exemplars discussed between the two students and first
306 author, and final coding decisions on those were agreed within the team.

307 This coding scheme was then applied to the 17 first words obtained from the
308 dictation. A new team of French coders was involved, including a SLP masters student and a
309 research assistant. Each coder was trained to use the scheme with a subset of two dictation
310 samples per year group (N = 10 dictation samples per coder). This round of coding was then
311 discussed with the first and second author, and understanding of the coding scheme was

312 refined and decisions recorded for future application to the rest of the data. A second round of
313 coding on another two samples per year group ($N = 10$) allowed for further refinement and
314 decisions to be made with the first and second author. At this point it was agreed that the
315 coders felt confident enough applying the coding scheme, and the rest of the data was then
316 coded independently. Only problematic exemplars were discussed with the first and second
317 authors at this final round of coding, and decisions made on those after discussion. In order to
318 check inter-rater reliability, the first author also coded ten randomly-selected samples from
319 this last round of coding from each coder. Cohen's Kappa between Coder 1 and the first
320 author reached 0.92, whilst Cohen's Kappa between Coder 2 and the first author reached
321 0.95.

322 The French POMAS coding scheme resulting from this procedure is provided in
323 supplemental material S2, with a description and examples for each fine-grained error type,
324 for future replications and adaptations.

325 **Results**

326 **Analytical approach**

327 Text productivity (measured in the number of words produced in a text) and spelling
328 accuracy (measured as the proportion of correctly spelled words within the texts or the 17
329 words-to-dictation) are considered in the first instance. Phonological, orthographic and
330 morphological errors (out of the total number of misspellings) are then compared across
331 grades, following the POMAS-FR coding. Finally, a qualitative description of the different
332 types of errors found in French elementary school is provided. For all quantitative grade
333 comparisons, robust one-way ANOVAs with linear contrasts were computed, using the
334 `t1way()` and `lincon()` functions from the WRS2 package in R (R Core Team, 2020). Effect
335 sizes are reported using a robust explanatory measure of effect size from the same package,
336 with ξ -values of 0.10, 0.30, and 0.50 indicative of small, medium, and large effects (Mair &

337 Wilcox, 2020). Robust methods were used to account for some degree of skewness in the
338 phonological errors and productivity variables and for unequal variance in the phonological
339 errors, productivity and accuracy variables.

340 Productivity and accuracy This section considers changes in productivity and spelling
341 accuracy across grades, to account for the expected spelling growth within our sample, before
342 proceeding to qualitative error analysis using the POMAS-FR. There were significant and
343 large differences between grades in productivity ($F(4, 50.99) = 43.66, p < .001, \xi = 0.66$) for
344 the texts and in spelling accuracy for both the texts ($F(4, 51.28) = 31.75, p < .001, \xi = 0.85$)
345 and the 17 words-to-dictation ($F(4, 49.81) = 116.92, p < .001, \xi = 0.84$). More specifically,
346 productivity and accuracy increased between Grade 1 and 2, between Grade 2 and 3 and
347 between Grade 4 and 5, but not between Grade 3 and 4, as shown in Table 2

348 Table 2. Number of words misspelled, number of words produced (productivity),
349 percentage of words correctly spelled (accuracy) and results of the linear contrasts between
350 grades for productivity and accuracy.

351 Of the 194 children, two children produced no misspelling in their texts: one child in
352 Grade 1, who produced nine words and one child in Grade 4, who produced 10 words, all
353 correctly spelled. The dictation task was not attempted by two children in Grade 1, who were
354 not included in any of the dictation analyses. Of the remaining 192 children, all produced at
355 least one error on the target 17 dictated words, except one child in Grade 3, five children in
356 Grade 4 and seven children in Grade 5, who spelled all 17 words correctly.

357 Please insert Table 2

358 *Table 2. Number of words misspelled, number of words produced (productivity), percentage of words*
359 *correctly spelled (accuracy) and results of the linear contrasts between grades for productivity and*
360 *accuracy.*

361 here.

362 **POMAS-FR**

363 In this section, we aim to address our first research question and test the suitability of
364 the POMAS-FR to track developmental changes in linguistic sources of spelling knowledge
365 in French. The mean proportion and mean number of each error type per grade is provided in
366 Table 3.

367 **Texts**

368 The two children who had produced no errors in their texts were not included in the
369 qualitative analysis. One child in Grade 1, whose misspellings were all illegible, was also
370 excluded. For the remaining 191 children, there were significant and large differences
371 between grades in the proportion of phonological ($F(4, 50.8) = 11.05, p < .001, \xi = 0.49$),
372 orthographic ($F(4, 51.19) = 7.02, p < .001, \xi = 0.44$) and morphological errors ($F(4, 51.49) =$
373 $14.05, p < .001, \xi = 0.56$). The proportion of phonological and orthographic errors decreased
374 in the older grades, whilst the proportion of morphological errors increased.

375 More specifically, as shown in Table 3

376 *Table 3. Record of each error type in proportion of total errors and in raw numbers.*

377 , a significant decrease in the proportion of phonological errors was recorded between
378 Grades 1 and 3 (from 15% to 2%, $\Psi = 13[5 ; 22], p = .005, \xi = 0.94$), followed by a plateau in
379 Grades 3 to 5 (around 1-5% $\Psi = 1[-5 ; 7], p = .58, \xi = 0.12$). The proportion of orthographic
380 errors decreased steadily between Grades 1 and 5 (from 42% to 21%, $\Psi = 21[6 ; 37], p =$
381 $.003, \xi = 0.59$), with no significant single grade-on-grade decrease. Finally, the proportion of
382 morphological errors increased steadily in proportion between Grades 1 and 5 (from 40% to

383 74%, $\Psi = -34[-51 ; -18]$, $p < .001$, $\xi = 0.96$), with a sharp increase between Grade 2 and 3
384 (from 47% to 63%, $\Psi = -17[-33 ; 0]$, $p = .02$, $\xi = 0.50$).

385 **Dictation**

386 The children who had not attempted the dictation task or who did not produce any
387 errors on this task were excluded from the present qualitative analysis. For the remaining 179
388 children, there were significant and large differences between grades in the proportion of
389 phonological errors ($F(4, 46.33) = 9.76$, $p < .001$, $\xi = 0.39$) but not in the proportion of
390 orthographic ($F(4, 45.59) = 1.81$, $p = .14$, $\xi = 0.37$), or morphological errors ($F(4, 44.01) =$
391 1.91 , $p = .12$, $\xi = 0.36$) produced in the first 17 words-to-dictation.

392 More specifically, as shown in Table 3, there was a significant and steady decrease in
393 the proportion of phonological errors between Grades 1 and 5 (from 20% to 1%, $\Psi = 18[9;$
394 $28]$, $p < .001$, $\xi = 0.98$), with no significant single grade-on-grade decrease, whilst the
395 proportion of orthographic (from 62% to 79%, $\Psi = -17[-37; 3]$, $p = .17$, $\xi = 0.34$) and
396 morphological errors (from 17% to 8%, $\Psi = 8[-10; 27]$, $p = .75$, $\xi = 0.21$) remained relatively
397 stable between Grades 1 and 5.

398 Please insert Table 3

399 *Table 3. Record of each error type in proportion of total errors and in raw numbers.*

400 here

401 **Fine-grained description of French misspellings across elementary school years**

402 This section provides a qualitative description of the specific error types found in each
403 category of the POMAS-FR, in response to our second research question. A complete table of
404 the frequency and percentages for each error type, per grade, is available in supplementary
405 material S3 (for the texts) and S4 (for the words-to-dictation).

406 **Phonology.** In the texts, whilst the grade comparisons were marked by a decrease in
407 the proportion of phonological errors, the nature of these phonological errors did not change

408 across grades. In grade 1 and 2, a relatively high frequency of phoneme substitutions (*pitit* for
 409 *petit* -*little*, N = 71 in total across all grades), phoneme omissions, additions or inversions (*voi*
 410 for *voir* -*to see*, *plarfond* for *plafond* -*ceiling*, *avce* for *avec* -*with*) N = 70 in total across all
 411 grades) and errors with complex and contextual graphemes (*mouons* for *moins* -*less*, *ausi* for
 412 *aussi* -*also*) were found. This last error type was the most frequent type of phonological error
 413 across grades (N = 80 in total across all grades). A similar pattern of phonological errors -
 414 with a high frequency of phonological omissions, additions and inversions - was observed in
 415 the dictation samples, (*tuli* for *tulipe* -*tulip*, *accespte* for *accepte* -*accepts*, *doirte* for *droite* -
 416 *right*, N = 112 across grades), phonological substitutions (*tilipe* for *tulipe* -*tulip*, N = 95
 417 across grades), and errors on complex (*man* for *main* -*hand*) and contextual graphemes
 418 (*dessigne* for *désigne* -*refers to*) affecting phonology (N = 88 across grades), all found largely
 419 in the first two grades of elementary school.

420 **Orthography.** In the texts, the nature of orthographic errors was also consistent
 421 across grades, with a decrease in frequency for most error types. Phonologically-plausible
 422 grapheme substitutions (*ponney* for *poney* -*pony*, N = 266 in total across all grades) and
 423 silent letter omissions/substitutions/additions (*toujour* for *toujours* -*always*, N = 235 in total
 424 across all grades) were the most frequent error types across all grades. Errors with accents
 425 and other signs (*â* for *à*) were also frequent in the early grades and they remained frequent in
 426 later grades (N = 153 in total across all grades). A similar pattern was observed for the
 427 dictated words, where errors on silent letters (*plafon* for *plafond* -*ceiling*, N = 406 across all
 428 grades) and phonologically-plausible grapheme substitutions (*min* for *main* -*hand*, N = 385
 429 across all grades) were the most prominent type of orthographic errors, especially in Grades 1
 430 and 2.

431 **Morphology.** Morphological errors were dominated by word boundary errors (mostly
 432 liaison or contraction, e.g., *mon nanniversaire* for *mon anniversaire* -*my birthday*, or *jai* for

433 *j'ai -I have*) in Grades 1 and 2 (N = 240 in total across all grades). From Grade 2 onwards,
434 errors with verb agreement (tense, person or gender/number marking in verb phrases, e.g., *je*
435 *suis tomber* for *je suis tombé -I fell*) became particularly prominent (N = 419 in total across
436 all grades), as well as other -nonverb- agreement errors (number and/or gender marking in
437 noun phrases, e.g., *mes copine* for *mes copines -my friends*, N = 233 in total across all
438 grades), and homophone substitutions (e.g., *on à fait* for *on a fait*, N = 210 in total across all
439 grades). In the dictation, the pattern of errors was more consistent across grades, with a
440 majority of word boundary errors (*au'jour d'ui* for *aujourd'hui -today*, N = 88 across grades),
441 and a moderate frequency of errors with verb (*grimpat* for *grimpa - [he] climbed*, N = 69
442 across grade) and derivational morphology (*commencemant* for *commencement - [the]*
443 *beginning*, also N = 69 across grades).

444 Discussion

445 The present study used an iterative process to generate an adaptation of the POMAS
446 for French spelling error analysis (POMAS-FR) and to analyze free five-minute written
447 narratives and 17 words-to-dictation from 194 elementary school French students. This
448 process resulted in a 14-category grid, capturing the three linguistic source types of the
449 POMAS and accounting for misspellings found in our French sample. Quantitative analysis
450 of the samples showed, as expected, that older students produced longer and more accurate
451 texts than their younger peers, and more accurate words-to-dictation. The qualitative analysis
452 using the POMAS-FR demonstrated that text misspellings were primarily morphological in
453 nature, from as early as the second year of schooling, whilst orthographic errors dominated in
454 the first year. As seen in English texts (Bahr et al., 2012), phonological and orthographic
455 errors decreased proportionately throughout the elementary grades, whilst morphological
456 errors increased in proportion. A different trend was observed in the words-to-dictation,
457 where only phonological errors decreased in proportion and orthographic errors dominated

458 across the five elementary grades. Fine-grained analysis of the text misspellings identified
459 that morphological errors were found at word boundaries in first grade, whilst they were
460 affecting mostly verb and non-verb agreement from Grade 2 onwards. Complex and
461 contextual graphemes also appeared to be a source of difficulty in both the texts and words-
462 to-dictation, affecting the phonological plausibility of written words early on, and their
463 orthographic accuracy in late elementary school. Silent letters were also an important source
464 of orthographic misspellings in both the text and dictation samples.

465 **Spelling error analysis as a window into linguistic knowledge involved in French**
466 **spelling across primary grades**

467 By attempting a direct adaptation of the POMAS to French, the present study aimed
468 to assess the suitability of this three-category linguistic framework for describing French
469 misspellings in elementary school. Of all the spelling errors coded across our sample (N =
470 3763 in total across both tasks), all could be attributed to one or the other of the three
471 categories, and all three linguistic error types were present across the sample. After
472 discussions about the different subcategories, agreement could be reached, with no overlap
473 between categories. In that sense, our coding scheme differed from that of Bahr et al. (2012),
474 who allowed for between 10% and 20% of errors in their elementary education samples either
475 to be not coded, or to be in mixed/overlapping categories. We made the choice, by contrast,
476 to make these categories mutually exclusive, and to agree on the most suitable category for a
477 given error through discussions within the coding team. These discussions led to the
478 refinement of the coding scheme and to potentially controversial decisions. For example, we
479 posited that errors on complex and contextual graphemes were phonological in nature if they
480 affected the phonological plausibility of a words (e.g., *mian* for *main*, coded as an ‘Error on a
481 complex grapheme affecting phonology’) but orthographic in nature if it did not affect
482 phonological plausibility (*min* for *main*, coded as an “orthographic substitution error”). In

483 principle, both of these errors likely stem from a lack of knowledge for a complex grapheme
484 (i.e., in this case the trigraph *ain*, representing $\tilde{\epsilon}$, which may be spelled in French *in/ain* or
485 even *im/aim* depending on the context), rather than a misrepresentation of the word's
486 phonological structure within the child's phonological lexicon. Indeed, in other coding
487 schemes, these might both have been coded as orthographic errors (e.g., see for example the
488 'Mental Graphemic Representation' category of errors proposed by Apel & Masterson, 2001,
489 which could have been applied to both errors above). The strong interrater reliability of our
490 coding in both teams of coders suggests strong commonalities in our understanding of the
491 linguistic knowledge involved in French spelling. And in fact, between-category
492 disagreements were rare once the coding scheme was established and all coders trained.

493 Another early source of ambiguity during the coding process stemmed from
494 subcategories of errors that could overlap within a category. For example, within the
495 phonological category, a cluster reduction (e.g., *ros* instead of *gros*) could be considered to be
496 both a 'Phonological cluster error' and a 'Phonological omission' error within our scheme.
497 For these errors, we prioritized what we reasoned to be the potential source of the error (e.g.,
498 here the cluster, which might be difficult to perceive and represent for some children early
499 on), rather than a descriptive labelling of the error (e.g., an omission). Similarly, within the
500 orthographic category, discussions happened around potentially overlapping categories such
501 as 'Orthographic omissions' and 'Orthographic - silent letters'. Again, an error such as the
502 omission of the silent letter *d* at the end of *plafond* could have been attributed both these
503 codings – and again, we decided to provide a label that would indicate the potential pattern
504 on which the error occurred (e.g., here the final silent letter *d*, which seemed to be a common
505 source of error, and could be replaced by other common silent letters, as well as omitted),
506 rather than describe its nature (the omission per se).

507 The POMAS allowed us to anticipate the type of knowledge that would have led to a
508 correct spelling for the child's attempt, with clear implications for teaching and scaffolding
509 spelling knowledge. For example, a teacher who analyzed the spelling attempts described
510 above might be able to focus their lesson on particular aspects of spelling that remain difficult
511 for their class. Following the examples above, they might focus their lesson on teaching the
512 complex grapheme *ain*. However, for those students who produced *mian* for *main*, they
513 might explicitly teach the strategy of checking phonological plausibility (e.g., does *mian*
514 represent all the sounds for /mɛ/?). For those students who have produced *min* for *main*, they
515 might specifically teach orthographic strategies (e.g., teaching the analogy between *main*, and
516 *pain*, *train*, *grain*, *gain*, *nain* or other monosyllabic nouns ending in *ɛ* with the same spelling
517 pattern). The idea that spelling error analysis can inform teaching is not new. However, often
518 spelling error analysis systems have been applied to early and/or invented spellings (Lee &
519 Al Otaiba, 2017; Stage & Wagner, 1992; Tangel & Blachman, 1992; Treiman et al., 2019),
520 and have not considered the breadth of linguistic knowledge children may develop as they
521 evolve through the elementary years (but see the recent study by Daffern and Fleet (2021),
522 using the Triple Word Form Theory to inform targeted teaching of spelling in Grades 3-6).

523 Another potential application of the POMAS-FR might be the detection of children
524 with difficulties in specific language domains (e.g. children with DLD, see recent qualitative
525 spelling error analyses for French spellers with DLD by Broc et al., 2014; Godin et al., 2018;
526 Joye et al., 2020, and see Broc et al., 2021 for a review of the type of spelling errors produced
527 by this population in a range of languages). With this French adaptation of the POMAS, we
528 hope to provide a comprehensive system of analysis for the elementary years, that highlights
529 the importance of not only phonological and orthographic but also morphological knowledge
530 in spelling French accurately. We also hope to provide developmental benchmarks against
531 which a range of atypical French-speaking populations may be assessed in future.

532 **Finding a fit-for-purpose spelling task for spelling error analysis**

533 One of the striking findings of the current study was the discrepancy in quantitative
534 spelling results between the dictation and text production tasks. Whilst text length increased
535 with age, so did spelling accuracy, meaning the number of spelling errors remained relatively
536 stable across the elementary ages (between 8 and 12 errors coded across all grades), offering
537 opportunities for a broad range of errors at all grades. On the other hand, accuracy on the 17
538 words from the dictation reached a ceiling after Grade 3, which left very few spelling errors
539 to code in the later grades (between 2 and 5 errors coded on average in Grades 3 to 5, as
540 opposed to 12 and 20 on average in Grades 1 and 2), and very little scope for tracking trends
541 in the sources of phonological, orthographic and morphological knowledge involved in later
542 grades. This may be overcome in future studies by developing dictation tasks that provide a
543 broader range of opportunities for spelling error across grades. Recent efforts have been made
544 in this direction in English (see for example the pseudoword spelling task developed by
545 Daffern & Ramful, 2020), but are yet to be replicated in French and other languages.
546 Qualitatively, however, there was some consistency between the types of errors found in both
547 tasks, and opportunities for most error types were present in the 17 words selected, as 13 of
548 the 14 categories of the POMAS-FR were applied to code those, and some consistency in the
549 distribution of subcategories of errors across grades for both tasks. This suggests that
550 regardless of the task used, orthographic patterns such as silent letters and complex and
551 contextual graphemes are recurrent and long-lasting sources of difficulties in French spelling,
552 in line with the opacity of the French orthographic system described in introduction.

553 **Why is morphology so difficult in French?**

554 An important aspect of our analysis was the importance of morphological errors. This
555 is in contrast with previous studies in American English (Bahr et al., 2012) and Catalan
556 (Llaurado & Tolchinsky, 2016; Salas, 2020), where orthographic errors represented the

557 majority of misspellings. Firstly, there is an extensive literature on the role of derivational
558 morphology in learning to spell French (Pacton et al., 2013; Sénéchal et al., 2006). Secondly,
559 there is also evidence suggesting that applying verb agreements in French spelling is a highly
560 demanding activity in terms of attention and cognitive resources, even in skilled French
561 spellers (Fayol et al., 1994). We thus expected morphological knowledge to play an important
562 part in the errors found in our sample. Certainly, our results exceeded our expectations, with
563 over 70% of text errors being classified as morphological in nature in the last year of
564 elementary school (compared to about 20% of errors in the English sample of Bahr et al.,
565 2012). By comparison, orthographic and phonological errors represented a small proportion
566 of the errors encountered in our text samples (around 20% and 1% respectively in Grade 5),
567 compared to their American English sample (around 40% and 15% respectively, also in
568 Grade 5). It is also worth mentioning that although in proportion, morphological errors
569 increased in texts, in relative number, they remained relatively stable (around 6-8
570 morphological misspellings per sample across the elementary grades). In fact, when
571 opportunities for those morphological errors were constrained to only a couple of words in
572 the dictation task, they remained relatively low, and decreased to marginal levels in the later
573 grades (from 17 to 8% in proportion, from 3 to 0 in raw numbers between Grade 1 and 5).

574 Their nature, however, changed over time: from segmentation and liaison errors in
575 Grade 1, they became primarily agreement (and in particular verb agreement) errors in later
576 grades. Unconventional segmentations in early spelling have been reported in other languages
577 and they have been related to reading, vocabulary and morphological awareness (Correa &
578 Dockrell, 2007), suggesting that exposure to written language and increasing decoding skills
579 support the development of orthographic and morphological knowledge for early word
580 segmentation -and spelling. In our coding, we had also highlighted specific oral and written
581 conventions (liaisons and contractions) as potential sources of errors. The large number of

582 unconventional segmentations at the point where liaisons happen in oral language seems to
583 reflect refinement mechanisms that happen in French *oral* lexicon development. Indeed,
584 errors such as ‘*un nèbre*’ for ‘*un zèbre*’ (*a zebra*) are still present in 5-6 year olds’ oral
585 language, and are relatively common in 4-5 year-olds (Chevrot et al., 2005).

586 The emergence of errors with inflectional morphology in later grades suggests that
587 once children acquire a set of functional words for them to spell -and segment- correctly, they
588 may attempt longer and more complex sentences requiring the application of agreement. This
589 argument is partially supported by the overall increase in text length across elementary
590 grades, and by the comparatively low frequency of these errors in the dictation task in later
591 grades. Analysis of sentence length and complexity might provide further evidence in that
592 direction.

593 The relatively low number of errors with derivational morphemes in the texts is also
594 noteworthy. If inflectional morphology seems to represent a source of difficulty in our
595 sample, derivational morphemes, on the other hand, are a source of consistency that might
596 support rather than hinder French spelling (Casalis et al., 2018). There was a very low
597 occurrence of this error type in our text sample, and we consider this low error rate an
598 indicator of the consistency of these units in spelling French. The inclusion of the derived
599 word ‘*commencement*’ (*the beginning*) in the dictation did result in some errors of this nature,
600 but they were largely restricted to Grade 1 and 2. The inclusion of more morphologically-
601 complex words in future dictation tasks may allow to track the development of a broader
602 range of prefixes and suffixes relevant to learning to spell French.

603 Recently, Weth (2020) called for “syntactic” markers to be distinguished from
604 “morphological” (derivational) markers in spelling (but see also Morin et al., 2018; Van
605 Reybroeck, 2020 for a similar argument). Our data for French also suggests different
606 mechanisms might be at play in the spelling of syntactic and derivational units, with

607 syntactic/inflectional spelling being a particularly important element of spelling competence
608 in French.

609 **Spelling developmental trajectories: teaching/learning phases or interplay between**
610 **different linguistic knowledge sources at all grades?**

611 In terms of the trends observed across elementary school, there were some similarities
612 between our results and those of the American study by Bahr et al. (2012). In both our study
613 and theirs, the proportion of morphological errors in texts increased linearly throughout the
614 elementary grades, whilst orthographic and phonological errors decreased. It was the rate of
615 each of these error types that differed in the two languages (orthographic errors being the
616 main source of errors in English, whilst morphological errors were the main source of errors
617 in our French data). This overall trend in results suggests a development of spelling
618 competence relying more and more on morphological knowledge as children get older. There
619 are several possible interpretations to these data. On the one hand, this seems consistent with
620 phase theories of spelling development, which consider morphology to be a later acquired
621 spelling skill, whilst the early stages of learning to spell focus primarily on phonological and
622 orthographic mappings (Ehri, 1987; Frith, 1980). On the other hand, this is also consistent
623 with the French curriculum. –Because French includes many (and often silent) morphological
624 markers on verbs, the teaching of inflectional morphology spelling only starts at grade 2 and
625 continues until the end of middle school (Ministère de l'éducation nationale, 2020), well
626 beyond the age range for this study. The more inflectional markers children know, the more
627 they try to use them and the more mistakes are made initially.

628 Nevertheless, our fine-grained analysis of errors also suggests some interplay between
629 the different knowledge sources early on. For example, morphological segmentation and
630 word boundary errors often related to the application of phonological (e.g. *mon nanniversaire*
631 (my birthday), where the liaison is phonologically represented) or orthographic knowledge

632 (e.g. *ma méière à mi* [*ma meilleure amie*] (*my best friend*), where word segmentation likely
633 reflects the child's sensitivity to frequent words they have read or seen in writing *-à-*, as well
634 has their use of phonological information, *-mi-*). Similarly, morphological errors with word
635 agreement, already present in the earliest spellers' data, also reflected young children's
636 sensitivity to common orthographic patterns (e.g. *on écrie* (we write), where the final silent
637 letter *-e* likely reflects the child's orthographic sensitivity to the frequent final silent letters of
638 French). So, if different developmental moments seem to represent specific challenges, it also
639 seems that the full range of linguistic knowledge types are present and interacting early in the
640 spelling of French students (consistent with Bahr et al., 2012; Llauro & Tolchinsky, 2016;
641 Salas, 2020).

642 **The importance of looking across languages to identify the markers of development in**
643 **spelling and writing competence**

644 The patterns of development in each linguistic error type described above needs to be
645 considered in the context of the overall development of spelling and writing. In our French
646 sample, children's text production increased from an average of 11.05 words per text in 5
647 minutes, with 6.65 misspelled words in Grade 1, to writing an average of 40.74 words per
648 text and 6.89 misspelled words in Grade 5. It is worth noting that in the English study of Bahr
649 et al. (2012), productivity and accuracy were much higher (from 7.88 misspelled words out of
650 34.1 produced in grade 1 to 3.91 misspelled words out of 127.6 in grade 5). So effectively,
651 productivity and accuracy levels were similar in Grade 1 of the first (English) study, and in
652 Grade 5 of our (French) study.

653 There may be a number of methodological and contextual explanations for this
654 difference in productivity and accuracy (e.g., the fact that accuracy and productivity were
655 averaged across two different writing tasks in the American sample, and the fact that there is
656 little focus at present on writing practice in the French curriculum). Nevertheless, our result

657 seems consistent with direct comparisons of French and English written samples from
658 children with DLD (assessed on the same task and in the same conditions, blinded for
659 review), which have shown discrepancies between productivity and accuracy rates in writing
660 tasks across French and English, with the English students producing more writing overall
661 and more accurate texts. This suggests that French inflectional morphology may not only
662 represent a constraint for spelling, but for writing more generally. This is also in line with at
663 least one previous study contrasting English (orthographically opaque and morphologically-
664 simple and transparent), Catalan (semi-transparent and morphologically-rich and transparent)
665 and Spanish (transparent, both orthographically and morphologically) on a comparable
666 writing task (Llaurado & Dockrell, 2020). Only in the most opaque orthography (English)
667 was spelling predictive of writing quality, whilst reading skills and handwriting determined
668 text quality and productivity in the more transparent languages. With its high orthographic
669 and morphological opacity, French writing productivity and quality may also well be
670 hindered by spelling (and particularly morphological spelling), even in comparison to
671 English.

672 **Limitations and recommendations**

673 Despite the unique contribution of our study there are a number of limitations which
674 impact the conclusions. Participants were drawn from only three schools, just under 200
675 participants in the sample, and only monolingual students were included in the current
676 analysis. Future studies may consider both bilingual and monolingual learners in separate
677 analyses (see Salas, 2020, for an example of such analyses). Furthermore, the words from the
678 dictation task, whilst representative of a range of spelling difficulties of the French
679 orthographic system, was not balanced for opportunities in each linguistic knowledge type.
680 Future studies may address this by providing a controlled set of words or pseudowords (see
681 Daffern & Ramful, 2020 for an example in English). Similarly, whilst ecologically valid, our

682 writing task was free and so gave children the opportunity to choose the words they spelled.
683 Finally, the overall relationship between linguistic spelling-related skills, spelling and writing
684 was not formally explored in the present study. We restricted our analysis to the development
685 of the coding scheme and its use to provide a linguistic snapshot of the spelling errors
686 produced in French for each year group. Further studies may want to explore this link further,
687 as a way to further investigate the linguistic skills underpinning spelling and writing in
688 French.

689 **Conclusion**

690 The present study offers a characterization of the spelling errors produced by French
691 children across elementary grades. It adapts and uses a linguistic coding scheme, based on
692 Triple Word Form Theory, POMAS, for French. The resulting coding scheme (POMAS-FR)
693 is available in this paper and open to further adaptations and applications to a range of
694 clinical populations. In the present analysis, it allowed us to highlight the weight of
695 morphological knowledge (and especially knowledge and application of verb agreements) in
696 spelling competence in French. It also showed the progressive shift in spelling competence,
697 from relying on phonological and orthographic knowledge in the early phases of spelling, to
698 relying more heavily on morphological knowledge as sentences become more complex.
699 There are some commonalities and differences between the present results and those of
700 previous studies in either more or less transparent languages. The combined evidence
701 indicates that spelling competence draws on a growing range of linguistic skills as children
702 become more proficient spellers. However, the type of linguistic skills children rely on at the
703 different stages may vary, depending on the opacity and morphological complexity of the
704 language considered.

705 **Acknowledgements**

706 We would like to thank the schools and children who participated to this study. We
707 would also like to thank Ruth Bahr and Elaine Silliman for providing an American English
708 version of POMAS for the present French adaptation, and Jeanne Lebrun, Pamela Parent,
709 Charlotte Texier and Sandrine Belkadi for their help with data coding.

710 References

- 711 Apel, K., & Masterson, J. J. (2001). Theory-guided spelling assessment and intervention: A
 712 case study. *Language, Speech, and Hearing Services in Schools, 32*(3), 182–195.
- 713 Bahr, R. H., Silliman, E. R., & Berninger, V. W. (2009). What spelling errors have to tell
 714 about vocabulary learning. In C. P. Wood & V. Connelly (Eds.), *Contemporary*
 715 *perspectives on reading and spelling*. Routledge.
- 716 Bahr, R. H., Silliman, E. R., Berninger, V. W., & Dow, M. (2012). Linguistic pattern analysis
 717 of misspellings of typically developing writers in grades 1–9. *Journal of Speech*
 718 *Language and Hearing Research, 55*(6), 1587. [https://doi.org/10.1044/1092-](https://doi.org/10.1044/1092-4388(2012/10-0335))
 719 [4388\(2012/10-0335\)](https://doi.org/10.1044/1092-4388(2012/10-0335))
- 720 Bahr, R. H., Silliman, E. R., Danzak, R. L., & Wilkinson, L. C. (2015). Bilingual spelling
 721 patterns in middle school: It is more than transfer. *International Journal of Bilingual*
 722 *Education and Bilingualism, 18*(1), 73–91.
 723 <https://doi.org/10.1080/13670050.2013.878304>
- 724 Bigozzi, L., Tarchi, C., & Pinto, G. (2017). Consistency and stability of Italian children’s
 725 spelling in dictation versus composition assessments. *Reading & Writing Quarterly,*
 726 *33*(2), 109–122. <https://doi.org/10.1080/10573569.2015.1102111>
- 727 Bishop, D. V. M., & Clarkson, B. (2003). Written language as a window into residual
 728 language deficits: A study of children with persistent and residual speech and
 729 language impairments. *Cortex, 39*(2), 215–237. [https://doi.org/10.1016/S0010-](https://doi.org/10.1016/S0010-9452(08)70106-0)
 730 [9452\(08\)70106-0](https://doi.org/10.1016/S0010-9452(08)70106-0)
- 731 Broc, L., Bernicot, J., Olive, T., Favart, M., Reilly, J., Quémart, P., Catheline, N., Gicquel,
 732 L., & Jaafari, N. (2014). Évaluation de l’orthographe des élèves dysphasiques en
 733 situation de narration communicative: Variations selon le type d’orthographe, lexicale

- 734 versus morphologique. *European Review of Applied Psychology*, 64(6), 307–321.
735 <https://doi.org/10.1016/j.erap.2014.09.004>
- 736 Broc, L., Joye, N., Dockrell, J. E., & Olive, T. (2021). Capturing the nature of the spelling
737 errors in developmental language disorder: A scoping review. *Language, Speech, and*
738 *Hearing Services in Schools*. https://doi.org/10.1044/2021_LSHSS-20-00086
- 739 Bruck, M., & Waters, G. (1988). An analysis of the spelling errors of children who differ in
740 their reading and spelling skills. *Applied Psycholinguistics*, 9(1), 77–92.
- 741 Caravolas, M., Bruck, M., & Genesee, F. (2003). Similarities and differences between
742 English-and French-speaking poor spellers. In *Dyslexia in different languages: Cross-*
743 *linguistic comparisons*. Whurr Publishers. [http://psycnet.apa.org/psycinfo/2003-](http://psycnet.apa.org/psycinfo/2003-02126-008)
744 02126-008
- 745 Caravolas, M., Lervåg, A., Defior, S., Málková, G. S., & Hulme, C. (2013). Different
746 patterns, but equivalent predictors, of growth in reading in consistent and inconsistent
747 orthographies. *Psychological Science*, 24(8), 1398–1407.
748 <https://doi.org/10.1177/0956797612473122>
- 749 Caravolas, M., Lervåg, A., Mousikou, P., Efrim, C., Litavský, M., Onochie-Quintanilla, E.,
750 Salas, N., Schöffelová, M., Defior, S., Mikulajová, M., Seidlová-Málková, G., &
751 Hulme, C. (2012). Common patterns of prediction of literacy development in different
752 alphabetic orthographies. *Psychological Science*, 23(6), 678–686.
753 <https://doi.org/10.1177/0956797611434536>
- 754 Casalis, S., Pacton, S., Lefevre, F., & Fayol, M. (2018). Morphological training in spelling:
755 Immediate and long-term effects of an interventional study in French third graders.
756 *Learning and Instruction*, 53, 89–98.
757 <https://doi.org/10.1016/j.learninstruc.2017.07.009>

- 758 Cassar, M., & Treiman, R. (1997). The beginnings of orthographic knowledge: Children's
759 knowledge of double letters in words. *Journal of Educational Psychology*, 89(4),
760 631–644. <https://doi.org/10.1037/0022-0663.89.4.631>
- 761 Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: Reading acquisition
762 from novice to expert. *Psychological Science in the Public Interest*, 19(1), 5–51.
763 <https://doi.org/10.1177/1529100618772271>
- 764 Catach, N., Gruaz, C., & Duprez, D. (1995). *L'orthographe française* (Nathan Université).
- 765 Chevrot, J.-P., Dugua, C., & Fayol, M. (2005). Liaison et formation des mots français: Un
766 scénario développemental. *Langages*, 39(158), 38–52.
767 <https://doi.org/10.3406/lgge.2005.2661>
- 768 Correa, J., & Dockrell, J. E. (2007). Unconventional word segmentation in Brazilian
769 children's early text production. *Reading and Writing: An Interdisciplinary Journal*,
770 20(8), 815–831. <https://doi.org/10.1007/s11145-006-9049-3>
- 771 Daffern, T., & Fleet, R. (2021). Investigating the efficacy of using error analysis data to
772 inform explicit teaching of spelling. *Australian Journal of Learning Difficulties*,
773 26(1), 67–88. <https://doi.org/10.1080/19404158.2021.1881574>
- 774 Daffern, T., & Ramful, A. (2020). Measurement of spelling ability: Construction and
775 validation of a phonological, orthographic and morphological pseudo-word
776 instrument for students in Grades 3–6. *Reading and Writing*, 33(3), 571–603.
777 <https://doi.org/10.1007/s11145-019-09976-1>
- 778 Desoete, A., & Van Vreckem, C. (2018). Issue editor foreword: Spelling across language
779 systems and languages. *Topics in Language Disorders*, 38(4), 269–271.
780 <https://doi.org/10.1097/TLD.0000000000000169>
- 781 Ehri, L. C. (1987). Learning to read and spell words. *Journal of Literacy Research*, 19(1), 5–
782 31.

- 783 Fayol, M., Largy, P., & Lemaire, P. (1994). Cognitive overload and orthographic errors:
784 When cognitive overload enhances subject–verb agreement errors. A study in French
785 written language. *The Quarterly Journal of Experimental Psychology Section A*,
786 47(2), 437–464. <https://doi.org/10.1080/14640749408401119>
- 787 Flower, L., & Hayes, J. R. (1981). A cognitive process theory of writing. *College*
788 *Composition and Communication*, 365–387.
- 789 Frith, U. (Ed.). (1980). *Cognitive Processes in Spelling*. Academic Press.
- 790 Godin, M.-P., Gagné, A., & Chapleau, N. (2018). Spelling acquisition in French children
791 with developmental language disorder: An analysis of spelling error patterns. *Child*
792 *Language Teaching and Therapy*, 34(3), 221–233.
793 <https://doi.org/10.1177/0265659018785938>
- 794 Joye, N., Dockrell, J. E., & Marshall, C. R. (2020). The spelling errors of French and English
795 children with developmental language disorder at the end of primary school. *Frontiers*
796 *in Psychology*, 11, 1789. <https://doi.org/10.3389/fpsyg.2020.01789>
- 797 Kessler, B., & Treiman, R. (2001). Relationships between sounds and letters in English
798 monosyllables. *Journal of Memory and Language*, 44(4), 592–617.
799 <https://doi.org/10.1006/jmla.2000.2745>
- 800 Lee, J. A. C., & Al Otaiba, S. (2017). End-of-kindergarten spelling outcomes: How can
801 spelling error analysis data inform beginning reading instruction? *Reading & Writing*
802 *Quarterly*, 33(3), 226–238. <https://doi.org/10.1080/10573569.2016.1165639>
- 803 Limpo, T., Salas, N., Van Reybroeck, M., & Castro, S. L. (2020). *Research Topic: Spelling*
804 *Across Orthographies*. Frontiers. [https://www.frontiersin.org/research-](https://www.frontiersin.org/research-topics/9716/spelling-across-orthographies#overview)
805 [topics/9716/spelling-across-orthographies#overview](https://www.frontiersin.org/research-topics/9716/spelling-across-orthographies#overview)

- 806 Llaurado, A., & Dockrell, J. E. (2020). The impact of orthography on text production in three
807 languages: Catalan, English, and Spanish. *Frontiers in Psychology, 11*, 878.
808 <https://doi.org/10.3389/fpsyg.2020.00878>
- 809 Llaurado, A., & Tolchinsky, L. (2016). The developmental pattern of spelling in Catalan
810 from first to fifth school grade. *Writing Systems Research, 8*(1), 64–83.
811 <https://doi.org/10.1080/17586801.2014.1000812>
- 812 Magalhães, S., Mesquita, A., Filipe, M., Veloso, A., Castro, S. L., & Limpo, T. (2020).
813 spelling performance of Portuguese children: Comparison between grade level,
814 misspelling type, and assessment task. *Frontiers in Psychology, 11*, 547.
815 <https://doi.org/10.3389/fpsyg.2020.00547>
- 816 Mair, P., & Wilcox, R. (2020). Robust statistical methods in R using the WRS2 package.
817 *Behavior Research Methods, 52*(2), 464–488. [https://doi.org/10.3758/s13428-019-](https://doi.org/10.3758/s13428-019-01246-w)
818 [01246-w](https://doi.org/10.3758/s13428-019-01246-w)
- 819 Masterson, J. J., & Apel, K. (2010). The spelling sensitivity Score: Noting developmental
820 changes in spelling knowledge. *Assessment for Effective Intervention, 36*(1), 35–45.
821 <https://doi.org/10.1177/1534508410380039>
- 822 McLeod, S. (Ed.). (2007). *The international guide to speech acquisition*. Thomson Delmar
823 Learning.
- 824 Ministère de l'éducation nationale. (2020). *Le BO. Bulletin officiel de l'éducation nationale*
825 *n°31 du 30 juillet 2020*. CNDP Publications administratives.
826 https://www.education.gouv.fr/pid285/bulletin_officiel.html?pid_bo=39771
- 827 Moll, K., Ramus, F., Bartling, J., Bruder, J., Kunze, S., Neuhoff, N., Streiftau, S., Lyytinen,
828 H., Leppänen, P. H., Lohvansuu, K., & others. (2014). Cognitive mechanisms
829 underlying reading and spelling development in five European orthographies.
830 *Learning and Instruction, 29*, 65–77.

- 831 Morin, M.-F., Alamargot, D., Diallo, T. M. O., & Fayol, M. (2018). Individual differences in
832 lexical and grammar spelling across primary school. *Learning and Individual*
833 *Differences*, 62, 128–140. <https://doi.org/10.1016/j.lindif.2018.02.002>
- 834 Pacton, S., & Deacon, S. H. (2008). The timing and mechanisms of children’s use of
835 morphological information in spelling: A review of evidence from English and
836 French. *Cognitive Development*, 23(3), 339–359.
837 <https://doi.org/10.1016/j.cogdev.2007.09.004>
- 838 Pacton, S., Foulin, J. N., Casalis, S., & Treiman, R. (2013). Children benefit from
839 morphological relatedness when they learn to spell new words. *Frontiers in*
840 *Psychology*, 4. <https://doi.org/10.3389/fpsyg.2013.00696>
- 841 Pacton, S., Perruchet, P., Fayol, M., & Cleeremans, A. (2001). Implicit learning out of the
842 lab: The case of orthographic regularities. *Journal of Experimental Psychology.*
843 *General*, 130(3), 401–426.
- 844 Peereman, R., Lété, B., & Sprenger-Charolles, L. (2007). Manulex-infra: Distributional
845 characteristics of grapheme—phoneme mappings, and infralexical and lexical units in
846 child-directed written material. *Behavior Research Methods*, 39(3), 579–589.
- 847 Peereman, R., Sprenger-Charolles, L., & Messaoud-Galusi, S. (2013). The contribution of
848 morphology to the consistency of spelling-to-sound relations: A quantitative analysis
849 based on French elementary school readers. *Topics in Cognitive Psychology–L’Année*
850 *Psychologique*, 113(1), 3–33.
- 851 Pothier, B., & Pothier, P. (2004). *Échelle d’acquisition en orthographe lexicale: Pour l’école*
852 *élémentaire, du CP au CM2*. Retz.
- 853 Protopapas, A., Fakou, A., Drakopoulou, S., Skaloumbakas, C., & Mouzaki, A. (2013). What
854 do spelling errors tell us? Classification and analysis of errors made by Greek

- 855 schoolchildren with and without dyslexia. *Reading and Writing*, 26(5), 615–646.
856 <https://doi.org/10.1007/s11145-012-9378-3>
- 857 R Core Team. (2020). *R: A Language and Environment for Statistical Computing*. R
858 Foundation for Statistical Computing. <https://www.R-project.org/>
- 859 Raven, J., Raven, J. C., & Court, J. H. (1998). *Manuel Matrices Progressives de Raven*,
860 *Section 2: Progressive Matrices Couleur (CPM ou PM47)* (ECPA).
- 861 Salas, N. (2020). Non-phonological strategies in spelling development. *Frontiers in*
862 *Psychology*, 11, 1071. <https://doi.org/10.3389/fpsyg.2020.01071>
- 863 Sénéchal, M. (2000). Morphological effects in children’s spelling of French words. *Canadian*
864 *Journal of Experimental Psychology/Revue Canadienne de Psychologie*
865 *Expérimentale*, 54(2), 76–86. <https://doi.org/10.1037/h0087331>
- 866 Sénéchal, M., Basque, M. T., & Leclaire, T. (2006). Morphological knowledge as revealed in
867 children’s spelling accuracy and reports of spelling strategies. *Journal of*
868 *Experimental Child Psychology*, 95(4), 231–254.
869 <https://doi.org/10.1016/j.jecp.2006.05.003>
- 870 Seymour, P. H. K., Aro, M., Erskine, J. M., & collaboration with COST Action A8 network.
871 (2003). Foundation literacy acquisition in European orthographies. *British Journal of*
872 *Psychology*, 94(2), 143–174. <https://doi.org/10.1348/000712603321661859>
- 873 Share, D. L. (2008). On the Anglocentricities of current reading research and practice: The
874 perils of overreliance on an ‘outlier’ orthography. *Psychological Bulletin*, 134(4),
875 584–615. <https://doi.org/10.1037/0033-2909.134.4.584>
- 876 Stage, S. A., & Wagner, R. K. (1992). Development of young children’s phonological and
877 orthographic knowledge as revealed by their spellings. *Developmental Psychology*,
878 28(2), 287–296. <https://doi.org/10.1037/0012-1649.28.2.287>

- 879 Tangel, D. M., & Blachman, B. A. (1992). Effect of phoneme awareness instruction on
880 Kindergarten children's invented spelling. *Journal of Reading Behavior*, 24(2), 233–
881 261. <https://doi.org/10.1080/10862969209547774>
- 882 Treiman, R. (1993). *Beginning to spell: A study of first-grade children*. New York : Oxford
883 University Press.
- 884 Treiman, R., & Cassar, M. (1996). Effects of morphology on children's spelling of final
885 consonant clusters. *Journal of Experimental Child Psychology*, 63(1), 141–170.
- 886 Treiman, R., Kessler, B., & Caravolas, M. (2019). What methods of scoring young children's
887 spelling best predict later spelling performance? *Journal of Research in Reading*,
888 42(1), 80–96. <https://doi.org/10.1111/1467-9817.12241>
- 889 Van Reybroeck, M. (2020). Grammatical spelling and written syntactic awareness in children
890 with and without dyslexia. *Frontiers in Psychology*, 11, 1524.
891 <https://doi.org/10.3389/fpsyg.2020.01524>
- 892 Wechsler, D. (2005). *Wechsler Individual Achievement Test Second Canadian Edition*.
893 Pearson Canada.
- 894 Weth, C. (2020). Distinguishing syntactic markers from morphological markers. A cross-
895 linguistic comparison. *Frontiers in Psychology*, 11, 2082.
896 <https://doi.org/10.3389/fpsyg.2020.02082>
- 897 Ziegler, J. C., Jacobs, A. M., & Stone, G. O. (1996). Statistical analysis of the bidirectional
898 inconsistency of spelling and sound in French. *Behavior Research Methods*,
899 *Instruments, & Computers*, 28(4), 504–515. <https://doi.org/10.3758/BF03200539>
- 900 Ziegler, J. C., Stone, G. O., & Jacobs, A. M. (1997). What is the pronunciation for-ough and
901 the spelling for/u/? A database for computing feedforward and feedback consistency
902 in English. *Behavior Research Methods, Instruments, & Computers*, 29(4), 600–618.
903

Supplemental material provided

Supplemental material S1 provides a table detailing the characteristics of the 17 words used from the WIAT dictation task.

Supplemental material S2 is a table describing the French POMAS (POMAS-FR) coding scheme, with examples of errors for each category, from both tasks.

Supplementary material S3 provides a contingency table for the number and proportion of each fine-grained spelling error type across grades in text production.

Supplementary material S4 provides a contingency table for the number and proportion of each fine-grained spelling error type across grades in the WIAT dictation task.

Tables

Table 1.

Table 1. Characteristics of the participants

Grade	N (girls)	Mean age (SD)	Mean Raven (SD)	Mean WIAT (SD)
1	32 (19)	6.8 (0.4)	105.2 (15.6)	110.7 (11.2)
2	54 (40)	7.7 (0.3)	102.8 (18.5)	106.8 (7.6)
3	24 (15)	8.6 (0.3)	119.0 (11.8)	105.7 (7.6)
4	41 (23)	9.7 (0.3)	111.0 (12.8)	99.7 (9.9)
5	43 (24)	10.7 (0.4)	109 (11.9)	100.3 (10.8)

Notes. The Raven's Coloured progressive matrices assess non-verbal performance, whilst the Wechsler Individual Achievement test (WIAT) assesses word spelling. Each group's performance on these tests is expressed in standard scores, which have a mean of 100 and a standard deviation of 15. Age is given in years.

POMAS-FR: Misspellings in French Elementary School

Table 2

Table 2. Number of words misspelled, number of words produced (productivity), percentage of words correctly spelled (accuracy) and results of the linear contrasts between grades for productivity and accuracy.

	Grade (N)	Number of words misspelled ¹	Productivity - Number of words produced ¹	Productivity - Comparison to previous grade ²	p^3	ξ^4	Accuracy - Percentage of words correctly spelled ¹	Accuracy - Comparison to previous grade ²	p^3	ξ^4
Texts	1 (32)	6.65 (0.85)	11.05 (0.86)				37.87 (4.91)			
	2 (54)	8.00 (0.93)	19.21 (1.50)	-8 [-13 ; -3]	<.001***	0.62	56.48 (2.51)	-19 [-35 ; -3]	.005**	0.48
	3 (24)	8.69 (1.09)	28.63 (3.10)	-9 [-19 ; 0.3]	.01**	0.43	69.16 (2.85)	-13 [-23 ; -2]	.004**	0.59
	4 (41)	7.16 (0.61)	28.68 (2.63)	0 [-11 ; 11]	.99	0.14	72.97 (2.23)	-4 [-14 ; 6]	.27	0.15
	5 (43)	6.89 (0.91)	40.74 (2.58)	-12 [-23 ; -2]	.007**	0.46	81.35 (1.58)	-8 [-16 ; -0.5]	.007**	0.52
Dictation	1 (30)	11.5 (0.49)	17 (0)				32.35 (2.86)			
	2 (54)	7.79 (0.38)	17 (0)				54.15 (2.23)	-22 [33 , -12]	<.001***	0.96
	3 (24)	4.13 (0.40)	17 (0)				75.74 (2.38)	-22 [-31 ; -13]	<.001***	1.13
	4 (41)	2.96 (0.41)	17 (0)				82.13 (2.40)	-7 [-16 ; 3]	.04	0.33
	5 (43)	1.52 (0.22)	17 (0)				91.07 (1.29)	-8 [-16 ; 0]	<.007*	0.54

Notes. ¹Robust Mean (Standard Error) per grade, computed with 20% trimming, ²Robust paired mean differences Ψ with 95% confidence interval, adjusted for multiple testing, ³significance levels at * $p < .05$, ** $p < .01$, *** $p < .001$, p -values are also adjusted for multiple testing, ⁴robust measure of effect size, with ξ -values of 0.10, 0.30 and 0.50 indicative of small, medium and large effect sizes.

Table 3

Table 3. Record of each error type in proportion of total errors and in raw numbers.

	Grade (N)	Proportion of phonological errors in total errors ¹	Raw number of phonological errors ¹	Proportion of orthographic errors in total errors ¹	Raw number of orthographic errors ¹	Proportion of morphological errors in total errors ¹	Raw number of morphological errors ¹	Total number of all errors produced ¹
Texts	1 (30)	15.27 (2.16)	1.72 (0.25)	42.40 (2.91)	4.39 (0.72)	39.94 (2.88)	4.39 (0.71)	10.83 (1.31)
	2 (54)	10.63 (2.16)	1.32 (0.25)	40.90 (2.94)	4.94 (0.64)	46.62 (3.07)	5.18 (0.70)	12.06 (1.34)
	3 (24)	1.97 (1.86)	0.19 (0.16)	32.28 (4.98)	3.19 (0.70)	63.33 (4.98)	6.75 (0.84)	10.38 (1.44)
	4 (40)	5.19 (1.69)	0.54 (0.21)	24.90 (3.46)	2.00 (0.34)	65.72 (4.17)	5.58 (0.43)	8.71 (0.83)
	5 (43)	0.84 (1.17)	0.11 (0.11)	21.23 (4.56)	1.74 (0.41)	74.33 (5.05)	5.11 (0.61)	7.59 (1.00)
Dictation	1 (30)	19.63 (2.60)	3.94 (0.53)	61.67 (2.31)	11.72 (0.58)	16.83 (0.95)	3.28 (0.15)	19.61 (0.63)
	2 (54)	16.31 (2.61)	1.94 (0.27)	62.75 (2.44)	7.91 (0.36)	18.53 (1.15)	2.24 (0.18)	12.24 (0.75)
	3 (23)	12.17 (5.48)	0.67 (0.31)	71.34 (8.94)	3.67 (0.54)	10.65 (3.76)	0.60 (0.18)	5.33 (0.65)
	4 (37)	12.16 (5.71)	0.50 (0.14)	61.46 (4.78)	2.32 (0.35)	13.66 (4.35)	0.64 (0.22)	3.91 (0.43)
	5 (36)	1.17 (1.96)	0.09 (0.12)	78.73 (6.37)	1.41 (0.23)	8.44 (5.92)	0.27 (0.14)	1.86 (0.34)

Notes. ¹Robust Mean (Standard Error) per grade, computed with 20% trimming