

# Morphology and spelling in French students with dyslexia: the case of silent final letters

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**Abstract** Spelling is a challenge for individuals with dyslexia. Phoneme-to-grapheme correspondence rules are highly inconsistent in French, which make them very difficult to master, in particular for dyslexics. One recurrent manifestation of this inconsistency is the presence of silent letters at the end of words. Many of these silent letters perform a morphological function. The current study examined whether students with dyslexia (aged between 10 and 15 years) benefit from the morphological status of silent final letters when spelling. We compared, their ability to spell words with silent final letters that are either morphologically justified (e.g., *tricot*, “knit,” where the final “t” is pronounced in morphologically related words such as *tricoter*, “to knit” and *tricoteur* “knitter”) or not morphologically justified (e.g., *effort*, “effort”) to that of a group of younger children matched for reading and spelling level. Results indicated that the dyslexic students’ spelling of silent final letters was impaired in comparison to the control group. Interestingly, morphological status helped the dyslexics improve the accuracy of their choice of final letters, contrary to the control group. This finding provides new evidence of morphological processing in dyslexia during spelling.

**Keywords** Dyslexia · Morphology · Silent letters · Spelling

Developmental dyslexia is typically defined as a specific and severe difficulty in learning to read and spell that is unexpected given the individual’s cognitive abilities and the appropriateness of their education (Lyon, Shaywitz, & Shaywitz, 2003). Most existing studies describing and explaining the cognitive and behavioral impairments of individuals with dyslexia have

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focused on their reading difficulties; only a few have investigated spelling difficulties. This reflects the dominant tendency in studies on typical written language development, where spelling studies are “the abandoned stepchild” (Joshi, Treiman, Carreker, & Moats, 2008–2009), largely neglected in favor of reading studies. Nevertheless, individuals with dyslexia often perform even worse in spelling than in reading (Casalis, 2014). Given the importance of spelling abilities for social integration and employment, there is a pressing need to further investigate the spelling difficulties of children with dyslexia. The aim of the present study was to examine how these children represent one of the forms of linguistic information represented in written language: morphological information.

Although few studies have investigated spelling in children with dyslexia, a number have reported impaired spelling in this group compared to children matched for reading level (Casalis, 2014; Plisson, Daigle, & Montésinos-Gelet, 2013) or spelling level (Cassar, Treiman, Moats, Pollo, & Kessler, 2005). The majority of studies looking at spelling errors in dyslexia have focused on the errors’ phonological plausibility (Caravolas & Volin, 2001; Landerl & Wimmer, 2000). This interest can be explained by the phonological nature of the deficit in dyslexia (Boets et al., 2013; Snowling, 2000), which disrupts the application of sound-to-letter mappings and prevents individuals with dyslexia from successfully using the phonological procedure when spelling (Vellutino, Fletcher, Snowling, & Scanlon, 2004). These difficulties limit the ability to learn to spell in languages that use an alphabetic writing system, where writing essentially represents phonemes through graphemes.

However, because of the morphophonological nature of alphabetic orthographies, learning to spell also requires learning to represent morphological information. The representation of this information obeys at least at two principles. First, inconsistent biphones (i.e., adjacent pairs of phonemes that have several possible phoneme–grapheme mappings) are always spelled the same way for a given morpheme. For example in French, the biphone /*ɛt*/ is always spelled “ette” when it corresponds to a suffix (e.g., *fillette*, “little girl”). These units’ morphological status therefore constrains their spelling. Second, according to the principle of root consistency, the spelling of a root is maintained independently of pronunciation changes when it is embedded in a word built with several morphemes (i.e., morphologically complex word; e.g., in English: *nature-natural*, in French: *berger-bergerie*, “shepherd, sheepfold”). Another specificity of French orthography (which can also be found in the English and other languages) is related to this second principle; the spelling of roots sometimes includes silent letters which represent their relationship to morphologically related words (e.g., in English: *sign-signature*; in French: *tricot-tricoter*, “knit—to knit”). In French, these mute letters are mostly located at the end of roots and are therefore transition letters between the root and the suffix added.

Because of these specificities, children also need knowledge of morphological rules and relationships to spell words correctly. Morphological awareness predicts variance in word spelling even after the effect of phonological awareness is controlled for (Nagy, Berninger, & Abbott, 2006). From the age of 6, developing spellers take into account the morphological structure of words into account in order to select the correct spelling (Deacon & Bryant, 2006a). They are better able to spell a suffix-ending when it is preceded by a lexical base than when it is not (e.g., *smarter* vs. *corner*) and to spell a letter string when it is included in a morphologically complex word than when it is included in a morphologically simple one (e.g., *turning* vs. *turnip*, Casalis, Deacon, & Pacton, 2011; Deacon & Bryant, 2005, 2006b). In addition, the existence of words in the same morphological family that can be relied on as a guide increases the probability of selecting an appropriate silent final letter. Sénéchal (2000) showed that children in grades 2 and 4 were better able to spell lexical bases ending with a silent letter that is pronounced in a morphologically related word (e.g., in

French, *bavard*, “chatty,” which is related to *bavarder*, “to chat,” *bavardage*, “chatting”) than one that is not (e.g., in French, *foulard*, “scarf”). This ability was significantly related to children’s morphological awareness and vocabulary.

Here, we examine whether students with dyslexia benefit from morphology when learning to spell words. This question is motivated by several observations. First, there is increasing evidence that typically developing children use phonological and morphological rules simultaneously from the beginning of spelling development (Bourassa & Treiman, 2009, 2014; Treiman & Cassar, 1997). This parallel involvement of these two levels of representation (phonological and morphological) leaves open the possibility that dyslexic children may rely on morphology despite their phonological deficit. Second, the general language skills (i.e., vocabulary and syntax) of dyslexics and normally achieving readers are likely to be similar, in particular when the tasks do not involve the use or manipulation of phonological information (Vellutino et al., 2004). The naming deficits of children with dyslexia are not due to impoverished vocabulary and have been found to disappear when the task does not draw on phonological knowledge (Snowling, van Wagtenonk, & Stafford, 1988; Swan & Goswami, 1997; Wolf & Obregon, 1992). Third, in line with the previous argument, children with dyslexia show greater morphological fluency than their younger peers matched for reading level (Casalis, Colé, & Sopo, 2004).

The way dyslexic students deal with morphological information in spelling has only been investigated in a few studies, mostly in English, and with differing control groups. A study by Carlisle (1987) in English-speaking dyslexic ninth graders showed that their ability to spell morphologically complex words (e.g., *magician*) lagged behind what would have been expected given their level of morphological awareness; They tended to use different spellings for the same lexical base depending on whether it was dictated alone (e.g., *magic*) or in a morphologically complex word (e.g., *\*magishion*). Using the same procedure as Carlisle (1987), Tseemeli and Seymour (2006, 2009) showed that the ability of English-speaking adolescents with dyslexia (aged between 13 and 15) to spell lexical bases alone or in derived forms corresponds to their reading level. Other studies have found children with dyslexia to be as capable of using morphology in spelling as other spelling-level-matched children. For example, in English, Bourassa, Treiman, and Kessler (2006) found that dyslexic children (mean age: 11 years) made fewer mistakes when spelling a grapheme embedded in a morphologically complex word (e.g., “p” in *creeps*, where “creep” and “s” are two distinct morphemes) than in a simple word (e.g., “p” in *collapse*). They found a similar pattern of results when the children had to spell an inconsistent grapheme (e.g., “t”, which in most of North America can be pronounced either /d/ or /t/) that either belongs to a morphologically complex word (e.g., *waiting*) or to a simple word (e.g., *beauty*). This effect of word morphology was also found when dyslexic second graders and spelling-level-matched children spelled word endings that were either a suffix (e.g., *tricked*; *tricky*) or not (e.g., *trickle*; Bourassa, Deacon, Barga, & Delmonte, 2011, cited by Bourassa & Treiman, 2014). Only one study on this issue in a language other than English has been published. Greek-speaking dyslexic children between the ages of 10 and 13 were found to perform as accurately as spelling-level-matched children when spelling derivational suffixes, but worse than chronological age-matched children (Diamanti, Goulandris, Stuart, & Campbell, 2013).

In view of the potential importance of morphology for spelling in dyslexia, the present study attempted to explore whether students with dyslexia rely on morphology when spelling silent letters at the end of French words. French orthography is very inconsistent (Ziegler, Jacobs, & Stone, 1996), in particular because French has far more graphemes ( $n = 133$ ) than phonemes ( $n = 36$ ; Catach, 1973). This type of asymmetry makes an orthography difficult to master

(Caravolas, 2006), especially for individuals with dyslexia (Landerl, Wimmer, & Frith, 1997; but see Caravolas & Volín, 2001). In French, the use of multiple graphemes to spell a given phoneme is very often motivated by morphology (Fayol & Jaffré, 2012). Silent consonants at the end of many French words are one of the most obvious examples; They typically attest to the relationship between a given word (e.g., *tricot*, “knitting”) and other words in the same morphological family (*tricoter*, “to knit,” *tricoteur*, “knitter,” *tricotage*, “the action of knitting”...). Such morphologically motivated silent characters are referred to as *morphograms*. Being sensitive to this morphophonological principle makes developing spellers more likely to select the appropriate grapheme at the end of words. For example, French-speaking children in grades 2 and 4 spell French words ending with a silent letter related to a morphological family (e.g., *bavard*, “talkative”) more accurately than those with a non-morphological silent final letter (e.g., *foulard*, “headscarf”), and this effect is predicted by their level of morphological awareness (Sénéchal, 2000). Note, however, that in another study in French-speaking deaf and typically developing children, this benefit of the morphological status of silent final letters was observed in the group of typically developing children with a mean age of 13.3 years, but not found in the younger group of typically developing children with a mean age of 10.9 years (Leybaert & Alegria, 1995).

## The present study

Individuals with dyslexia experience considerable difficulties with spelling, in particular in French (Casalis, 2014; Plisson et al., 2013). This is partly due to the etymological nature of French orthography, as a result of which many letters have no phonological counterpart. The spelling of these silent letters can nonetheless often be aided by making links with words in the same family. Given (1) prior work demonstrating that typical children are better able to spell such silent final letters when they are found in words that belong to a morphological family including words where they are pronounced and (2) the ability of individuals with dyslexia to rely on morphology when spelling, the aim of this study was to examine whether dyslexic adolescents are able to take advantage of morphologically related words when spelling silent letters at the end of words. To that end, their ability to correctly spell silent final letters in two types of words (morphological, e.g., *tricot*, “to knit,” and control, e.g., *effort*, “effort”) was compared to that of typical children matched for reading and spelling level.

## Material and method

### Participants

Two groups of participants took part in the study. They were recruited near the city of Poitiers, France. The dyslexia group consisted of 19 adolescents (12 boys and 6 girls) diagnosed with dyslexia (mean chronological age = 12;7, *SD* = 19 months) and the typical group consisted of 19 typically developing children (6 boys and 13 girls) matched for word reading and spelling (mean chronological age = 9;4, *SD* = 14 months). Three dyslexic participants were in the last year of primary school. The 16 others were in secondary school (seven in first year, three in second year, three in third year, and three in fourth year). Seventeen of the typically developing children were in primary school (five in second grade, five in third grade, six in fourth grade, one in fifth grade), and two were in first year in secondary school.

The dyslexic participants had all been previously diagnosed by a multidisciplinary team, which included a speech therapist and an educational psychologist. The dyslexic participants all had ongoing difficulties with reading and/or spelling, and they had a mixed reading profile of dyslexia (i.e., poor irregular word and pseudoword reading, Castles & Coltheart, 1993). All the dyslexic participants were, or had been, enrolled in a remedial program with a speech therapist. This program was based on phonemic awareness instruction. Two dyslexic children were removed from the initial sample (along with the two matched controls) because they did not report any silent letters in the experimental task. The analyses were conducted on the remaining 17 participants.

All the participants had a nonverbal IQ >80 according to the Wechsler Nonverbal Scale of Ability (Wechsler & Naglieri, 2009), and parental consent was obtained before their participation. The dyslexic students were older than the typical children,  $t(30) = 6.79$ ,  $p < 0.001$ , and they had slightly lower nonverbal IQ than the controls,  $t(30) = 2.33$ ,  $p = 0.027$ . All the participants were native French speakers.

Several linguistic measures were used to match the participants on word reading and spelling and to establish a precise description of the linguistic profile of our population. Table 1 reports mean scores and their range for each group.

## Matching measures

### Reading level

The Alouette reading test (Lefavrais, 1967) was used to assess the reading delay of the dyslexic participants. This test is the most commonly used reading test in France, and it is administrated individually. It consists of reading a text of 265 words aloud as quickly and accurately as possible. Since the Alouette text has no meaning, the words are not predictable

**Table 1** Means and standard deviations of participants' ages and scores on the nonverbal IQ, spelling, reading, phonological awareness, and morphological awareness tests

Measures	Group				<i>p</i>
	Dyslexics ( <i>N</i> = 17)		Controls ( <i>N</i> = 17)		
	M	Range	M	Range	
Chronological age (in months)	152	125–181	112	90–138	<0.001
Reading age (in months)	105	86–124	106	95–118	ns
Nonverbal IQ	93	80–119	102	81–122	0.027
EVIP (nb of err; max = 25)	5.06	2–12	8.41	2–14	0.002
Spelling: regular words (max = 10)	8.47	5–10	9.00	7–11	ns
Spelling: irregular words (nb corr; max = 10)	6.24	2–10	6.24	2–10	ns
Spelling: pseudowords (nb corr; max = 10)	8.12	6–10	9.00	7–10	0.037
PA (nb corr; max = 10)	4.29	2–9	6.53	2–9	0.008
MA: analogy (nb corr; max = 12)	9.65	6–12	9.47	5–12	ns
MA: fluency (nb of words)	10.53	6–17	8.35	3–13	0.045

EVIP Echelle de Vocabulaire en Images Peabody, PA phonological awareness, MA morphological awareness; *nb corr* number of correct responses, *nb of err* number of errors, *ns* not significant

from the context. The final score provides a reading age taking into account both speed (how many words are read during 3 min) and accuracy. The dyslexic participants were reading at least 20 months below age expectations on the Alouette test. They were matched to the control participants in terms of reading age,  $t < 1$ .

### *Spelling level*

The spelling test used was a part of the ODEDYS 2 French test (Jacquier-Roux, Valdois, & Zorman, 2005). The participants were asked to spell 10 regular words, 10 irregular words, and 10 pseudowords. The dyslexic and control participants were matched for their regular and irregular word spelling levels, ( $t(30) = 1.21$ ,  $p = 0.24$ , and  $t < 1$ , respectively), but the dyslexic children were less able to spell pseudowords than control peers,  $t(30) = 2.20$ ,  $p = 0.037$ .

## **Other measures**

### *Phonological awareness*

Phonological awareness was assessed with the initial phoneme deletion task of the ODEDYS 2 French standardized test (Jacquier-Roux et al., 2005). Children in the control group had a higher level of phonological awareness than the dyslexic children,  $t(30) = 2.85$ ,  $p = 0.008$ .

### *Morphological awareness*

**Analogy** We used the same task as Sénéchal (2000). The experimenter orally presented the children two morphologically related words (e.g., *danse*—*danser*, “dance— to dance”). The experimenter then pronounced a new word (e.g., *saute*, “jump”), and the children’s task was to produce a morphologically related word based on the analogy to the example (here, *sauter*, “to jump”). The reliability for this task was  $\alpha = 0.72$ . The performance of the two groups did not significantly differ on this measure of morphological awareness,  $t < 1$ .

**Morphological fluency** The task was that of Casalis et al. (2004). The participants had to generate as many words as possible belonging to the same morphological family and sharing a given base (e.g., *chausser*, “to put on”). The participants with dyslexia gave more words from the same morphological family than the children in the control group,  $t(30) = 2.09$ ,  $p = 0.045$ .

### *Vocabulary*

Children’s vocabulary was assessed with the French adaptation of the Peabody Picture Vocabulary Test (EVIP: Dunn, Theriault-Whalen, & Dunn, 1993). Due to time constraints, a shortened version of the test was administered. All of the participants saw the same 30 items (designated for children between 9 and 13 years old). The number of naming errors was compared between the groups. The dyslexic group made fewer errors than controls,  $t(30) = 3.31$ ,  $p = 0.002$ .

## Experimental stimuli

The stimuli were 40 words ending with a silent consonant, divided equally between two conditions: morphological and control. The 20 words in the morphological condition end with a silent consonant that is also present in morphologically complex words (e.g., *tricot*, “knitting,” which is related to *tricoter*, *tricotage*...). The 20 words in the control condition end with a silent letter but are not part of a morphological family (e.g., *effort*, “effort”).

Each morphological stimulus was strictly matched to one control stimulus on final consonant, type frequency,<sup>1</sup> and token frequency<sup>2</sup> ( $ts < 1$ ). The Cronbach’s alpha reliability was 0.78 in the morphological condition and 0.71 in the control condition. A complete list of stimuli and their frequencies is provided in [Appendix](#).

## Procedure

The procedure was as described by Sénéchal (2000). The participants were tested individually in a quiet room. The experimenter presented the target words in random order. Each target was pronounced three times: Once individually, then in a sentence in order to clarify its meaning, then again individually (e.g., “*Tricot. Grand-mère aime le tricot. Tricot.*” “Knit. Grandma likes knitting. Knit”). The participants had to write each of the target words in a booklet. Two practice items were given at the beginning of the task to ensure that the participants understood the instructions.

## Scoring method

Children’s responses were scored in two ways. The aim of the first scoring method was to assess word spelling in general; one point was given for each correctly spelled word. The aim of the second scoring method was to assess spelling accuracy on the silent final consonant: in this case, one point was given for each correct final letter independently of the accuracy of the rest of the word. The percentages of correctly spelled words and correct final letters could thus be calculated.

## Results

Two words were excluded from the data analysis because they were wrongly included in the control list (*corps*, which is related to *corporel* and *doigt*, which is related to *doigté*). The two matched words from the morphological list were also deleted from data analysis (*tapis* and *respect*).

Data were analyzed using a linear mixed effect model with binomial error distribution. The analysis included two fixed-effect factors and their interaction (group, condition, group  $\times$  condition) and two random-effect factors (items, participants).

<sup>1</sup> Frequency of a pattern, i.e., the number of times that a certain pattern occurs. In this count, the frequency of the feminine and plural forms is not provided separately from the frequency of the base word.

<sup>2</sup> Frequency of an actual item, i.e., the number of times a particular form occurs in texts. In this count, the frequency of each orthographic form is provided, be it a plural or a feminine form.

## Word spelling

The mean percentages of correctly spelled words by group and condition are reported in Table 2.

The main effect of group was marginally significant,  $z = 1.94$ ,  $p = 0.053$ , indicating that children with dyslexia tended to spell words less accurately than the younger typical children of the same reading level. The main effect of condition was not significant,  $z = 1.51$ ,  $p = 0.13$ , nor was the interaction between group and condition,  $z = 1.24$ ,  $p = 0.22$ .

## Final letter spelling

The mean percentages of correctly spelled silent final letters by group and condition are reported in Table 2.

The dyslexic group gave a lower percentage of correct responses than the younger control group,  $z = 2.74$ ,  $p = 0.006$ . The main effect of condition was not significant ( $z < 1$ ), but it did significantly interact with the group,  $z = 2.99$ ,  $p = 0.003$ ; Specifically, there was no difference between the control and morphological conditions in the control group ( $z < 1$ ), but the dyslexics performed better in the morphological condition than in the control condition,  $z = 2.47$ ,  $p = 0.013$ .

The interaction also reflects the fact that the dyslexics performed worse than the younger control group in the control condition,  $z = 2.95$ ,  $p = 0.003$ , but not in the morphological condition,  $z = 1.40$ ,  $p = 0.16$ . The two groups did not differ with respect to the type of error they made in the control condition (letter omission: 72.63 % in the dyslexic group and 72.97 % in the control group; letter substitution: 27.27 % in the dyslexic group and 27.03 % in the control group).

## Discussion

The present study was designed to investigate how dyslexic students deal with one of the most important challenges of spelling in French: silent letters. Many French words end with a letter with no phonological counterpart, making their spelling difficult to master. Selection of the appropriate word ending can be facilitated by activation of members of the

**Table 2** Mean percentages of correct responses (standard deviations in parentheses) in the experimental spelling task, by condition and group

Measures	Dyslexics	Controls
% Whole word correct		
Morphological condition	48.69 (24.43)	50.98 (21.63)
Control condition	32.68 (22.21)	40.20 (19.50)
% Final letter correct		
Morphological condition	58.17 (21.71)	53.92 (21.41)
Control condition	41.18 (23.98)	51.63 (17.76)



same morphological family (Sénéchal, 2000). Given that the dyslexics' general language skills (in particular vocabulary) are relatively intact (Snowling et al., 1988; Swan & Goswami, 1997; Wolf & Obregon, 1992), and given that their level of morphological awareness is sometimes higher than what would be expected on the basis of their reading level (Casalis et al., 2004), we predicted that they might rely on these abilities to overcome their spelling difficulties.

The results partly confirmed this hypothesis; Dyslexic students were more accurate in spelling silent final letters in the morphological condition (e.g., *tricot*, “knit”) than in the control condition (e.g., *effort*, “effort”). In contrast, the control group showed equal accuracy in choosing the final letter in the two spelling conditions, indicating that they did not take morphologically related words into account when spelling silent final letters.

We report here for the first time that dyslexic students benefit from the morphological status of silent final letters when spelling. Several studies have previously shown such a morphological advantage, in two different orthographies: In English, dyslexic students spell letter strings that are embedded in a morphologically complex word more accurately than strings that are not (Carlisle, 1987; Tsesmeli & Seymour, 2006, 2009), and in Greek, students with dyslexia spell letter strings that form a morpheme better than strings that do not (Diamanti et al., 2013). Our results in French add to this body of research by showing that dyslexics also activate morphological representations when spelling graphemes with no phonological counterpart.

This result is important given that a significant proportion of French words end with a silent letter. Few previous studies have examined the spelling of silent letters in dyslexia, but it should be challenging given the difficulties of dyslexic individuals with developing well-specified orthographic representations (Share & Shalev, 2004; Suárez-Coalla, Ramos, Álvarez-Cañizo, & Cuetos, 2014; Wang, Marinus, Nickels, & Castles, 2014). The present study provides evidence of such a deficit, as adolescents with dyslexia were less able to produce silent final letters that are not morphologically justified in a word spelling task than typically developing children matched for reading and spelling level. The spelling of letters with no phonological counterpart thus appears to be a specific area of difficulty in dyslexics. Plisson et al. (2013) examined spelling errors in a narration writing task and reported the percentages of errors involving the omission, addition, or substitution of a silent letter within words. The authors found no difference between children with dyslexia, chronological age-matched children, and reading-level-matched children. However, this task left participants free to choose words they knew, and therefore the results might not reflect their ability to spell silent letters in general. Additional studies are needed to directly investigate the issue of silent letter spelling in dyslexia, independently of morphological status.

Another important result of our study is the finding that the possibility of activating morphological family members did not influence the spelling of silent final letters in the younger typically developing children. In this context, the literature in French has produced inconsistent results. Sénéchal (2000) found that second graders benefit from the presence of morphologically related words when spelling silent final letters. By contrast, Leybaert and Alegria (1995) showed that morphologically related words increased spelling accuracy of silent final letters in one group with a mean age of 13.3 years, but not in a younger group with a mean age of 10.9 years. At least two explanations can be put forward for this contrast. First, close inspection of Sénéchal's

(2000) items show that her morphological items were more than three times as frequent as ours (33 occurrences per million vs. 100 occurrences per million, as indicated by Manulex: Lété, Sprenger-Charolles, & Colé, 2004) and her morphological items were almost three times as frequent as her control items. Therefore, the apparent morphological effects observed by Sénéchal (2000) in grades 2 and 4 might be explained by the high frequency of the items in the morphological condition.

Second, the two studies mentioned above (Leybaert & Alegria, 1995 and Sénéchal, 2000) and our study were conducted in three different countries: Canada, Belgium, and France, respectively. The different results can be related to the ways in which morphological strategies are—or are not—taught in different countries. Morphological instruction does not occur before grade 4 in France and is presented as a way to improve vocabulary, but not as a way to improve word reading or spelling (Conseil Supérieur des Programmes, 2015). In Quebec, morphological instruction occurs earlier, and it is presented as a way to guess word spellings beginning in grade 2, and not only a means for developing vocabulary (Programme de formation de l'école québécoise, 2009). If teachers in Ontario French-language schools follow the Quebec program with French-speaking students, then the difference in results might be the consequence of differences in the timing and aims with which morphology was taught in the schools attended by the participants. French students certainly develop an implicit knowledge of morphological rules, but explicit instruction in morphological strategies is a more efficient way of ensuring that children directly use this knowledge when reading or spelling words (Apel, Masterson, & Hart, 2004). Cross-national studies with the same material might provide direct insights into such differences in studies performed in different countries.

It is important to keep in mind that dyslexic students did not outperform children from the control group when spelling morphologically justified silent letters. Instead, they performed at a lower level than control children for control words, but caught up to typical children in the morphological condition. The greater benefit of morphologically related words in children with dyslexia is no doubt a result of their better general language abilities in comparison to younger typical children. The dyslexic students had a larger vocabulary than controls and were able to provide more morphologically related words in the morphological fluency task. The small size of the groups made it impossible to conduct correlation analyses, but several studies have already reported a relationship between morphological awareness and spelling (Casalis et al., 2011; Nagy et al., 2006; Sénéchal, 2000). Our findings provide evidence that morphological analysis, which can be viewed as an indicator of general language abilities, may be a helpful strategy to use with dyslexic students.

The adolescents with dyslexia who participated in the present study had not benefited from morphological remediation with speech therapists. Consequently, their greater spelling performance with final letters that are morphologically justified results from a spontaneous strategy, not a learned one. The effects of morphological structure would therefore likely be greater in case of direct morphological instruction. Elbro and Arnbak (1996) showed that dyslexic students responded positively to morphological awareness training, which significantly improved their spelling scores: the experimental group progressed more than the controls in the spelling of derived words. The sensitivity of individual with dyslexia to morphology, together with their positive response to morphological training, opens new ways for the treatment of their spelling deficit.

## Educational implications

Spelling difficulties are common in students with dyslexia (Casalis, 2014), even though the nature of these difficulties remains largely unknown. Silent letter spelling is a specific area of difficulty, but students with dyslexia can rely on their vocabulary (and more particularly on their knowledge of morphologically related words) to select the appropriate silent ending letter. Word knowledge should include information on morphology, since it provides important information on how words should be spelled. Therefore, educators should help students to develop their vocabulary in order to enable them to organize their lexicons around morphological families. As emphasized by Bowers and Kirby (2010, p. 531), vocabulary instruction “motivates children to enjoy and actively engage in the study of words and their meanings”.

Teaching morphological families of words has proved to be efficient (Bowers & Kirby, 2010). For example, teachers can point out the meaningful relationships between morphologically related words (e.g., *magician—magic*). Students also need to understand the spelling–meaning connection between morphologically related words. Goodwin, Lipsky, and Ahn (2012) reported several morphological spelling strategies that can be taught to increase this understanding. One strategy consists in sorting words as a function of their endings to show the importance of word meaning at the cost of phoneme-grapheme consistency (e.g., in English: the same sound can be spelled in different ways: *trees* vs. *freeze*). Another morphological spelling strategy includes root identification within morphologically complex words: *electricity* is easier to spell when connecting it to its root *electric*. In short, morphology should be used to augment current instructional practices for all students.

## Limitations

There are several limitations in the study reported here. First, the sample size is fairly small and the study should be replicated with a larger sample size. Another limitation lies in the absence of a control group matched for chronological age. Such a group would provide information regarding the specificity of morphological processing in individuals with dyslexia compared to non-dyslexic students of the same age; Do chronological age-matched peers rely on morphologically related words when spelling to the same extent as dyslexics students? Further studies should be conducted to address this issue. In addition, we did not manipulate the size and the frequency of the morphological family of the targets. As reported by Carlisle and Katz (2006), fourth and sixth graders read morphologically complex words from the larger families and they read those with higher average family frequencies with greater facility than morphologically complex words from smaller and less common families. Additional studies are needed to test the influence of these variables on spelling.

In conclusion, morphological processing significantly contributes to spelling accuracy, beyond the application of phoneme-to-grapheme conversion rules: Accuracy increases when spellers activate morphological representations, especially in French where many words end with a silent letter that is morphologically justified. Such processing does not arise early in development and requires a large vocabulary. It is nonetheless available to dyslexic students who have developed normal general language skills.

## Appendix

**Table 3** Complete list of the stimuli and their token and type frequencies

Morphological condition			Control condition		
Item	Frequency		Item	Frequency	
	Token	Type		Token	Type
Abricot (« apricot »)	10	18	Rempart (« rampart »)	0.76	7
Avis (« opinion »)	94	94	Autrefois (« formerly »)	86	86
Biscuit (« cookie »)	6	21	Artichaut (« artichoke »)	4	7
Blond (« blond »)	11	45	Boulevard (« boulevard »)	8	13
Climat (« climate »)	11	11	Escargot (« snail »)	43	70
Confort (« comfort »)	6	6	Haricot (« bean »)	12	41
Désert (« desert »)	68	97	Soldat (« soldier »)	23	69
Drap (« sheet »)	26	51	Sirop (« sirop »)	16	17
Friand (« gourmand »)	0.4	2	Dossard (« number sign »)	0.2	0.5
Front (« forehead »)	60	61	Défaut (« default »)	19	26
Gant (« glove »)	13	38	Endroit (« place »)	186	207
Récit (« story »)	64	81	Effort (« effort »)	39	67
Refus (« refusal »)	3	3	Talus (« bank »)	6.5	6.5
*Respect (« respect »)	13	14	*Doigt (« finger »)	84	193
Retard (« late »)	88	88	Crapaud (« toad »)	27	35
Second (« second »)	50	89	Plafond (« ceiling »)	29	29
Suspect (« suspect »)	3	6	Hublot (« porthole »)	5	6
*Tapis (« rug »)	98	97	*Corps (« body »)	142	142
Tricot (« knit »)	16	16	Mulot (« field mouse »)	5	9
Univers (« universe »)	18	18	Velours (« velvet »)	27	27

\*These items were removed from the analysis

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