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Intensive and explicit derivational morphology training in school-aged children: an effective way to improve morphological awareness, spelling and reading?

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Abstract

Morphological awareness has been shown to contribute to the acquisition of literacy in various languages. The current study focuses on an explicit derivational morphology training program in French-speaking fourth graders with the aim of measuring direct effects on morphological awareness and transfer effects on spelling and reading. The intensive training given in class consisted of (1) learning how to segment words into smaller units and (2) understanding the meaning of affixes in relation to words. Thirty-six children received the morphology training and 34 age-matched participants followed an alternative visuo-semantic training matched for intensity. The results of this pre-post group comparison study show a significant Group by Time interaction: Substantial progress in morphological awareness is observed for the group trained in morphology, on both trained as well as on untrained items. A similar gain was observed for the spelling of morphologically derived words, for trained and untrained words. Both roots and affixes were spelled more accurately. For reading however, we found a learning effect in speed and accuracy on trained words, but no generalization to untrained words. All effects were maintained four months after training. These results highlight the role that morphology plays in children's literacy development.

Keywords Morphological awareness · Training · Spelling · Reading · School-aged children

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Introduction

Learning to read and to spell is a real challenge for young school-aged children, especially for those who are confronted with an inconsistent writing system in which there are many possible phoneme-grapheme (in spelling) or grapheme-phoneme (in reading) associations. Some orthographies are (1) fully regular both in reading and in writing (e.g., Finnish or Italian) (2) regular in reading, but irregular in writing (e.g., French, see Ziegler, 2018) or (3) irregular in both directions (e.g., English). In inconsistent orthographies, morphemic-level regularities may support literacy acquisition (Breadmore et al., 2021). For example, in inconsistent orthographies, children use morphological cues to spell words and studies show that children spell morphologically derived words better than the same set of letters in monomorphemic words ("illness" spelled better in children of 6-to 8-year-olds than "witness") (Deacon & Bryant, 2006). The finding that morphological processes are associated with literacy development has led to the development of morphological training programs to develop children's reading and spelling abilities. The efficacy of such programs has been well documented in English-speaking children; however, there are few studies on morphological training in French-speaking children and those that exist are subject to limitations. In this study, we investigate the impact of a training program in derivational morphology on literacy skills in 9-10-year-old French-speaking children. Our aim is to determine whether training in derivational morphology leads to improvement in reading and spelling compared to visuo-semantic training. In the following paragraphs, we define derivational morphology and its influence on literacy development and describe studies that have examined the influence of morphological training on reading and spelling.

Role of morphology in literacy development

Morphology is the study of word-formation processes (Nagy et al., 2014), that is, how morphemes, which are the smallest units carrying meaning within words, combine with each other. Morphological processes are usually divided into two types: implicit and explicit. Implicit morphological processes operate through language immersion: Confronted with language input, children become receptive to morphological regularities without needing to learn precise rules. Explicit morphological processes, also called morphological awareness skills, enable children to consciously analyze and manipulate the morphological structure of complex words (Carlisle, 1995; Deacon & Kirby, 2004). For instance, morphological awareness is recruited to extract the root (*happy*) in the word "happiness" and to associate it with other affixes to form different words belonging to the same family (e.g., unhappy, happily). Both these skills, implicit and explicit, increase with age and with schooling (Anglin et al., 1993; Berninger et al., 2010; Casalis et al., 2011).

Different studies have investigated the link between morphological and literacy skills, both in reading and in spelling. Levesque and colleagues (2021) recently reviewed this literature and proposed a theoretical model, The Morphological Pathways Framework, that aims to understand the role of morphological knowledge in word identification, spelling, reading comprehension and writing composition. In this model, knowledge about morphology is multidimensional and distributed over several levels: Morphological awareness is part of the linguistic system, whereas knowledge regarding the orthographic structure of morphemes is located in the orthographic system, and the structure of individual words resides within the lexical representations. This model further specifies three different bidirectional routes. A first direct pathway links morphological awareness and text comprehension processes in a general way. A second indirect pathway, called morphological analysis, links morphological awareness to lexical representations and corresponds to a process of word meaning analysis. This process consists of identifying the meaning of the morphemes that compose a word in order to reconstitute its global meaning. Finally, a third indirect pathway, called morphological decoding, links the representations of morphemes in the orthographic system to those in the lexical representations. This pathway allows the recognition of written morphemes that enables the reading of larger units and eventually words.

It has indeed been shown that morphological awareness, as a result of morphological decoding, contributes to the reading of complex derived words (Kearns, 2015; Levesque & Deacon, 2022; Rastle, 2018). A synthesis by Duncan (2018) indicates that morphological awareness explains additional variance in word reading from that of phonological awareness. The contribution of morphological awareness appears to be effective from the 3rd grade on, while the contribution of phonological awareness progressively decreases after the 2nd grade in English and French (Kirby et al., 2012; Mahony et al., 2000), and even faster in more consistent orthographies (Diamanti et al., 2017; Pittas, 2018). Moreover, morphology appears to facilitate immediate word recognition. For example, Casalis and colleagues (2009) showed the involvement of a morphological level in visual word recognition that was independent of the orthographic level. In their experiment, the target word ("mariage", [marriage]) was preceded either by a morphologically related word ("marier", [marry]), by an orthographically related word ("marine", [marine]), or by an unrelated word ("animal"). The priming word was presented 75ms or 250ms before the target word. The results showed that at 75ms, the orthographic and morphological primes decreased word recognition speed, whereas at 250ms, only the morphological prime had an effect. The authors interpreted this difference as indicating that there were two different levels of activation when reading, one for orthographic information, and another for morphological information, even though these two levels of processing are not distinct at the earlier stage (at 75ms). These results thus suggest that morphological processes contribute to word recognition.

Similar results were observed by Levesque and Deacon (2022) who showed that, after controlling for the contribution of vocabulary and phonological awareness, morphological awareness is a unique predictor of morphologically complex word reading, but not of broader word reading, in third and fourth grade children. In addition, a reciprocal causal link between derivational morphology and reading is likely, as the two skills influence each other (Deacon et al., 2013; Nunes et al., 2012). This reciprocal link is likely to be influenced by the degree of consistency of the orthographic systems, as it has been shown that its strength is more important in inconsistent orthographies like English (Mousikou et al., 2020) than in consistent ones such as German, Greek and Norwegian. (Görgen et al., 2021; Pittas, 2018; Torkildsen et al., 2021). The potentially stronger reciprocal link between derivational morphology and reading may explain why morphological processes are more developed in English adults compared to French, German, or Italian readers, whereas morphological complexity is less important in English than in these other languages (Mousikou et al., 2020).

Regarding spelling, the Morphological Pathways Framework (Levesque et al., 2021) stipulates that morphological decoding is also involved in that morphological representations allow for more accurate spelling at all levels of spelling processing: input identification, central and peripheral orthographic processes. Depending on the nature of the spelling task (dictation, copying or free writing), morphological analysis can be recruited in addition to morphological decoding when lexical representations are mobilized. This is in line with the results obtained by Pacton and colleagues (2018), who showed that French-speaking children in Grades 3 and 5 benefited from the implicit use of morphology to learn the spelling of new words. The longitudinal study of Deacon and colleagues (2009) further showed that in English-speaking children, morphological awareness at Grade 2 was predictive of spelling skills at Grade 4, after controlling for nonverbal reasoning and phonological processes. Similar results were observed in French-speaking third and fourth grade children (aged 8–10) by Casalis et al. (2011) and Fejzo (2016), who documented significant correlations between morphological awareness and spelling.

Other studies have documented the fact that, in inconsistent orthographies like English and French, children use morphological clues to spell words -especially inconsistent ones- from an early age (Carlisle & Stone, 2005; Casalis et al., 2011; Pacton et al., 2005). For instance, children spell the sound /z/, written -s, -z or -zz, better when the word can be morphologically segmented (e.g., children spell the word “noisy”, which is composed of two morphemes: noise and y, better than “busy”, which is made up of a single morpheme; Kemp, 2006). Likewise, Deacon and Bryant (2006) showed that 6-to-8-year-olds spell the roots of morphologically derived words better than the same set of letters in a monomorphemic word (e.g., “art” in “artist” vs. “article”), a result that is consistent with the use of morphemes to spell morphologically related words. Moreover, several authors have shown that children preferentially add silent final letters when these letters have a morphological explanation (Sénéchal, 2000; Sénéchal et al., 2006).

To sum, morphological processes are associated with the development of many literacy-related skills such as reading accuracy, reading comprehension, and spelling. In particular, children pay attention to the morphology of related words to spell another word (Pacton & Deacon, 2008). Since morphology is clearly involved in literacy development, the question of whether training morphological skills improves literacy is an important one.

Intervention focused on morphology

Compared to numerous studies on phonological training (see Suggate, 2016, for a review), research on morphological training is rather recent. However, there is a growing body of work in this domain, including meta-analyses of studies conducted with English-speaking school aged children, such as those by Goodwin and Ahn

(2013) and Bowers et al. (2010). In the 30 studies included in Goodwin and Ahn, participants ranged from preschool to 9th grade and sample sizes ranged from 12 to 1569 participants per study. Global results indicated significant effects of morphological training on decoding ($d=0.59$), phonological awareness ($d=0.48$), morphological knowledge ($d=0.44$), vocabulary ($d=0.34$) and spelling ($d=0.30$). There was no effect on reading comprehension or fluency. Similar results were observed by Bowers and colleagues (2010) in their review of 22 studies (2652 participants from preschool to 8th grade) when the intervention group was compared to a passive control group. This meta-analysis found a moderate effect size of morphological training on spelling and reading (respectively $d=0.49$ and $d=0.41$) but this effect disappeared when the intervention group was compared to an alternative treatment group (spelling and reading: $d=0.05$), which benefited from phonological awareness training. This result thus showed that morphological interventions were as effective as evidence-based phonological interventions.

As for the content of morphological interventions, Carlisle (2010) distinguished four different approaches: (1) increasing morphological awareness of word structure, for example by splitting up words into morphemes (e.g., in the word "transformation", trans- is the prefix, form is the root and –ation is the suffix); (2) focusing on the meaning of affixes and roots, for instance by explicit teaching of the meaning of the suffixes (e.g., re- means "again"); (3) supporting morphological problem solving so that students can infer the meaning or grammatical class of an unfamiliar word in a variety of contexts (i.e., creating new words from known affixes); and (4) teaching analysis strategies about the meaning of unfamiliar derived words from their reading (i.e., the adult explains how to analyze a word and then guides the students through the process of analysis before leaving them to fend for themselves). In her narrative review, Reed (2008) concluded that interventions focusing on the roots of words were more effective than those which targeted only affixes. Goodwin and Ahn (2010) added that interventions that included an explanation of morphology in relation to semantics had a stronger effect than those in which there was no semantic explanation. As for spelling, the meta-analysis conducted by Goodwin and Ahn (2010, 2013) showed that morphological interventions resulted in a small effect size, while the one of Galuschka et al. (2020) found a large mean effect ($d=0.80$). The fact that the studies selected in Galuschka et al.'s (2020) meta-analysis also included interventions targeting the syllable, and by extension phonology, could explain this difference.

To our knowledge, there have been only three studies on derivational morphology training that have aimed at improving spelling skills in typically developing children. Nunes et al. (2003) conducted an intervention study with 3rd and 4th grade children (*M*age = 8;3), consisting of a control group and four experimental subgroups: oral morphological training only, morphological training with writing (i.e., implementation of morphological rules to writing), oral phonological training only, and phonological training with writing (i.e., implementation of phonological rules to writing). All four subgroups showed a significant improvement compared to the control group on a standardized reading test but not on a standardized spelling test, with the two groups that received training on writing having the highest raw scores on the standardized spelling test. Specifically, the group trained in morphology and writing was the only one to show significant effects on spelling suffixes in a word dictation task.

However, the effects of the morphological and phonological interventions (with or without writing) on the reading of morphologically complex words were identical. These results thus suggest that the use of the written modality is an active ingredient for spelling improvement.

Similarly, a second study conducted by Devonshire and Fluck (2010) showed the benefits of explicit training in morphology and etymology (i.e., explanation of the rules for how morphemes combine) in 3rd and 4th grade children, compared to an alternative spelling training that did not include derivational morphology. The morphology-trained group performed better on all spelling measures compared to the alternative treatment group, a result that was interpreted as showing the advantage of being able to recognize suffixes and decompose untrained words, as well as to combine morphemes with each other.

Finally, a recent study conducted by Casalis and colleagues (2018) focused on improving spelling through a morphological training program conducted by teachers with 3rd grade French-speaking children (aged 8–9). Two different activities related to word analysis (segmentation of words into morphemes and production of derived words) were carried out in each session. More specifically, the morphological training aimed at analyzing and writing roots and affixes, whereas the control training consisted of "business-as-usual" spelling lessons at the same dosage (i.e., the same amount of training time). Results showed that unlike the control group, the experimental group demonstrated significant improvement in morphological awareness (root production and extraction), as well as in the spelling of morphologically complex words. Importantly, the spelling gain was still present at the delayed post-test five months later. Casalis et al.'s (2018) study is relevant to the current study since it deals with morphological training in French-speaking children. However, it is subject to several limitations, including a large number of teachers who conducted the training that may have led to individual "trainer" effects, a "business as usual" control group, a limited number of word items that did not allow for the dissociation of learning and generalization effects (9 spelled complex words), training conducted only in the written modality, and no evaluation of reading. All of these factors lessen the impact of the findings. We address these limitations in the current study.

Aim of the current study

The main aim of our study is to explore the effectiveness of a training program targeting derivational morphology on the morphological awareness, reading, and spelling performance of 70 typically developing 4th grade French-speaking children, aged 9 to 10 years.

A number of studies have underscored the relevance of derivational morphology training in school-aged children, with effect sizes ranging from small to large (Galuschka et al., 2020; Goodwin & Ahn, 2013). However, most of these interventions were conducted in English, a language which is more inconsistent than French and which has different morphological properties[1] (Duncan et al., 2009). As Casa-

[1] French and English orthographies are highly inconsistent in spelling, and are both morphophonemic systems (Bowers & Bowers, 2018). More specifically, 80% of the lexical entries included in the French dic-

lis and Colé (2018) point out, studies on derivational morphology interventions in French are lacking. More specifically, with the exception of Casalis et al. (2018), very few studies have investigated the impact of the systematic teaching of morphology on reading and spelling in French. Our study therefore aims to extend the results of this study, by addressing some of its limitations (see above). In addition, we introduce several methodological innovations inspired by other studies on morphological training. Concerning major methodological points, we increased the number of pre- and post-test items, compared to Casalis et al.'s (2018) study, in order to test the effects of both learning and generalization on reading and spelling, and to more precisely examine the type of morphemes (affixes and/or roots) in which gain is observed. To avoid individual "trainer" effects, the same person (the first author) conducted the training of both groups. We chose explicit teaching of the meaning of affixes because this has been shown to speed up learning (Burton et al., 2021; Pacton & Deacon, 2008); however, a drawback is that it may take time for children to learn the rules and use them systematically when spelling (Totereau et al., 1998). This is one of the reasons why we carried out a delayed post-test to assess the maintenance of the gains four months later. We also assessed children's reading performance for morphologically complex words since several studies have reported an association between decoding and morphological awareness in children from Grade 2 onwards (Carlisle, 1995, 2000; Desrochers et al., 2018). Finally, our active control group took part in a training program on lexical spelling rather than simply continuing business-as-usual classroom spelling instruction. Concerning minor methodological points, we used two matched versions of the protocol to avoid any test-retest effects. We also offered training both in oral and in written modalities (as advocated by Nunes et al., 2003).

As suggested by previous studies, training in derivational morphology should improve morphological awareness skills, spelling and reading of trained morphologically complex words. More specifically:

1) We predict a direct (**learning**) effect on items learned during training, in both the morphological training and the active control group.
2) We expect an indirect (**generalization**) effect on untrained items for morphological awareness, reading and spelling only in the morphological training group.
3) Finally, we predict that progress will be maintained over time (=**long-term effects**) for both groups.

tionary "Robert-méthodique" are morphologically complex (Rey-Debove, 1984). The role of morphology may vary from one language to another. For instance, English has a less prevalent and a less productive morphological system than French ; it is also less phonologically transparent (Duncan, 2018). In addition, there are about 170 suffixes in French (e.g., -ion, -eau, -ième, -ette, etc.) while only 50 are in common use in English (Duncan et al., 2009).

Method

Participants

A total of 75 typically developing 4th French-speaking children (*M* age = 9;7) from public schools in the Geneva area participated in our study. Approval for the research was granted by the Ethics Committee of the Faculty of Psychology and Educational Sciences of the University of Geneva. All parents received detailed information on the study and signed the consent form. The final sample included seventy children. Five participants were excluded: one child was not French-speaking, three children did not complete the full training (due to relocations), and one child had a diagnosis of specific learning disorder. Four classes (including 16 to 19 children in each), situated in three different schools, took part in the study: two classes followed the morphological training (in two different schools) and two the visuo-semantic control training (in two different schools). In order to counterbalance the effect of socio-economic level (SES), the training assigned to each class was selected according to the SES of the neighborhood: one class with a medium level and one class with a rather low level in each group. The targeted morphological training group (MTG) consisted of thirty-six participants (20 girls, 27 bilinguals) and the alternative, visuo-semantic, training group (VSTG) consisted of thirty-four children (22 girls, 25 bilinguals). The two groups did not differ in gender, language status (mono/bilinguals), age, vocabulary level, non-verbal reasoning, spelling or reading (see Table 1). More specifically, 52 children in our sample spoke one or more languages in addition to French. Fifteen different languages were represented, the most frequent being Spanish (30.8%), English (15.4%), Portuguese (15.4%), Italian (7.7%), Russian (5.8%), Serbian (3.8%), Turkish (3.8%) and Arabic (3.8%)[2]. Most of the children's (91%) literacy skills were limited to French.

Table 1 Means and standard deviations of participant scores on the vocabulary, nonverbal reasoning, spelling and reading tests

Variable	VSTG[a] N = 34 M (SD)	MTG[b] N = 36 M (SD)	*T* test value	*p*
Age in months	115.1 (3.20)	116.7 (4.00)	-1.88	0.07
Gender	20 girls	22 girls	0.61	0.43
Language status	27 bilinguals	25 bilinguals	0.19	0.88
Vocabulary (EVALEO, max = 100)	59.9 (17.10)	58.9 (21.10)	0.22	0.83
Nonverbal reasoning (Raven matrices, max = 36)	30.8 (3.10)	30.6 (2.90)	0.22	0.83
Spelling (Chronodictées - N errors)	21.31 (11.00)	21.3 (9.90)	0.02	0.98
Reading (EVALEO - N words correctly read)	166.56 (62.11)	172.9 (66.60)	-0.41	0.68

[a] VSTG: Visuo-semantic training group

[b] MTG: Morphological training group

[2] The other languages were Mongolian, Farsi, Albanian, Afrikaans, Indonesian, Dari and Kurdish.

Materials

Expressive vocabulary

We tested children's productive vocabulary levels using the EVALEO test (Launay et al., 2018), a computerized standardized picture naming test. Children were asked to name pictures that appear one after the other on a screen. A total of 100 pictures (64 nouns, 8 adjectives and 28 verbs) were presented. The score (max = 100) allowed us to check the matching of training groups at a lexical level (see Table 1).

Nonverbal reasoning

Raven's progressive matrices (Raven et al., 1998) allowed us to confirm that no participants had an intellectual disability as all children scored above the 10th percentile. According to the manual, the test-retest reliability is between 0.83 and 0.93.

Morphological awareness

We used three oral tasks to assess morphological awareness: a segmentation task, an odd one out test, and a pseudoword definition test, detailed in Appendix A. We specifically chose tasks that assess explicit knowledge of derivational morphology because several studies have shown that the shift between implicit and explicit knowledge occurs at the beginning of first grade (Carlisle, 1995; Casalis & Louis-Alexandre, 2000; Kirby et al., 2012). Our three tasks aimed to assess the three dimensions of morphological awareness described by Tyler and Nagy (1989) : relational knowledge (the ability to recognize words that share a common morpheme), syntactic knowledge (the ability to identify the grammatical class of a morpheme), and distributional knowledge (the ability to grasp the composition rules of complex words). Cronbach's alphas were 0.56 for the segmentation task, 0.54 for the odd one out task, and 0.63 for the pseudoword definition. Reliability was fairly low because some items were failed, while others were passed by all children.

Spelling

Standardized spelling test. We used the standardized "Chronosdictées" test (Baneath et al., 2015), a sentences dictation, to check the matching of the groups (see Table 1). Children were asked to write five sentences made up of 58 words (3 morphologically complex words). This test allows the calculation of the total number of errors: errors in lexical spelling, grammatical spelling, phonetic spelling, segmentations and omissions. To check this scoring, we rescored 20% of the dictations and obtained a 98.1% inter-judge agreement.

Experimental word spelling task. For this study, we created a specific word dictation task in which children were asked to spell 80 words equally divided into four different lists, as shown in Table 2. Three lists - baseline 1 (list A) and baseline 2 (lists B1 and B2) - contained morphologically complex words, with half of the items (20 words – list A, Cronbach's alpha = 0.66) being trained in the intervention to test for

Table 2 Spelling and reading baselines (experimental tasks)

Baseline 1	Baseline 2		Baseline 3	Baseline 4	
Learning Effect	Generalisation Effect		Specificity Effect	Controlled items	
List A	**List B1**	**List B2**	**List C**	**List D1**	**List D2**
Morphologically complex words	Morphologically complex words	Morphologically complex words	Complex monomorphemic words	Complex monomorphemic words	Complex monomorphemic words
Words trained in MTG[a]	Words untrained in MTG	Words untrained in MTG	Words trained in VSTG[b]	Words untrained in VSTG	Words untrained in VSTG
Matched lists (Lists A & B)			Matched lists (Lists C & D)		

[a] MTG: Morphological training group.

[b] VSTG: Visuo-semantic training group.

a direct learning effect, and the other half being untrained (20 words – baseline 2) to test for a generalization effect. There were two versions of the generalization list to control for test-retest effects (lists B1 and B2). Untrained words were made up of affixes studied during the training with roots that had not been trained. For example, the suffix “-ion” is trained in the word “arrestation” (arrest), which belongs to list A, but not the word “affectation” (posting), which belongs to list B. Cronbach alphas for lists B1, and B2 were 0.70 and 0.78 respectively. These three lists of morphologically complex words were matched for number of letters (M=9.15; p>.17), number of graphemes (M=7.6; p>.45), number of syllables (M=3.1; p>.17), frequency (M=4.35; p>.85) and spelling consistency (M=74.8; p>.59), using the *Manulex* database[3] (Lété et al., 2004). Each word had only one affix. Each correctly spelled root yielded 1 point, as did each correctly spelled affix. Thus, each correctly spelled word was awarded a maximum of 2 points. To check the scoring of the word dictations, 20% of the word dictations were rescored by a second examiner; we obtained an inter-judge agreement score of 99.2%.

The other three lists (C, D1 and D2) contained inconsistent monomorphemic words. For example, the word “verre” (glass) in French is irregular because it is written with a double-r. The first list (list C) of words came from “l’Orthographe illustrée” (=’illustrated spelling’), a rehabilitation tool created by Valdois and colleagues (2003) (see Fig. 1), and was trained in the visuo-semantic training group. Cronbach’s alpha for list C was 0.85. The second list contained untrained complex words (lists D). There were two untrained lists of words (lists D1 and D2) to control for test-retest effects. Cronbach alphas for lists D1 and D2 were 0.73 and 0.83 respectively. The items in these three lists (C, D1 and D2) were matched for number of letters (M=5.75; p=1), number of graphemes (M=4.53; p>.46;), number of syllables (M=1.62; p>.17), frequency (M=8.81; p>.61) and spelling consistency (M=62.30; p > .10). Each correctly spelled word yielded 1 point. The word to be spelled was first dictated alone and then presented within a sentence to supply a context and to differentiate between possible homophones. Finally, the target word alone was repeated. For example, the word “surhomme” (superman) was presented in a sentence, as in “He has incredible strength, he is a **superman**!“.

[3] Matching of all experimental lists was based on data provided in the *Manulex* database (Lété et al., 2004).

Fig. 1 The word glass with a visual clue to help with spelling difficulty in "l'Orthographe illustrée" (illustrated spelling) (Valdois et al., 2003)

Reading

Standardized reading test. We used the standardized EVALEO test (Launay et al., 2018) to assess text reading fluency and check group matching (see Table 1). Children were instructed to read a meaningful text as quickly and accurately as possible in two minutes. The score corresponds to the number of words correctly read in two minutes.

Experimental reading task. The composition of the lists for our specific tasks of word reading was identical to that of the spelling lists (see Table 2) but the word lists were different from those in the experimental spelling task. Cronbach's alphas were 0.72, 0.78 and 0.77 for lists A, B1 and B2. The items in these three lists of morphologically complex words were matched for number of letters ($M=8.93$; $p>.82$), number of graphemes ($M=7.92$; $p>.81$), number of syllables ($M=3.05$; $p=1$), frequency ($M=4.23$; $p>.28$) and reading consistency ($M=77.41$; $p>.52$).

We also administered three lists of monomorphemic inconsistent words. Cronbach's alphas were 0.78, 0.68 and 0.65 for lists C, D1 and D2. The items in these three lists were matched for number of letters ($M=6.13$; $p>.59$), number of graphemes ($M=4.70$; $p=1$), number of syllables ($M=1.80$; $p=1$), frequency ($M=21.92$; $p>.76$) and reading consistency ($M=82.45$; $p>.37$). Every correctly read word scored 1 point and the reading time for each list was noted.

Procedure

The spelling tasks were administered by the first author to the whole class as a group, while the other tests were administered on a one-to-one basis by a trained speech and language therapy Master's student who was blind to the intervention group in which the child belonged. The vocabulary test and Raven's matrices were only used as pre-tests because they were control tasks; the other tasks (morphological awareness, reading and spelling) were administered as pre- and post-tests. The pre-test (T1) took place two weeks before the start of the training sessions. Post-test 1 (T2) took place two weeks after the intervention and (delayed) post-test 2 (T3) was conducted four months after the end of the interventions.

Intervention

Both interventions took place over 20 sessions spread over 5 weeks, 4 times a week. Each session lasted approximately 45 min. Therefore, the total time of the intervention was 13 to 14 h, as recommended in the meta-analysis of Goodwin and Ahn (2010). Morphological and visuo-semantic conditions were conducted by the same (not blind) researcher in the classroom in the presence of the teacher. At the end of each week, the children received stickers to keep them motivated.

Morphological training

The training was designed to follow the scientific literature recommendations, as described by Carlisle (2010). Hence, the teaching was explicit with the training sessions providing multiple opportunities for theoretical application (Goodwin & Ahn, 2010) and covering the three morphological dimensions: relational, syntactic and distributional (Tyler & Nagy, 1989). The affixes chosen for the intervention were frequent ones that generated the many words, as checked in the *Polymots* database (Gala & Rey, 2008). The first four sessions were devoted to the study of the basics: how to segment a word into morphemes, how to recognize words of the same family, and how to segment the word into prefixes, suffixes and roots. This phase is considered a crucial prerequisite for successful morphological decomposition (Carlisle, 1995). The next six sessions focused on prefixes, and the last eight on suffixes. All sessions were organized in the same way: a whole class introduction to the meaning of particular affixes, along the lines of Ehri (2014), an application phase with a series of written exercises and a whole class correction session. During the beginning sessions, children were first made aware of the fact that the root of the word could undergo changes when an affix was added to it, which was illustrated by providing concrete examples (e.g., fleuve [river] > fluvial). For the application phase, the five types of exercises were as follows: (1) segmenting words into affix and root; (2) finding a word from a definition (e.g., "what is not readable is… unreadable."); (3) finding a pseudoword from a definition (e.g. "what is not *rouvisse* is…*unrouvisse*"); (4) finding the morphologically odd one out of three words; (5) finding the maximum number of words from a root. The last two sessions were revision sessions in which all the affixes were mixed. Children had their own exercise book, created specifically for the purpose of the intervention by the first author.

It is important to note that the school program in French-speaking Switzerland (Conférence intercantonale de l'instruction publique de la Suisse romande et du Tessin, 2010) makes no mention of using derivational morphology to support literacy learning throughout the primary grades. The reference textbook for Grades 4, 5 and 6 briefly mentions the use of morphology but only a few exercises related to lexical enrichment are proposed.

Visuo-semantic control training

Visuo-semantic training was offered under the same conditions and dosage as the morphological one. It focused on lexical spelling of inconsistent words, which are numerous in French (Veronis, 1988). For this purpose, we used a well-known visuo-semantic method (De Partz et al., 1992) which aims to facilitate the memorization of the orthographic structure of words by supplying visuals cues (Fig. 1). During each session, the children learned and drew eight words. In the first sessions, children were familiarized with the mental imagery before moving on to words. At the end of the week, a session was set aside to review previously trained words. Based on ethical considerations, we gave teachers access to the material for the morphological training, after the delayed post-test, so that it could also be used with children who did not receive the targeted intervention.

Results

Data analysis

After verifying that all variables met standard assumptions of normality and heterogeneity, we conducted repeated measures ANOVAs for each task (morphological awareness, spelling and reading) to test for the effect of Time with testing phase (T1: pre-test, T2: immediate post-test, T3: delayed post-test) as the within-subject factor and the Training (VSTG: visuo-semantic training group; MTG: morphological training group) as the between-subjects factor. When we found an interaction effect between Time and Training, we conducted Bonferroni post-hoc *t*-tests, with a corrected significance level at $p = .003$. No effect of class was found on the main variables: spelling dictation, $F(3,66) = 0.87$, $p = .46$, text reading, $F(3,66) = 0.09$, $p = .97$, and the total morphological awareness score, $F(3,66) = 2.46$, $p = .07$.

Impact of training on morphological awareness

For the sake of conciseness, we created two composite scores. The first one included the sum of the items trained on the root extraction and odd-one-out tasks (score out of 20 points, 10 points per task). The second composite score included the sum of the untrained items in the root extraction and odd-one-out tasks, (score on 20 points, 10 points per task). No group differences were found at T1 for the trained composite score, $F(1,68) = 1.74$, $p = .19$, the untrained composite score, $F(1,68) = 0.12$, $p = .73$, or the pseudoword definition tasks, $F(1,68) = 1.39$, $p = .24$.

The raw scores of the morphological awareness tests at all three time points are presented in Table 3. For all morphological awareness tests, results of the ANOVAs showed main effects of Time (trained composite score, $F(2,136) = 191.48$, $p < .001$; untrained composite score, $F(2,136) = 57.67$, $p < .001$; pseudoword definition, $F(2,136) = 182.27$, $p < .001$) and Training (trained composite score, $F(1,68) = 94.53$, $p < .001$; untrained composite score, $F(1,68) = 46.25$, $p < .001$; pseudoword definition, $F(1,68) = 23.82$, $p < .001$), as well as Time by Training interactions (trained composite score, $F(2,136) = 117.94$, $p < .001$; untrained composite score, $F(2,136) = 57.67$, $p < .001$; pseudoword definition, $F(2,136) = 64.93$, $p < .001$). Table 3 indicates that the interaction effect resulted from greater growth in the MTG group for all three tasks.

Table 3 Means and standard deviations for morphological awareness tasks at T1: pre-test, T2: post-test and T3: delayed post-test

		T1		T2		T3	
		MTG[a]	VSTG[b]	MTG	VSTG	MTG	VSTG
	N	36	34	36	34	36	34
Trained items (extraction root+odd one out)	max=20	8.69 (2.36)	9.47 (2.55)	17.58 (2.26)	10.00 (2.40)	16.81 (1.91)	11.21 (1.94)
Untrained items (extraction root+odd one out)	max=20	7.69 (2.03)	7.88 (2.46)	13.19 (2.42)	8.18 (2.65)	13.39 (2.18)	8.79 (2.20)
Pseudoword definition	max=25	9.97 (2.83)	11.03 (4.53)	20.17 (3.23)	13.38 (4.63)	19.61 (3.69)	13.74 (3.51)

[a] MTG: Morphological training group.

[b] VSTG: Visuo-semantic training.

Table 4 Means and standard deviations for spelling tasks at T1: pre-test, T2: post-test and T3: delayed post-test

		T1		T2		T3	
		MTG[a]	VSTG[b]	MTG	VSTG	MTG	VSTG
	N	36	34	36	34	36	34
List A : Trained words by MTG	Affix Score (max=20)	9.44 (2.91)	10.68 (3.33)	17.67 (2.76)	10.38 (2.55)	16.58 (3.24)	11.47 (2.49)
	Roots (max=20)	7.78 (3.20)	8.00 (2.73)	15.78 (4.35)	8.53 (2.64)	13.92 (3.39)	9.76 (3.01)
List B : Untrained words	Affix Score (max=20)	10.75 (3.62)	11.59 (3.26)	17.19 (3.45)	10.74 (2.30)	16.33 (3.03)	11.82 (2.63)
	Roots (max=20)	9.36 (3.63)	9.97 (3.18)	12.81 (3.90)	10.44 (2.34)	12.86 (3.67)	10.71 (3.10)
List C: Inconsistent trained words by VSTG	Trained by the VSTG (max=20)	5.39 (4.32)	4.32 (3.61)	5.72 (4.27)	14.41 (4.85)	6.72 (4.27)	12.53 (4.59)
List D: Inconsistent untrained words	Untrained (max=20)	5.67 (3.87)	5.44 (3.43)	6.31 (3.90)	6.00 (3.51)	8.14 (4.13)	7.41 (3.98)

[a] MTG: Morphological training group.

[b] VSTG: Visuo-semantic training group.

The post-hoc Bonferroni tests showed that all T2 and T3 comparisons between the groups were significant with large effect sizes ($1.63 < d < 3.25$).

Impact of training on spelling

There were no group differences at T1 for trained roots, $F(1,68)=0.10$, $p=.76$, trained affixes, $F(1,68)=2.73$, $p=.10$, untrained roots, $F(1,68)=0.56$, $p=.46$, or untrained affixes, $F(1,68)=1.00$, $p=.31$. There were also no differences between the groups at T1 on lists C, $F(1,68)=1.25$, $p=.27$, and D, $F(1,68)=0.07$, $p=.80$. The raw scores of the spelling tests at all three time points are presented in Table 4.

For list A, results of the ANOVAs revealed significant main effects of Time (affixes, $F(2,136)=147.12$, $p<.001$; roots, $F(2,136)=95.45$, $p<.001$) and Training (affixes, $F(1,68)=35.94$, $p<.001$; roots, $F(1,68)=30.30$, $p<.001$), as well as significant Time by Training interactions (affixes, $F(2,136)=137.43$, $p<.001$; roots, $F(2,136)=59.50$,

$p<.001$). Table 4 indicates that the MTG improved more than the VSTG. Post-hoc Bonferroni tests showed that all T2 and T3 differences were significant with effect sizes (*d*) varying from 1.30 to 2.74.

For list B, both main effects of Time (affixes, $F(2,136)=72.49$, $p<.001$, roots, $F(2,136)=26.46$, $p<.001$) were significant. The main effect of Training was significant for affixes, $F(1,68)=25.52$, $p<.001$, but not for roots, $F(1,68)=3.39$, $p=.07$. However, the Time and Training interaction was again significant for both affixes, $F(2,136)=95.27$, $p<.001$, and roots, $F(2,136)=13.11$, $p<.001$. As with List A, the participants in the MTG improved significantly more than the VSTG participants in spelling affixes and roots, although the between group differences in spelling roots were not significant at T2 or T3 ($d=0.74$ and $d=0.63$ respectively), suggesting smaller improvement with untrained roots than with trained affixes attached to untrained roots ($d=2.20$ for T2 and $d=1.59$ for T3).

For list C, repeated measures ANOVA revealed that the main effects of Time, $F(2,136)=118.20$, $p<.001$, and Training, $F(1,68)=22.63$, $p<.001$, were both significant, as was the Time x Training interaction, $F(2,136)=88.89$, $p<.001$. List C consisted of inconsistent words that were trained in the VSTG condition and Table 4 indicates that they spelled these words more accurately than participants in the MTG condition ($d=1.90$ for T2 and $d=1.31$ for T3).

List D consisted of untrained inconsistent words and the analyses showed a significant main effect of Time, $F(2,136)=25.65$, $p<.001$, but no effect of Training, $F(1,68)=0.25$, $p=.62$, or Time by Training interaction, $F(2,136)=0.35$, $p=.70$.

Impact of training on reading

Multimorphemic words

There were no group differences at T1 for lists A, $F(1,68)=1.36$, $p=.25$, and B, $F(1,68)=1.02$, $p=.32$, reading accuracy or speed (List A, $F(1,68)=2.18$, $p=.15$, and List B, $F(1,68)=1.12$, $p=.29$). The raw scores of the reading tests are presented in Table 5.

Results of the ANOVA on List A words showed significant main effects of Time (reading speed, $F(2,136)=53.83$, $p<.001$; accuracy, $F(2,136)=53.29$, $p<.001$), as well as significant Time by Training interactions (reading speed, $F(2,136)=12.60$, $p<.001$; accuracy, $F(2,136)=13.44$, $p<.001$). The effects of Training were not significant (reading speed, $F(1,68)=0.35$, $p=.56$; accuracy, $F(1,68)=2.48$, $p=.12$). Table 5 indicates that the MTG group were initially slightly slower and less accurate than the VSTG participants, whereas the opposite was true for T2 and T3 scores. However, the only significant difference between the groups was for T2 accuracy ($d=0.96$). These results suggest that the training effect was significant but small.

Results of the ANOVA on List B words showed a main effect of Time for reading speed, $F(2,136)=19.49$, $p<.001$, but no effect for accuracy, $F(2,136)=1.76$, $p=.18$. No effects of Training was observed for reading speed, $F(1,68)=0.26$, $p=.61$, or for accuracy, $F(1,68)=0.05$, $p=.82$, and no Time by Training interactions were found for reading speed, $F(2,136)=2.24$, $p=.11$, or accuracy, $F(2,136)=1.60$, $p=.20$.

Table 5 Means and standard deviations for reading tasks at T1: pre-test, T2: post-test and T3: delayed post-test

		T1		T2		T3	
		MTG[a]	VSTG[b]	MTG	VSTG	MTG	VSTG
	N	36	34	36	34	36	34
List A : Trained words by MTG	Speed	51.58 (36.32)	41.62 (15.69)	22.81 (12.00)	34.06 (12.86)	23.17 (11.05)	28.50 (10.07)
	Accuracy (max = 20)	15.47 (3.21)	16.29 (2.64)	18.92 (1.42)	17.21 (2.09)	18.92 (1.36)	17.71 (2.14)
List B : Un-trained words	Speed	47.44 (33.93)	41.62 (15.69)	35.14 (18.33)	36.38 (12.68)	32.78 (15.60)	31.97 (10.07)
	Accuracy (max = 20)	16.31 (2.81)	17.33 (5.32)	17.83 (1.90)	17.41 (1.86)	17.5 (1.87)	17.24 (2.37)
List C: Incon-sistent trained words by VSTG	Speed	27.56 (20.43)	24.00 (9.27)	20.28 (10.49)	16.53 (8.39)	19.83 (9.55)	16.15 (6.26)
	Accuracy (max = 20)	17.78 (2.15)	17.15 (1.89)	18.47 (1.36)	19.12 (1.37)	18.36 (1.90)	18.91 (1.33)
List D: Incon-sistent untrained words	Speed	26.69 (15.5)	24.68 (10.21)	23.33 (13.38)	22.53 (7.78)	21.94 (10.32)	19.56 (5.80)
	Accuracy (max = 20)	17.06 (2.22)	17.06 (2.75)	17.97 (1.95)	17.94 (1.46)	17.89 (2.20)	17.68 (3.23)

[a] MTG: Morphological training group.

[b] VSTG: Visuo-semantic training group.

Inconsistent monomorphemic words

There was no group difference at T1 for lists C and D for accuracy, respectively, $F(1,68)=1.69$, $p=.20$, and, $F(1,68)<0.001$, $p=1$, or for speed, respectively, $F(1,68)=0.86$ $p=.36$, and, $F(1,68)=0.40$, $p=.53$.

List C words were trained in the VSTG condition. The results showed a main effect of Time, $F(2,136)=25.31$, $p<.001$, but no effects of Training, $F(1,68)=2.29$, $p=.13$, or Time by Training interaction effect $F(2,136)=0.003$, $p=1$, for reading speed. For accuracy, results revealed a significant main effect of Time, $F(2,136)=35.61$, $p<.001$, and Time by Training interaction, $F(2,136)=8.49$, $p<.001$, but no effect of Training, $F(1,68)=0.28$, $p=.60$. Post-hoc comparisons between the groups at T2 and T3 found no significant differences and the significant interaction effect likely resulted from the VSTG participants performing slightly poorer at T1 than the MTG participants whereas the opposite was true at T2 and T3.

List D consisted of untrained inconsistent words. The results showed a main effect of Time for reading speed, $F(2,136)=10.87$, $p<.001$, and accuracy, $F(2,136)=5.99$, $p=.003$. There were no effects of Training for reading speed, $F(1,68)=0.55$, $p=.46$, or accuracy, $F(1,68)=0.03$, $p=.86$. Time by Training interaction was also not significant for reading speed, $F(2,136)=0.30$, $p=.74$, or accuracy, $F(2,136)=0.09$, $p=.92$.

Discussion

The aim of our study was to investigate the effect of an explicit derivational morphology training on morphological awareness, as well as on the spelling and reading of morphologically derived words in French-speaking school-aged children in Grade 4. We compared two groups: one who received morphological training and one who received visuo-semantic training. Our main findings revealed interaction effects between Time and Training Type on morphological awareness on the spelling of morphologically complex words and a learning effect for reading morphologically derived words (accuracy and speed). More precisely, we found significant differences between the two groups after training in favor of the morphological training group, with large effect sizes. Furthermore, we also found a learning effect for the spelling and reading of inconsistent and monomorphemic words (not for speed), with greater improvement in the VSTG compared to the MTG children. We start by presenting the findings of the study with respect to its three aims and then go on to discuss the limitations of the study.

Learning effect

The first aim was to test the differential effect of training on the different outcome measures related to the **trained items**: morphological awareness, spelling and reading (speed and accuracy). We found an effect of morphological training on morphological awareness itself, on the spelling of roots and affixes, and on reading (accuracy and speed). More specifically for spelling, learned affixes were spelled better than learned roots, which was expected given the teaching of explicit rules for the meaning and spelling of affixes. All these results are in line with the existing literature for morphological awareness (Bowers, 2006; Bowers & Kirby, 2010; Filippini, 2007; Harris et al., 2011; Tyler et al., 2003), spelling (Casalis et al., 2018; Devonshire & Fluck, 2010; Nunes et al., 2003; Walter et al., 2007) and reading (Bowers et al., 2010; Goodwin & Ahn, 2013).

Regarding list C (words trained in the VSTG) spelling, our results showed a positive effect of the visuo-semantic intervention. A significant but small effect was also found for the reading. These results are interesting because they are the first to show the effect of a visuo-semantic method for the spelling of the target words.

Generalization effect

Our second aim was to test for a generalization effect of training on **untrained items**. Our results indicated that the training resulted in an improvement in morphological awareness (on the composite score of untrained items in the segmentation and odd one out test, and on the pseudoword definition test) in the MTG only. This confirms that training in derivational morphology has an effect on the process of segmenting words into morphemes, i.e., a generalization effect (as in Casalis et al., 2018).

One of the most interesting findings concerns the generalization effects observed in measures of spelling by the morphologically trained group. Indeed, children in the MTG spelled trained affixes better than children in the VSTG after training even when the affixes were embedded in words that had not been trained. This is evidence that generalization occurred and children were able to recognize affixes that had been learned during training in new words. In addition, we found a significant but smaller effect for untrained root spelling in favor of MTG. It seems that children in the MTG were able to break down words they had not been taught in the morphological training into morphemes and to spell them more accurately. This could be explained by the fact that they recognized some roots that they were already familiar with before the intervention. These results are important because they reflect a genuinely productive strategy: from the knowledge of a small number of affixes, children can correctly spell many complex words. However, some roots undergo phonological and orthographic changes when the word is derived (i.e., pluie [rain] > pluvieux [rainy]), which may limit the scope of the generalization process.

According to Nagy and Anderson (1984), 60–80% of words encountered in texts after Grade 3 are derived words. Thus, knowing how to decompose such words could be of great help for school-aged children. Our results are in line with those of Casalis et al. (2018) and extend them as Casalis et al. (2018) did not separate out the spelling of affixes and roots. Furthermore, the effects we documented were based on 40 items (versus only 9 in Casalis et al.'s study). We also used the same experimenter for the MTG and VSTG, which was generally not the case in earlier studies (Casalis et al., 2018; Devonshire & Fluck, 2010; Nunes et al., 2003) in which different teachers conducted the interventions, possibly introducing other sources of variance.

For measures on reading, no generalization effects were found, suggesting that morphological training, at least as implemented in the current study, has a limited effect on word identification processes. A study by Rassel et al. (2021), which focused on morphological training in 2nd and 3rd grade French-speaking children with a low socio-economic level, showed a significant improvement only in the fluency of untrained derived words compared to a control group that had continued with conventional school learning. However, this difference no longer appeared when the morphological training group was compared to an active control group undergoing vocabulary training. Bowers et al. (2010) review showed no difference between morphological instruction and alternative treatments (phonological intervention), but a difference was found when compared to passive control groups. Our results are in line with these studies suggesting no specific impact of morphological training on reading measures. A possible explanation for the lack of effect on reading could be that the focus of our study was not on reading words aloud but on silent reading as part of the training exercises. Even if the existing literature shows a compelling link between morphological awareness and the reading of multimorphemic words (Duncan, 2018; Levesque & Deacon, 2022), our intervention did not demonstrate how children use morphemes in reading. This result is consistent with the granularity theory, which postulates that children in transparent orthographies do not need to use larger units (morphemes) to read efficiently (Ziegler & Goswami, 2005). As Mousikou et al. (2020) showed, the use of morphology during reading is indeed dependent on the orthographic consistency of the language.

For the spelling and the reading of monomorphemic words (= list D), we found no generalization effect for the VSTG. This means that the visuo-semantic method seems effective but only in an item-specific way, which limits its usefulness as an intervention. Another possible reason for the lack of generalization effect is the reliability of the D list was low.

Finally, our results can be interpreted in light of the Morphological Pathways Framework (Levesque et al., 2021) which postulates that morphological awareness and spelling are related. The fact that training morphological awareness allows for the improvement of spelling skills in morphologically complex words is a strong argument for a causal link between these two components. Hence, morphological analysis (through the meaning of morphemes and words) and morphological decoding (through the recognition of morphemes within words) can be reinforced to optimize the use of semantic representations as well as the orthographic system. However, the link between morphological awareness and word identification processes is more or less important depending on the productivity of the morphological composition of words in a given language, but also on the depth of its orthographic system, with a weaker link in transparent orthographies, such as French in terms of reading.

Long term effect

Our final aim was to test for a sustained effect of gains over the long term (four months after the end of the training). Our results highlight that the benefits of the morphology intervention were still significant in the delayed post-test. The MTG differed from VTSG at T3 for all measures of morphological awareness: all gains were sustained in the delayed post-test, both on trained and on untrained items. Similarly, the MTG outperformed the VSTG in the spelling of both trained and untrained derived words (only on affixes) at the delayed post-test. Casalis and colleagues (2018) also reported long-term effects at one and five months after the immediate end-of-intervention post-test. The sustainability of effects on spelling tests nevertheless depended on the tests considered (for example, a non-significant effect 5 months later on the spelling of graphemes targeted by the morphology intervention, but a significant effect 5 months later for the spelling of the whole word). Our study supports the long-term impact of derivational morphology intervention on the spelling of derived words. Thus, these results reinforce the value of teaching derivational morphology which leads to long-term improvement, the goal of all teaching.

Limitations and future directions

Our study has some limitations. First, our sample size was modest (N = 70) and our training should be examined with larger groups. Second, even if the fact that the instructor was the same for both groups can be viewed as an advantage, it was not possible to make her blind to the type of training. As a result, a possible instructor bias towards one of the training conditions cannot be ruled out. Third, we developed the morphological awareness tests used in the study and despite the care taken to select the items and control their characteristics, the internal consistency of some of the lists was relatively low and below the threshold of 0.7 that is recognized as indicating sufficient reliability (Nunnally, 1978). It is therefore important to construct other tests with better psychometric qualities.

Moreover, an additional task assessing lexical comprehension could be added to test whether intervention targeting the meaning of affixes improves children's lexical skills on trained and untrained words. Future research could focus on this aspect to confirm the predictive effect of morphological awareness on vocabulary (as in Sparks & Deacon 2015). Finally, it should be added that the visuo-semantic training was much more pleasant for the children than the morphological training, as it involved visual imagery and drawing. In that sense, it would be interesting to improve the morphological training by varying the material and the activities to make it more appealing.

Conclusion

To the best of our knowledge, this study is the first to show that an explicit intervention regime targeting morphological rules related to the meaning of affixes in French has a positive impact on morphological awareness and on written spelling, with limited effects on reading. It also demonstrates that a generalization effect, in morphological awareness and spelling, is possible on words with untrained roots, the highest level of generalization according to Bowers and Kirby (2010). These findings strongly support the use of derivational morphology instruction for typically developing children in schools. They also suggest that morphological intervention is likely to help children with learning disabilities. For this reason, a study targeting children with dyslexia is already underway to evaluate the effectiveness of such a training in children with severe and persistent literacy difficulties.

Appendix A

Morphological awareness tests

	Description of the task	Number of items
Segmentation task	This task consists of segmenting morphologically composed words. The children have to find the smallest word that makes sense, i.e., the root. For example, the word "dixième" (tenth) contains the little word "dix" (ten). The two lists are matched on the number of prefixes and suffixes contained in the words (12 affixes for each) and on the number of syllables ($M=3.4$ for each).	20 items: – 10 items with trained prefixes and suffixes in the MTG – 10 with untrained affixes Each correct answer is credited one point, leading to a maximum score of 20. If the children do not give the expected root, they do not receive a point.

Morphological awareness tests

	Description of the task	Number of items
Odd one out	The experimenter pronounces three words, and the child has to find the two complex words and reject the odd one, which is a pseudo-affixed word. For example, among the words “abricotier” (apricot tree), “janvier” (january) and "avocatier” (avocado tree), “janvier” (january) was the odd one because 1) it is not a tree and 2) does not have the suffix -ier; the word “janv” does not mean anything. The two lists were matched on the number of prefixes and suffixes contained in the words (5 prefixes and 5 suffixes for each) and on the number of syllables ($M = 2.74$ for each).	20 series of three words: – 10 series with trained affixes – 10 series with untrained affixes. Each correct answer is credited one point, leading to a maximum score of 20.
Pseudoword definition	The child listens to a definition and has to select the pseudoword that best matches this definition out of four possibilities. For this task, we used written material to avoid overloading the child’s verbal working memory. We also used pseudowords in order to assess a generalization effect and to reduce as much as possible the contribution of the child’s vocabulary knowledge.	25 definitions: – 15 pseudowords concerned the meaning of affixes, for example, “replutage” was to “plute again” because the prefix “re” means “again” in French – 10 pseudowords dealt with suffixes that are indicative of a grammatical class, for example, a “jodraiteur” could only be a name because of the suffix -eur, which means “the person who…”.

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Declarations

Nothing to report.

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