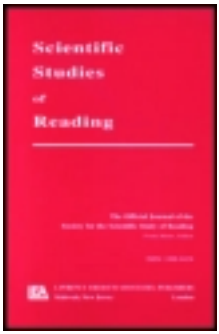

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Exploring the Role of Bases and Suffixes When Reading Familiar and Unfamiliar Words: Evidence From French Young Readers

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Exploring the Role of Bases and Suffixes When Reading Familiar and Unfamiliar Words: Evidence From French Young Readers

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We examined whether French third- and fifth-grade children rely on morphemes when recognizing words and whether this reliance depends on word familiarity. We manipulated the presence of bases and suffixes in words and pseudowords to compare their contribution in a lexical decision task. Both bases and suffixes facilitated word reading accuracy and speed across all grades, even though the co-occurrence of a base and a suffix reduced the benefit associated to the presence of morphemes in third-grade children. Speed of pseudoword (i.e., unfamiliar word) reading was also influenced by base and suffix, and the combination of these units leaded to a high rate of false alarms. These results bring new evidence of morphological analysis in the reading of French familiar and unfamiliar words.

The acquisition of word recognition skills is one of the first tasks confronting young readers. Although most theories of reading development stress the essential role of phonological (Goswami & Bryant, 1990) and orthographic activation (Castles, Davis, Cavalot, & Forster, 2007) in children's word recognition, the role of morphology has been far less studied. A large number of the new words encountered over the school years are polymorphemic (Nagy & Anderson, 1984) in that they contain at least two morphemes, the smallest units of meaning

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in words (e.g., *read-able*). Although the ability of children in second through eighth grade to manipulate morphemes orally significantly predicts word and pseudoword naming (Casalis & Louis Alexandre, 2000; Deacon & Kirby, 2004; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009) and reading comprehension (Carlisle, 2000), the influence of morphemic units on visual word recognition remains unclear, and the aim of this article is to investigate this issue.

THE ROLE OF MORPHOLOGY IN DEVELOPMENTAL MODELS OF WORD RECOGNITION

The developmental models of Frith (1985), Seymour (1997), and Ehri (1998, 2005) all propose that children make use of larger letter patterns such as morphemes at advanced reading levels. Two hypotheses have been proposed to explain how morphemic representations might develop.

Rastle and Davis (2003, 2008) proposed that morphemic representations emerge through extraction of the statistical properties of written language (see also Seidenberg, 1987). According to this "*orthographic view*," children exploit orthographic redundancy within words, either by analyzing the sequential probabilities of letter combinations to detect morphemic units or by grouping high-frequency letter sequences—which often correspond to morphemes—into single units (e.g., "e" and "r" as in *brother* are more frequently associated in English than "e" and "l" as in *brothel*).

Another hypothesis, proposed by Schreuder and Baayen (1995, see also Rastle & Davis, 2008), is that morphemic representations develop as young readers encounter units that systematically share form *and* meaning properties. According to this "*semantic view*," polymorphemic words are recognized with regard to their constituents if the meaning of the whole word can be calculated from the meaning of these subcomponents. Evidence from the English language is consistent with this hypothesis, as children in second through sixth grade read polymorphemic words such as *lucky* more easily than control words matched for orthography, such as *pretty* (Carlisle & Stone, 2005).

THE INFLUENCE OF ORTHOGRAPHIC DEPTH

The *Orthographic Depth* hypothesis suggests that deep orthographies, where graphemes and phonemes have an inconsistent relationship, favor reliance on a lexical code (Frost, Katz, & Bentin, 1987). English is a deep orthography, characterized by many inconsistent grapheme–phoneme correspondences (GPC), which is based on the morphophonemic principle that morphemes tend to be spelled identically even when pronounced differently (e.g., *nature – natural*).

Therefore, recognition of morphemes may enable children to assign correct word pronunciations in deep orthographies (Verhoeven & Perfetti, 2003).

In transparent orthographies such as Italian, GPC are more consistent and reliance on morphemes is not necessary to read words correctly. Nonetheless, sensitivity to morphemes has been reported by Burani and her colleagues among Italian readers (Burani, Dovetto, Spuntarelli, & Thornton, 1999; Burani, Marcolini, De Luca, & Zoccolotti, 2008; Burani, Marcolini, & Stella, 2002). Both adults and children showed speed and accuracy advantages in naming new words that have an apparent morphological structure (e.g., *donn-ista*; "woman-ist") compared to new words that contain no morphemes (e.g., *denn-osta*). The presence of morphemes in pseudowords also increased the likelihood of considering pseudowords as lexical items.

In French, the issue of whether young readers rely on morphemes during word recognition has been little investigated. The French orthography is characterized by consistent GPC but inconsistent phoneme-to-grapheme correspondences. Morphological information has been shown to help French children to spell words for which the phoneme-to-grapheme correspondences are inconsistent, especially those words ending with a silent letter that is motivated by morphology (Pacton & Deacon, 2008; Sénéchal, 2000). For example, 7-year-old children infer the presence of the silent letter *–p* at the end of *galop* (/galo/, "gallop") from the morphologically related verb *galoper* (/galope/, "to gallop").

As the French GPC are fairly consistent, recognition units smaller than morphemes ought to be sufficient for reading. However, the French derivational system is rich and particularly suitable for using morphemes as recognition units. As noted by Rey-Debove (1984), 75% of the French words are polymorphemic and can be analyzed in terms of their morphemic constituents. In addition, French derivatives are mostly phonologically transparent, even though the derivation often involves slight orthographic shifts at the end of bases that do not obscure morphological relations between base and derived forms (e.g., *plume – plumage*, "feather – plumage"). The prevalence of morphemes in words, along with phonological transparency, appears to facilitate the development of oral knowledge of morphology in French-speaking children (Duncan, Casalis, & Colé, 2009) and may also promote their use of written morphology.

The only empirical evidence of the impact of the morphological structure in French arises from *pseudoword* reading. First- and second-grade children are more accurate when naming polymorphemic pseudowords (e.g., *mordage*, "bitage") than pseudowords containing only a base (e.g., *fermine*, "farmin") or only a suffix (e.g., *soumage*, "somage"; Marec-Breton, Gombert, & Colé, 2005; Colé, Bouton, Leuwers, Casalis, & Sprenger-Charolles, 2011). Nevertheless, it remains unclear whether French children would also rely on morphemes to facilitate *lexical* access.

ROLE OF BASES AND SUFFIXES IN CHILDREN'S READING

The influence of the different types of morphemes on lexical access has also to be clarified. Specifically, suffixed words—on which we focus in this study—encode two components: a base (e.g., *read*-*able*) that gives words their meaning and a suffix (e.g., *read*-*able*) that modifies the meaning of bases and, in most cases, their syntactic category.

Studies conducted in English emphasize the role of bases in word naming. For example, 7-year-olds read suffixed words more accurately than simple words with matched endings (e.g., *lucky* vs. *pretty*; Carlisle & Stone, 2003; Laxon, Rickard, & Coltheart, 1992). In addition, base characteristics such as frequency (Carlisle & Stone, 2005), family size (Carlisle & Katz, 2006), and phonological and orthographic transparency (Carlisle, 2000) affect word naming from the lower elementary years. Following Schreuder and Baayen (1995), Carlisle and Stone (2003) argued that a left-to-right analysis of words may allow the activation of bases that have a lexical status, leading to the recognition of both familiar and unfamiliar polymorphemic words *via* their base.

The role of suffixes is less established. Suffixes appear to provide clues to English word pronunciation when their presence reconfigures the pronunciation of the base (e.g., *nature – natural*) among third- to sixth-grade children (Mann & Singson, 2003). In addition, fragment completion (e.g., *TURN* expected for *T_ _N*) is easier in English when fragments are primed by a morphologically related word (e.g., *turned-T_ _N*) than an orthographically related word (i.e., *turnip-T_ _N*; Feldman, Rueckl, DiLiberto, Pastizzo, & Vellutino, 2002), even for children in first grade (Rabin & Deacon, 2008). The absence of a suffix at the end of orthographically related primes (e.g., *-ip* in *turnip*) may have prevented words from being decomposed into smaller units. Similar results have been observed in a primed lexical decision task by Casalis, Dusautoir, Colé, and Ducrot (2009) among French fourth-grade children. Additional evidence of the influence of the suffix has been provided in comprehension tasks, where suffix analysis plays a role in the interpretation of word meaning (Anglin, 1993; Carlisle & Fleming, 2003).

To our knowledge, the only study that has contrasted children's use of bases and suffixes when reading has been conducted by Traficante, Marcolini, Luci, Zoccolotti, and Burani (2011). Italian sixth-grade children were asked to read aloud pseudowords, which were made up of a nonexistent base plus suffix combination (B+S+, e.g., *bagnezza*: *bagn-*, "bath" + *-ezza*, "-ness"), a base only (B+S-, e.g. *bagnezzo,* where "ezzo" is not a suffix), a suffix only (B-S+, e.g., *bognezza* where "bogn" is not a base), or neither a base nor a suffix (B-S-, e.g. *bognezzo*). Children in sixth grade took advantage of the base when naming pseudowords, in terms of accuracy and speed. They also took advantage of the suffix, but only in naming accuracy.

Traficante et al.'s (2011) investigation speaks to the importance of examining simultaneously the influence of base and suffix in children's reading. An innovative aspect of this work is that the items were matched in bigram frequency to control for orthographic familiarity. Therefore, the significant base and suffix effects suggest that sixth-grade children's reliance on morphology cannot be explained in terms of bigram frequency. However, one limitation of this study is that only pseudoword reading was investigated. When examining which properties of words influence lexical access, one needs to examine the impact of the morphological structure in *word* reading. Further, the naming task draws heavily on pronunciation skills (Coltheart, Davelaar, Jonasson, & Besner, 1977) and may not reflect silent reading.

THE PRESENT STUDY

The purpose of the present study was to form a more detailed understanding of young French readers' use of morphemes during visual word recognition. The two research questions were as follows: Does morphemic content (base and suffix) influence word recognition among French third- and fifth-grade children? Does lexicality (i.e., familiarity) influence their reliance on morphemes?

To this end, French students in third and fifth grade performed a lexical decision task in which we manipulated the presence of base (B+/B-) and suffix (S+/S-) not only in pseudowords, as Traficante et al. (2011) did, but also in words. The lexical decision task requires participants to determine whether a letter string is a word or a not by checking whether the string corresponds to a lexical representation. Accuracy scores and reaction times make it possible to uncover the units involved in lexical access. This task, which is one of the most widely used in reading research (Seidenberg & McClelland, 1989), has already proven to be a valuable tool in investigating the influence of morphological structure in children's reading (Burani et al., 2002). As it involves silent reading, it is also representative of children's independent reading after 2 or 3 years of instruction. In addition, as most of the studies conducted on the role of morphology in children's reading have used naming tasks, the lexical decision task will make it possible to investigate whether children's reliance on morphology goes beyond pronunciation issues.

Influence of Morphemic Content

The manipulation of the presence of base and suffix will allow examination of how each of these units influences word recognition. We controlled orthographic familiarity by matching words and pseudowords in bigram frequency, by matching bases (B+) in the word and pseudoword conditions on token frequency, and

by matching suffix (S+) and nonsuffix (S-) endings in the word and pseudoword conditions on token trigram frequency. These controls should enable us to test the "*orthographic view*" that children's use of morphology is not separable from their sensitivity to frequent orthographic patterns. The observation of base and/or suffix effects on lexical decisions would disprove this view and would suggest that morphemes are taken into account beyond orthographic familiarity issues. In addition, analyses of simple effects and interactions between base and suffix will allow us to establish whether these units have cumulative effects on word recognition or whether the co-occurrence of base and suffix strengthens children's use of morphological structure during word recognition.

Influence of Lexicality

We manipulated the morphological structure of both words and pseudowords to confirm that morphemes facilitate pseudoword (i.e., unfamiliar word) reading, as already shown in French by Marec-Breton et al.(2005), and to investigate whether familiar words, which already have a lexical representation, are also recognized through their morphemic constituents. If the lexicon is organized around morphemes, we expect decisions for words to be easier when readers can make use of morphemes, leading to fewer errors (less false rejections) and faster reaction times. Regarding pseudowords, we expect the presence of morphemes to interfere with the decisions, leading to more errors (more false alarms, as evidenced by Burani et al., 2002) and slower reaction times.

We adopted a cross-sectional design: Third-grade children were selected, as this is the youngest age group that has been shown to use morphemes when reading words (Carlisle & Stone, 2003; Laxon et al., 1992), and fifth-grade children were chosen for comparison due to their higher expertise in reading. If children rely on morphemes only at advanced reading levels (Ehri, 1998, 2005; Seymour, 1997), we expect fifth-grade children to benefit more from the morphological structure of words than children in third grade. Specifically, we expect a main effect of base in third-grade children, as they are less fluent in reading and therefore tend to process information sequentially. However, we expect a main effect of base and of suffix in fifth-grade children, because they are able to process more information in parallel.

METHOD

Participants

Thirty third-grade children and 30 fifth-grade children from three schools in middle-class cities of northern France took part to the experiment with informed parental consent. All children were native French speakers with no reported

history of speech, language, or hearing difficulties. The mean chronological age of the third-grade children (15 girls, 15 boys) was 8 years 9 months ($SD = 4$ months), and the mean chronological age of the fifth-grade children (16 girls, 14 boys) was 10 years 8 months ($SD = 5$ months). Reading level (speed and accuracy combined) was calculated using the French standardized test, "L'Alouette" (Lefavrais, 1967). The mean reading ages in third grade ($M = 8$ years 9 months, $SD = 10$ months) and fifth grade ($M = 10$ years 11 months, $SD = 14$ months) did not differ significantly from chronological age (ts < 1).

Materials

Four sets of 24 words and 24 matched pseudowords (listed in the appendix) were selected, resulting in a total of 192 items.

Words. Suffixes were selected using an analysis of the French grade-level lexical database Manulex Infra (Peereman, Lété, & Sprenger-Charolles, 2007) by Dusautoir and Casalis (2008). The constraints on selection were the following: Suffixes had to be frequent so that they would be known by children, to be mainly used in polymorphemic words whose length does not exceed nine letters and to be representative of the words children encounter in print so both nominal and adjectival suffixes were included. This led us to select the suffixes "eux," "eur," "eau," "ier," "age," and "al."

This information was used to construct the four word conditions:

1. *B+S+* (e.g., *pêcheur*, "fisherman")—semantically transparent polymorphemic words constructed from a base word (*pêcher*, "to fish") and a suffix (*-eur*)
2. *B–S+* (e.g., *janvier*, "January")—words ending in a suffix (*-ier*) but beginning with an orthographic string that was not a word and could not be a base in French (*janv-*)
3. *B+S–* (e.g., *barque*, "boat")—words that included a base word at the beginning (*bar*, "bar") and whose ending was not a suffix (*-que*)
4. *B–S–* (e.g., *brousse*, "bush")—words that contained an orthographic string at the beginning, which was neither a word nor a base (*brou-*), and a nonsuffix ending (*-sse*).[1]

Undergraduate students were asked to estimate the semantic transparency of the polymorphemic words (B+S+) by rating the semantic similarity between each

[1]The only condition where words are polymorphemic and follow the combinatorial principles of the French morphology is the B+S+ condition. In the B+S– and B–S+ conditions, words contain a morpheme (a base or a suffix, respectively) but their presence is purely accidental and they do not have any morphological relationship with the whole word.

TABLE 1
Means (Standard Deviations) for Length (Number of Letters) and Frequency (Occurrences per Million) of Words and Pseudowords as Indicated by the Manulex Infra Database (Peereman et al., 2007)

			Frequency			
Construction	*n*	*Length*	*Surface*	*Base Word*	*Total Bigrams*	*Ending Trigrams*
Words						
B+S+	24	7.00 (0.66)	27.40 (17.38)	114.70 (137.20)	9,650 (4237)	3,596 (1,377)
B+S–	24	6.67 (1.09)	37.97 (41.93)	61.82 (85.63)	9,058 (3037)	3,489 (1,518)
B–S+	24	6.75 (0.99)	40.22 (36.29)		8,728 (4188)	3,505 (1,686)
B–S–	24	6.42 (0.83)	33.17 (36.40)		8,757 (3259)	3,617 (1,479)
Pseudowords						
B+S+	24	6.92 (0.88)	—	105.35 (152.18)	—	3,596 (1,377)
B+S–	24	6.75 (0.89)	—	84.10 (77.39)	—	3,489 (1,518)
B–S+	24	6.37 (0.82)	—		—	3,505 (1,686)
B–S–	24	6.16 (0.92)	—		—	3,617 (1,479)

word and its base on a scale ranging from 1 (*unrelated*) to 4 (*highly related*). Unrelated pairs were included as fillers in the questionnaire. The mean rating of each B+S+ pair was above 3.5, indicating a high degree of semantic transparency.

All items were regular in terms of GPC, and all but one B+S+ word (*national,* "national") were phonologically transparent derived forms. The final letter was generally removed from the base in the B+S+ and B+S– conditions (e.g., *plume – plumage,* "feather – plumage"), which is characteristic of French derivation (see the introduction section to this article).

Nonsuffix endings (S–) were matched to suffixes in trigram frequency and number of graphemes ($Fs < 1$) and all four word sets were matched for length, $F(3, 92) = 1.76$, $p = .16$, surface frequency and bigram frequency ($Fs < 1$). The two sets of words that included a base word (B+) were also matched for base frequency, $t(46) = 1.60$, $p = .12$ (see Table 1 for the mean values for each of these variables across the four conditions).

Pseudowords. A matched list of 96 pseudowords was constructed:

1. *B+S+* (e.g., *moucheau*, a comparable English example would be *farmage*) – pseudowords containing a base and a suffix, leading to a legal combination that does not exist in French
2. *B+S–* (e.g., *crémeque*, a comparable English example would be *trimach*) – pseudowords containing an orthographic string that could be a French base and a nonsuffix ending

3. *B–S+* (e.g., *mivage*, a comparable English example would be *hettage*) – pseudowords containing an orthographic string that was not a word and could not be a base together with a French suffix
4. *B–S–* (e.g., *riosse*, a comparable English example would be *birtace*) – control pseudowords which did not contain any morphemes.

Pseudoword construction mirrored the selection of real words. Namely, pseudowords were always phonologically transparent, and the final letter was generally removed from the base in the B+ conditions. Pseudowords were matched for ending trigram frequency across conditions, $F < 1$, but we could not match them perfectly in length, $F(3, 92) = 3.63$, $p = .02$. Post hoc comparisons (Tukey's Honestly Significant Difference) indicate that the B+S+ pseudowords ($M = 6.92$ letters) contained more letters than the B–S– pseudowords ($M = 6.17$ letters). The two B+ conditions were matched for base frequency, $t < 1$ (see Table 1).

Words and pseudowords were matched in length, $t(95) = 1.23$, $p = .22$, and in ending trigram frequency ($F < 1$).

Procedure

Stimulus presentation and data collection were controlled using E-Prime Software, Version 1.0 (Schneider, Eschmann, & Zuccolotto, 2002), running on a Dell Latitude 131L laptop. A trial consisted of the presentation of a white cross at the centre of a black screen for 1,000 ms, followed by a white, lowercase target in Courier New font, point size 25. Targets were displayed until participants responded or for a maximum of 5,000 ms. Participants were instructed to decide as quickly and accurately as possible whether a string of letters constituted a French word or not in the lexical decision task. If the stimulus was a word, right-handed participants[2] had to press the letter "p" on the keyboard ("yes" responses), whereas if the stimulus was a pseudoword, participants had to press the letter "q" ("no" responses). Because the stimulus set contained an equal number of words and pseudowords, the number of "yes" and "no" responses was balanced. The training session consisted of five words and five pseudowords. The experimental stimuli were divided into two lists, each containing 48 words and 48 pseudowords. Presentation order was counterbalanced and items within each list were randomized. Participants had a rest period every 20 trials.

[2]Left-handed children did the opposite.

Data Treatment and Analysis

Words and pseudowords with error percentages either greater than the chance level of 50% or greater than 2.5 *SD* above the mean were excluded from the analysis (see items marked with an asterisk in the appendix). The new sets of stimuli were still matched for length and frequency. Reaction times (RTs) faster than 500 ms (2.17% of the third-grade data and 0.63% of the fifth-grade data) and slower than 4,000 ms (1.82% of the third grade and 0.36% of the fifth-grade data) were also excluded. Finally, RTs were log-transformed to correct a rightward skew.

To test the influence of base on lexical decisions, we compared the B+ items (B+S+ and B+S–) and the B– items (B–S+ and B–S–). We used the same methodology to test the suffix effect, in that we compared the S+ items (B+S+ and B–S+) and the S– items (B+S– and B–S–).

RESULTS

Four analyses of variance (ANOVAs) were performed, two on error percentages calculated on the new subset of items (one for words, one for pseudowords) and two on RT data for correct responses (one for words, one for pseudowords), each with grade, base, and suffix as independent variables. In the by-participant analyses (F_1), grade (Grade 3, Grade 5) was treated as a between-participants factor, whereas base (B+, B–) and suffix (S+, S–) were treated as within-participants factors. In the by-item analyses (F_2), grade was treated as a within-participants factor, whereas base and suffix were the between-participants factors.

Word Condition

Mean error percentages and RTs are reported in Table 2.

TABLE 2
Mean Error Percentages (Error %) and Reaction Times (RTs in ms) According to Word Construction and to Grade

	B+S+ *pêcheur*	*B+S–* *barque*	*B–S+* *janvier*	*B–S–* *brousse*
Error %				
Grade 3	7.66 (6.33)	10.37 (8.45)	7.80 (6.68)	16.85 (11.07)
Grade 5	3.06 (4.22)	8.05 (5.21)	4.17 (4.09)	12.33 (7.56)
RTs				
Grade 3	1,559 (294)	1,519 (257)	1,526 (247)	1,592 (298)
Grade 5	1,051 (211)	1,131 (248)	1,092 (193)	1,163 (251)

Note. Standard deviations are in parentheses.

Error percentages. There was a main effect of grade, indicating that third-grade children were less accurate than fifth-grade children in the lexical decision task, $F_1(1, 58) = 9.05$, $p = .004$, $\eta^2_p = .14$; $F_2(1, 86) = 21.22$, $p < .001$, $\eta^2_p = .20$. The main effect of base indicating reduced errors in the presence of a base was significant by participants, $F_1(1, 58) = 15.91$, $p < .001$, $\eta^2_p = .22$, and marginal by items, $F_2(1, 86) = 2.69$, $p = .10$, $\eta^2_p = .03$. This base effect did not interact with grade ($F_1 < 1$ and $F_2 < 1$). Error percentages were also lower when there was a suffix, $F_1(1, 58) = 52.82$, $p < .001$, $\eta^2_p = .48$; $F_2(1, 86) = 10.92$, $p = .001$, $\eta^2_p = .11$, and this effect did not interact with grade ($F_1 < 1$ and $F_2 < 1$). The interaction between base and suffix was significant by participants, $F_1(1, 58) = 12.68$, $p < .001$, $\eta^2_p = .18$, but not by items, $F_2(1, 86) = 1.55$, $p = .22$, $\eta^2_p = .02$. Finally, the three-way interaction between base, suffix, and grade did not achieve significance, $F_1(1, 58) = 1.41$, $p = .24$, $\eta^2_p = .02$; $F_2 < 1$.

Simple effects were used to investigate the base by suffix interaction. The presence of a base facilitated lexical decisions when there was no suffix, $F_1(1, 59) = 20.63$, $p < .001$, $\eta^2_p = .26$, but not when there was a suffix ($F_1 < 1$). The presence of a suffix also facilitated lexical decisions, both when there was a base, $F_1(1, 59) = 14.89$, $p < .001$, $\eta^2_p = .20$, and when there was no base, $F_1(1, 59) = 54.80$, $p < .001$, $\eta^2_p = .48$.

Reaction times. Fifth-grade children were faster than third-grade children at correctly accepting words, $F_1(1, 58) = 53.40$, $p < .001$, $\eta^2_p = .48$; $F_2(1, 86) = 855.60$, $p < .001$, $\eta^2_p = .91$. Decisions were faster when there was a base, by participants only, $F_1(1, 58) = 11.30$, $p = .001$, $\eta^2_p = .16$; $F_2(1, 86) = 1.20$, $p = .29$, $\eta^2_p = .01$. The effect of the base did not interact with grade, $F_1(1, 58) = 2.10$, $p = .15$, $\eta^2_p = .04$; $F_2 < 1$. Decisions were also faster when there was a suffix by participants only, F_1 $(1, 58) = 12.20$, $p < .001$, $\eta^2_p = .17$; $F_2(1, 86) = 2.20$, $p = .14$, $\eta^2_p = .02$. Suffix and grade effects interacted, $F_1(1, 58) = 12.20$, $p = .004$, $\eta^2_p = .13$; $F_2(1, 86) = 4.40$, $p = .04$, $\eta^2_p = .05$. Post hoc comparisons indicated that the presence of a suffix speeded up word recognition in fifth grade but not in third grade. The interaction between base and suffix was significant by participants only, $F_1(1, 58) = 4.20$, $p = .04$, $\eta^2_p = .07$; $F_2 < 1$. Finally, the three-way interaction between base, suffix, and grade was significant by participants, $F_1(1, 58) = 5.10$, $p = .03$, $\eta^2_p = .08$, and marginal by items, $F_2(1, 86) = 3.40$, $p = .07$, $\eta^2_p = .04$.

Simple effects were used to investigate this three-way interaction. The Base × Suffix interaction was significant in third grade, $F_1(1, 29) = 7.21$, $p = .01$, $\eta^2_p = .20$, but not in fifth grade ($F_1 < 1$). In third graders, the base effect was significant when there was no suffix, $F_1(1, 29) = 6.64$, $p = .02$, $\eta^2_p = .18$, but not when there was a suffix, $F_1(1, 29) = 2.62$, $p = .12$, $\eta^2_p = .08$. Similarly, the suffix effect was significant when there was no base, $F_1(1, 29) = 5.69$, $p = .02$, $\eta^2_p = .16$, but not when there was a base, $F_1(1, 29) = 2.68$, $p = .11$, $\eta^2_p = .08$.

Base frequency check. In spite of the statistical match for base frequency, bases tended to be more frequent in the B+S+ than in the B+S- condition (114.70 per million and 61.82 per million, respectively). As a check, the by-item analyses of error percentages and RTs were re-run with base frequency as a covariate. Base frequency did not influence errors percentages ($F < 1$) and did not interact significantly with grade ($F < 1$). Base frequency did not influence RTs either ($F < 1$) and did not interact significantly with grade, $F(1, 40) = 2.67$, $p = .11$, $\eta^2_p = .06$

Pseudoword Condition

Mean error percentages and RTs are reported in Table 3.

Error percentages. ANOVAs revealed no main effect of grade, F_1 and $F_2 < 1$. Error percentages were higher when there was a base, $F_1(1, 58) = 49.07$, $p < .001$, $\eta^2_p = .46$; $F_2(1, 85) = 20.31$, $p < .001$, $\eta^2_p = .19$, and this base effect did not interact with grade, $F_1(1, 58) = 2.28$, $p = .14$, $\eta^2_p = .04$; $F_2(1, 85) = 1.37$, $p = .24$, $\eta^2_p = .02$. The presence of a suffix also led to more errors, $F_1(1, 58) = 55.68$, $p < .001$, $\eta^2_p = .49$; $F_2(1, 85) = 22.85$, $p < .001$, $\eta^2_p = .21$, and the effect did not interact with grade, $F_1(1, 58) = 1.66$, $p = .20$, $\eta^2_p = .03$; $F_2(1, 85) = 1.31$, $p = .26$, $\eta^2_p = .02$. There was a significant interaction between base and suffix, $F_1(1, 58) = 26.67$, $p < .001$, $\eta^2_p = .31$; $F_2(1, 85) = 13.20$, $p < .001$, $\eta^2_p = .13$, but no interaction between base, suffix, and grade, F_1 and $F_2 < 1$.

We used simple effects to investigate the Base × Suffix interaction. The presence of a base increased error percentages when a suffix was present, $F_1(1, 59) = 49.72$, $p < .001$, $\eta^2_p = .70$, but not when there was no suffix, $F_1(1, 59) = 1.36$, $p = .25$, $\eta^2_p = .02$. The presence of a suffix also increased error

TABLE 3
Mean Error Percentages (Error %) and Reaction Times (RTs in ms) According to Pseudoword Construction and to Grade

	B+S+ *moucheau*	*B+S–* *crémeque*	*B–S+* *mivage*	*B–S–* *riosse*
Error %				
Grade 3	24.55 (16.34)	13.36 (9.87)	14.09 (14.16)	13.13 (13.30)
Grade 5	27.03 (15.21)	12.39 (10.67)	12.72 (12.77)	10.13 (11.68)
RTs				
Grade 3	2,082 (385)	2,042 (370)	2,086 (372)	1,920 (342)
Grade 5	1,554 (390)	1,500 (367)	1,481 (361)	1,370 (398)

Note. Standard deviations are in parentheses.

percentages when a base was present, $F_1(1, 59) = 74.60$, $p < .001$, $\eta^2_p = .56$, but had no effect in the absence of a base, $F_1(1, 59) = 1.57$, $p = .22$, $\eta^2_p = .03$.

Reaction times. Fifth-grade children were faster than third-grade children at rejecting pseudowords, $F_1(1, 58) = 38.54$, $p < .001$, $\eta^2_p = .40$; $F_2(1, 85) = 1055.40$, $p < .001$, $\eta^2_p = .92$. Lexical decisions were slower when there was a base, $F_1(1, 58) = 34.41$, $p < .001$, $\eta^2_p = .37$; $F_2(1, 85) = 6.50$, $p = .01$, $\eta^2_p = .07$, and the interaction between base and grade appeared only as a trend by participants, $F_1(1, 58) = 3.13$, $p = .08$, $\eta^2_p = .05$; $F_2(1, 85) = 2.4$, $p = .13$, $\eta^2_p = .03$. Decisions were also slower when there was a suffix, $F_1(1, 58) = 33.19$, $p < .001$, $\eta^2_p = .36$; $F_2(1, 85) = 5.0$, $p = .03$, $\eta^2_p = .06$, and the effect did not interact with grade (F_1 and $F_2 < 1$). The interaction between base and suffix was significant by participants only, $F_1(1, 58) = 9.51$, $p = .003$, $\eta^2_p = .14$, $F_2 < 1$, and the three-way interaction between base, suffix, and grade was significant by items only, $F_1 < 1$; $F_2(1, 85) = 4.2$, $p = .04$, $\eta^2_p = .05$.

Simple effects were used to investigate the interaction between base and suffix. The presence of a base tended to slow down decisions when there was a suffix, $F_1(1, 59) = 3.73$, $p = .058$, $\eta^2_p = .06$, and slowed down decisions when there was no suffix, $F_1(1, 59) = 49.54$, $p < .001$, $\eta^2_p = .46$. The presence of a suffix also slowed down decisions when there was a base, $F_1(1, 59) = 4.66$, $p = .03$, $\eta^2_p = .07$, and when there was no base, $F_1(1, 59) = 49.30$, $p < .001$, $\eta^2_p = .46$, but this effect was larger when there was a base.

DISCUSSION

The aim of this study was to investigate the role of morphology in children's word recognition. More specifically, we examined (a) the influence of different types of morphemes (base and suffix) in third and fifth grade children's word recognition, and (b) whether their use of morphology depends on word familiarity (i.e., lexicality).

Results indicate that children take account of morphemes when reading words *and* pseudowords as early as in third grade. The presence of a base and/or a suffix facilitates lexical access even though the GPC are consistent and increases the probability of classifying pseudowords as words. These data extend the influence of morphemes already observed in pseudoword reading in the shallow French (Marec-Breton et al., 2005) and Italian (Traficante et al., 2011) orthographies, to the recognition of familiar words.

As words and pseudowords were matched for sublexical frequency across the conditions, this result is not consistent with the view that developing readers analyze frequent letter combinations to develop representations for morphemic units (Rastle & Davis, 2008). Actually, bases and suffixes have acquired a specific

status for the word recognition system, and their presence offers young readers a reliable clue in lexical decision. One hypothesis is that the emergence of morphemes as recognition units depends on children's ability to make connections between units that systematically share form and meaning properties, as proposed in Schreuder and Baayen's (1995) "*semantic view*" (see also Rastle & Davis, 2008). A recent study using an artificial language learning paradigm is also consistent with this hypothesis, as semantic information about affixes played an important role in the acquisition of novel affix representations (Merkx, Rastle, & Davis, 2011)

The influence of base and suffix depends both on grade and on the variable under consideration. In terms of accuracy, third- and fifth-grade children are more likely to accept words in lexical decision when they contain either a base or a suffix. However, although bases influence word recognition only when there is no suffix in words, suffixes influence word recognition both when a base is present and absent. This result suggests that suffixes play a more critical role than bases in making a lexical decision. Regarding latencies, the influence of base and suffix depends on grade. In third grade, the presence of a suffix speeds up word recognition only when there is no base, and the presence of a base speeds up word recognition only when there is no suffix. This pattern suggests that these younger children are not yet able to capitalise fully on morphological structure to speed up word recognition. The co-occurrence of base and a suffix might involve an additional computational cost related to the decomposition or to the licensing check, which might slow down the recognition process (Tyler & Nagy, 1990). As the influence of bases and suffixes is separable in fifth grade, this processing cost is specific to third-grade children.

We expected a more important effect of the base (compared to the suffix) in third grade because reading is supposed to be more sequential than at the fifth-grade level. As familiarity is an important factor when reading polymorphemic words through their morphemic components (Reichle & Perfetti, 2003), we selected frequent bases that would be familiar to third-grade children. One possible explanation for the more important role of the suffix than the base in third grade is related to the reduced salience of bases in French, which sometimes include a smaller word that may interfere with less skilled readers' reliance on the base. For example, the base of the B+S+ word *fermier* ("farmer") is *ferme* ("farm"), but *fermier* also includes the word *fer* ("iron"). This presence of other words might delay the development of the base as an efficient orthographic unit in word recognition.

Suffixes appear to facilitate lexical access in all grades. Young French readers have developed sensitivity to the presence of suffixes at the end of words, which constitute relevant cues in considering lexical status, both in terms of speed and accuracy. Their reliance on suffixes may mirror the richness of French morphology, where approximately 170 suffixes exist, and although there is wide

variation in their productivity, Rey-Debove (1984) estimated that 75% of French words are polymorphemic. Only familiar suffixes were included in the present study, so additional studies are needed to examine the effect of familiarity on children's use of suffixes in reading. The important role of suffixes in French word recognition may also be reinforced by educational policy. Indeed, the French Ministry of Education encourages teachers to make express mention of derivational morphology from the 1st year of schooling in relation to the development of oral vocabulary, even though morphological rules for building new words are not generally taught until fourth grade (Observatoire National de la Lecture, 2007). This could lead children to pay greater attention to suffixes in written words and hence make a deeper use of suffixes when recognizing words.

Regarding pseudowords, the presence of any morpheme (base or suffix) increased decision latencies in both third and fifth grades, and this effect was reinforced by the co-occurrence of a base and a suffix. Furthermore, the probability of incorrectly classifying pseudowords as words increased only when there was both a base and a suffix (B+S+), as already reported by Burani et al. (2002). This result suggests that children access morphologically decomposed lexical representations when making a decision and that checking for the licensing of the B+S+ combination gives rise to false alarms (as proposed by Schreuder & Baayen, 1995).

Both bases and suffixes facilitate the processing of familiar and unfamiliar words that embed a morpheme. Nevertheless, although the role of suffixes is predominant in the recognition of familiar words, the influence of bases and suffixes is comparable when processing unfamiliar words. One explanation of this difference may be related to the time needed to reject a pseudoword, which is longer than the time needed to accept a word (Forster, 1976). As a consequence, when searching for a lexical entry on pseudoword trials, the cognitive system has more time to take advantage of all the units embedded in pseudowords, including bases, even though the latter are not efficient orthographic units in word recognition.

We only partially replicate Traficante et al.'s (2011) results, as they observed a base effect in accuracy and speed of pseudoword naming and a suffix effect in accuracy only. This might arise from task difference between the studies. The naming task used by Traficante et al. requires a left-to-right sequential analysis, which might give a more important role to the base than the suffix given that the base is encountered first. In contrast, the lexical decision task is a silent reading task, which does not necessitate sequential reading. Task choice may thus influence the interpretation of results depending on the particular aspect of reading emphasised in the task. In the present study, the lexical decision results have shown that children's reliance on morphology facilitates not only the recognition of unfamiliar words (as already evidenced by Marec-Breton et al., 2005) but also the recognition of familiar words.

Our results need to be interpreted within the context of the limitations of the present study. The statistical analyses are not always significant by items despite being significant by participants, which points to the importance of individual word-knowledge in determining children's performance. In addition, the use of a keyboard to collect data may have introduced noise into our reaction time data, with larger latency differences being required for statistical significance.

To conclude, we would like to emphasize the practical implications of our study. Despite morphological rules only being explicitly taught from the fourth grade onward in France, third-grade children have been able to develop orthographic representations for morphemes and make use of bases and suffixes in their reading. The use of morphemic strategies should thus be encouraged by teachers as it enables young readers to read easily both familiar and unfamiliar words.

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APPENDIX

Detailed List of the Stimuli According to Construction and Lexicality

B+S+		*B+S–*		*B–S+*		*B–S–*	
W	*PW*	*W*	*PW*	*W*	*PW*	*W*	*PW*
berceau	ameau	barque	baveque	auteur	bafeau	accueil	araque
coûteux	bandier	bourrique	boitive	bocal	cherpeux	angoisse	atire*
douceur	bruteux	boutique	cendril	bureau	fideux	attaque	bedale
douteux*	campage*	capitale	chancers	carnaval	gérieux	banque	burque
équipage	ceriseur	casque	colque	cerveau	larpal	brousse	chaders
fermier	ciral	cirque	comédire	chameau	lirtage	caisse	esique
garage	denteur	coque	comptale	corbeau	midal	cigale	fodive
grillage	écolage	crique*	conque	cristal	mivage	claque	gadale
hauteur	filtreux	disque	cremeque	dernier	mupleau	conseil	lifasse
joueur	fraisage	écureuil	cyque	entier	nadeur	époque	lique
lainage*	glaceau	envers*	écloque	étage	nondal	flaque	madil
national	grossal	fauteuil	envique	généreux	nupreau	ivoire	marique
olivier	lioncier	marque	fièson	gibier	pasier	lessive	nusique*
paysage	marial	masque	finique	hôpital	plimseur	manque	nutique
pêcheur	moucheau	mousse	fronque	janvier	risier	navire	pagire
plateau	normage	musique	guerril	marteau	rumal	pédale	paril
plumage	percheur*	nuque*	herbique	meilleur	sabeau*	persil	prique
policier	prunage	orgueil*	hique	ménage	sorier	phoque	prisse*
pommier	rasier	pinson	laique	métal	souvier	pique	rileque
rivage	révage	plaque	lionque	rumeur	talleau	remarque	riosse
signal	rosage	salive	nagasse	sérieux	tapinal	risque	rutrique
tonneau	roulage*	tactique	paters	vaisseau	tenal	rubrique	soque
troupeau	routeau	tirelire	pluque	vénéneux	vebeur	toque	sublique
verbal	séchier	univers	tablil	vertical	vitieau	travers	vamil

Note. The items removed from the analysis are marked with an asterisk. W = word; PW = pseudoword.