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

Pauline Quemart, Séverine Casalis, Lynne G Duncan

Please cite this paper as:

Quémart, P., Casalis, S. & Duncan, L. (2012). Exploring the role of base words and suffixes in word and pseudoword processing : Evidence from young French readers. *Scientific Studies of Reading, 16*(5), 424-442.

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

Pauline Quémart, Séverine Casalis and Lynne G. Duncan

Pauline Quémart and Séverine Casalis

Université Lille Nord de France, Laboratoire URECA, France

Lynne G. Duncan

School of Psychology, University of Dundee, United Kingdom

Author note

This research was supported by the French Ministry of Research and Technology (PhD fellowship to P.Quémart) and by the French National Agency of Research (ANR), program « Apprentissages, Connaissances et Société » project LECT MORPHO (award to S. Casalis). We are grateful to Marion Janiot for her assistance in data collection.

Abstract

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.

Abstract: 124 words

The acquisition of word recognition skills is one of the first tasks confronting young readers. While 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 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) propose 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, favour reliance on a lexical code (Frost, Katz, & Bentin, 1987). English is a deep orthography, characterized by many inconsistent grapheme-phoneme correspondences, but 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, grapheme-phoneme correspondences 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 never been investigated. The French orthography is characterized by consistent grapheme-to-phoneme correspondences (GPC) but inconsistent phoneme-to-grapheme correspondences (PGC). Morphological information has been shown to help French children to spell words for which the PGC 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). 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 will 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 emphasise 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 (in press). Italian sixth grade children were asked to read aloud pseudowords, which were made up of a non-existent 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 (in press) 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: (1) Does morphemic content (base and suffix) influence word recognition among French third and fifth grade children? and (2) 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. (in press) 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 two or three 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.

(1) 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 non-suffix (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.

(2) 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 these are 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, since 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.

Material and 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 and 15 boys) was 8 years and 9 months (*SD* = 4 months) and the mean chronological age of the fifth grade children (16 girls and 14 boys) was 10 years and 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 (*t*s < 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*); and 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 non-suffix 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 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 grapheme-to-phoneme correspondences 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 Introduction).

Non-suffix 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).

[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.

Pseudowords

A matched list of 96 pseudowords was constructed: 1) *B+S+* (e.g., *moucheau*, a comparable English example would be *farmag*e) – 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 non-suffix 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; and 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 HSD) 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).

[Insert Table 1 about here]

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 1000 ms, followed by a white, lower-case target in Courier New size 25. Targets were displayed until participants responded or for a maximum of 5000 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). Since 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.

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 and 0.63 % of the fifth grade data) and slower than 4000 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.

In order 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-).

[2] Left-handed children did the opposite.

Results

Four analyses of variance (ANOVAs) were performed, two on error percentages calculated on the new sub-set 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 while 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 while Base and Suffix were the between-participants factors.

Word Condition

Mean error percentages and RTs are reported in Table 2.

[Insert Table 2 about here]

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 by 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.

[Insert Table 3 about here]

Error percentages

Analyses of variance 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 by 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 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, $F_1(1, 59) = 49.54$, $p < .001$, $\eta^2_p = .46$. Nevertheless, this base effect was larger when there was a suffix. 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 1) the influence of different types of morphemes (base and suffix) in third and fifth grade children's word recognition, and 2) 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., in press) 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, in press)

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, while 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 first 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 and Baayen, 1995).

Both bases and suffixes facilitate the processing of familiar and unfamiliar words that embed a morpheme. Nevertheless, while 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 (in press) 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 not only facilitates 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. Additionally, 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 emphasise the practical implications of our study. Despite morphological rules only being explicitly taught from the fourth grade onwards 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.

References

Anglin, J. M. (1993). Vocabulary Development: A Morphological Analysis. *Monographs of the Society for Research in Child Development, 58*(10), 1-186.

Burani, C., Dovetto, F. M., Spuntarelli, A., & Thornton, A. M. (1999). Morpholexical Access and Naming: The Semantic Interpretability of New Root-Suffix Combinations. *Brain and Language, 68*(1-2), 333-339.

Burani, C., Marcolini, S., De Luca, M., & Zoccolotti, P. (2008). Morpheme-based reading aloud: Evidence from dyslexic and skilled Italian readers. *Cognition, 108*(1), 243-262.

Burani, C., Marcolini, S., & Stella, G. (2002). How early does morpholexical reading develop in readers of a shallow orthography? *Brain and Language, 81*(1-3), 568-586.

Carlisle, J. F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing: An Interdisciplinary Journal, 12*(3), 169-190.

Carlisle, J. F., & Fleming, J. (2003). Lexical processing of morphologically complex words in the elementary years. *Scientific Studies of Reading, 7*(3), 239-253.

Carlisle, J. F., & Katz, L. (2006). Effects of word and morpheme familiarity on reading of derived words. *Reading and Writing, 19*(7), 669-693.

Carlisle, J. F., & Stone, C. A. (2003). The effects of morphological structure on children's reading of derived words in English. In E. Assink & D. Sandra (Eds.), *Reading Complex Words: Cross-Language Studies* (pp. 27-52). New-York: Kluwer Academic.

Carlisle, J. F., & Stone, C. A. (2005). Exploring the role of morphemes in word reading. *Reading Research Quarterly, 40*(4), 428-449.

Casalis, S., Dusautoir, M., Colé, P., & Ducrot, S. (2009). Morphological effects in children word reading: A priming study in fourth graders. *British Journal of Developmental Psychology, 27*, 761-766.

Casalis, S., & Louis Alexandre, M. F. (2000). Morphological analysis, phonological analysis and learning to read French: A longitudinal study. *Reading and Writing, 12*(3), 303-335.

Castles, A., Davis, C., Cavalot, P., & Forster, K. I. (2007). Tracking the acquisition of orthographic skills in developing readers: Masked priming effects. *Journal of Experimental Child Psychology, 97*(3), 165-182.

Coltheart, M., Davelaar, E., Jonasson, J. T., & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and Performance VI*. New Jersey: Hillsdale.

Deacon, S. H., & Kirby, J. R. (2004). Morphological awareness: Just 'more phonological'? The roles of morphological and phonological awareness in reading development. *Applied Psycholinguistics, 25*(2), 223-238.

Duncan, L. G., Casalis, S., & Colé, P. (2009). Early meta-linguistic awareness of derivational morphology : Some observations from a comparison of English and French. *Applied Psycholinguistics, 30*, 405-440.

Dusautoir, M., & Casalis, S. (2008). Analyse morpho-lexicale de la base de données Manulex. Université Lille Nord de France.

Ehri, L. C. (1998). Grapheme-phoneme knowledge is essential to learning to read words in English. In J. L. Metsala & L. C. Ehri (Eds.), *Word recognition in beginning literacy.* (pp. 3-40). Mahwah, NJ: Erlbaum.

Ehri, L. C. (2005). Development of sight word reading: phases and findings. In M. J. Snowling & C. Hulme (Eds.), *The Science of Reading: A Handbook* (pp. 135-154). Oxford, England: Blackwell

Feldman, L. B., Rueckl, J., DiLiberto, K., Pastizzo, M. J., & Vellutino, F. R. (2002). Morphological analysis by child readers as revealed by the fragment completion task. *Psychonomic Bulletin & Review, 9*, 529-535.

Forster, K. I. (1976). Accessing the mental lexicon. In R. J. Wales & E. Walker (Eds.), *New approaches to language mechanisms* (pp. 257–287). Amsterdam: North-Holland.

Frith, U. (1985). Beneath the surface of developmental dyslexia. In K. E. Patterson, J. C. Marshall & M. Coltheart (Eds.), *Surface dyslexia: neuropsychological and cognitive studies of phonological reading* (pp. 301-330). London: Erlbaum.

Frost, R., Katz, L., & Bentin, S. (1987). Strategies for Visual Word Recognition and Orthographical Depth: A Multilingual Comparison. *Journal of Experimental Psychology: Human Perception & Performance, 13*(1), 104-115.

Goswami, U., & Bryant, P. (1990). *Phonological skills and learning to read*. London: Erlbaum.

Laxon, V., Rickard, M., & Coltheart, M. (1992). Children read affixed words and non-words *British journal of Psychology, 83*, 407-423.

Lefavrais, P. (1967). *Test de l'Alouette*. Paris: Editions du Centre de Psychologie Appliquée.

Mann, V., & Singson, M. (2003). Linking morphological knowledge to English decoding ability: Large effects of little suffixes. In E. M. H. Assink & D. Sandra (Eds.), *Reading Complex Words: Cross-Languages studies* (pp. 1-26). New York: Kluwer Academic.

Marec-Breton, N., Gombert, J.-E., & Colé, P. (2005). Traitements morphologiques lors de la reconnaissance des mots écrits chez les apprentis lecteurs. *L'Année Psychologique, 105*, 9-45.

Merkx, M., Rastle, K., & Davis, M. H. (in press). The acquisition of morphological knowledge investigated through artificial language learning. *The Quarterly Journal of Experimental Psychology*.

Nagy, W. E., & Anderson, R. C. (1984). How many words are there in printed school in English? *Reading Research Quarterly, 19*(3), 304-330.

Observatoire National de la Lecture (1998). *Apprendre à lire*. Paris: CNDP / Odile Jacob.

Pacton, S., & Deacon, S. H. (2008). The timing and mechanisms of children's use of morphological information in spelling: A review of evidence from English and French. *Cognitive Development, 23*(3), 339-359.

Peereman, R., Lété, B., & Sprenger-Charolles, L. (2007). Manulex-infra: Distributional characteristics of grapheme-phoneme mappings, and infralexical and lexical units in child-directed written material. *Behavior Research Methods*(39), 579-589.

Rabin, J., & Deacon, S. H. (2008). The representation of morphologically complex words in the developing lexicon. *Journal of Child Language, 35*(02), 453-465.

Rastle, K., & Davis, M. H. (2003). Reading morphologically complex words: Some thoughts from masked priming. In S. Kinoshita & S. J. Lupker (Eds.), *Masked priming: The state of the art.* (pp. 279-305). New York: Psychology Press.

Rastle, K., & Davis, M. H. (2008). Morphological decomposition based on the analysis of orthography. *Language & Cognitive Processes, 23*(7/8), 942-971.

Reichle, E. D., & Perfetti, C. A. (2003). Morphology in Word Identification: A Word-Experience Model That Accounts for Morpheme Frequency Effects. *Scientific Studies of Reading, 7*(3), 219.

Rey-Debove, J. (1984). Le domaine de la morphologie lexicale. *Cahiers de Lexicologie, 45*, 3-19.

Roman, A. A., Kirby, J. R., Parrila, R. K., Wade-Woolley, L., & Deacon, S. H. (2009). Toward a comprehensive view of the skills involved in word reading in Grades 4, 6, and 8. *Journal of Experimental Child Psychology, 102*(1), 96-113.

Schneider, W., Eschmann, A., & Zuccolotto, A. (Eds.). (2002). *E-prime reference guide*. Pittsburgh, PA.

Schreuder, R., & Baayen, R. H. (1995). Modeling morphological processing. In L. B. Feldman (Ed.), *Morphological Aspects of Language Processing* (pp. 131-154). Hillsdale, NJ: Erlbaum.

Seidenberg, M. S. (1987). Sublexical structures in visual word recognition: Access units or orthographic redundancy? In M. Coltheart (Ed.), *Attention and performance 12: The psychology of reading.* (pp. 245-263). Hillsdale, NJ: Erlbaum

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review, 96*(4), 523-568.

Sénéchal, M. (2000). Morphological effects in children's spelling of French words. *Canadian Journal of Experimental Psychology, 54*, 76-86.

Seymour, P. H. K. (1997). Foundations of orthographic development. In C. Perfetti, L. Rieben & M. Fayol (Eds.), *Learning to spell* (pp. 319-337). Hillsdale, NJ: Lawrence Erlbaum Associates.

Traficante, D., Marcolini, S., Luci, A., Zoccolotti, P., & Burani, C. (in press). How do roots and suffixes influence reading of pseudowords: A study of young Italian readers with and without dyslexia *Language & Cognitive Processes*.

Tyler, A., & Nagy, W. (1990). Use of derivational morphology during reading. *Cognition, 36*(1), 17-34.

Verhoeven, L., & Perfetti, C. (2003). Introduction to This Special Issue: The Role of Morphology in Learning to Read. *Scientific Studies of Reading, 7*(3), 209-217.

Table 1

Means and standard deviations (in parentheses) 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)

construction	n	length	Frequency			
			Surface	Base word	total bigrams	ending trigrams
Words						
B+S+	24	7.00 (0.66)	27.40 (17.38)	114.70 (137.20)	9650 (4237)	3596 (1377)
B+S-	24	6.67 (1.09)	37.97 (41.93)	61.82 (85.63)	9058 (3037)	3489 (1518)
B-S+	24	6.75 (0.99)	40.22 (36.29)		8728 (4188)	3505 (1686)
B-S-	24	6.42 (0.83)	33.17 (36.40)		8757 (3259)	3617 (1479)
Pseudowords						
B+S+	24	6.92 (0.88)	-	105.35 (152.18)	-	3596 (1377)
B+S-	24	6.75 (0.89)	-	84.10 (77.39)	-	3489 (1518)
B-S+	24	6.37 (0.82)	-		-	3505 (1686)
B-S-	24	6.16 (0.92)	-		-	3617 (1479)

Table 2

Mean error percentages (error %) and reaction times (RTs in ms) according to word construction and to grade (standard deviations in parentheses)

	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	1559 (294)	1519 (257)	1526 (247)	1592 (298)
Grade 5	1051 (211)	1131 (248)	1092 (193)	1163 (251)

Table 3

Mean error percentages (error %) and reaction times (RTs in ms) according to pseudoword construction and to grade (standard deviations in parentheses)

	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	2082 (385)	2042 (370)	2086 (372)	1920 (342)
Grade 5	1554 (390)	1500 (367)	1481 (361)	1370 (398)