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# PREFIX UNITS WITHIN THE MENTAL LEXICON

Hélène GIRAUDO (1) & Madeleine VOGA (2)

(1) CNRS & Université de Toulouse

(2) Université Paul-Valéry Montpellier III

## Abstract

Three masked priming experiments associated with the lexical decision task were carried out in order to examine the cognitive processing of prefixed words in French. To this end we systematically compared the effects of the prior presentation of prefixed words (e.g., *prénom*), prefixed nonwords (e.g., *dénom*) or orthographic nonwords (e.g., *danom*) on the recognition latencies of their root (e.g., *nom*) or of another related prefixed word (e.g., *surnom*). When compared to unrelated primes, both prefixed words and nonwords facilitated target recognition (Experiments 1 & 2) and this was not an effect arising from the frequency ratio between roots and prefixed derivations. However, when morphological priming effects were measured against orthographic nonword controls, that were combinations of existing roots with non-existing prefixes, morphological effects did not differ significantly from orthographic effects (Experiment 3). This finding suggests that morphological priming effects do not totally depend on the decomposition of the prime in two distinct morphemes, as suggested by Rastle & Davis (2008) but tend to be sensitive to formal factors (more precisely overlapping roots), even though they cannot be reduced to simple orthographic priming. Taken together, the present data moderate the full decomposition approach of morphological processing. A new model is proposed, integrating both sublexical units corresponding to “morphemes” (Aronoff, 1994) and supralexical units assimilated to “base-lexemes”.

## 1. Introduction

The fact that in most languages affixed words are present in a very high proportion leads to the conclusion that morphology constitutes an important variable in word processing. Thirty years of investigation have confirmed that morphology intervenes in automatic processes operating during the very early stages of lexical access, suggesting that morphemes are independently coded or stored somewhere in the mental lexicon. The masked priming paradigm (Forster & Davis, 1984) is the privileged technique used by psycholinguists to examine the early processes of word recognition. The principle governing this paradigm lies in the transfer of activation from a first processed stimulus (the prime) on the recognition latency of a second stimulus (the target). This activation transfer is accepted to operate on the basis of the shared representations

(orthographic/phonological/morphological/semantic) by prime-target pairs. Moreover, given that the prime is presented very briefly (stimulus onset asynchronies, SOAs, below 60 ms) and is generally masked (by a string of hash marks), any effect of the prime is considered to be the result of unconscious processes. In the precise case of morphology, many studies manipulated morphologically related words as well as pseudowords and found systematically very robust positive priming effects: two morphologically related words prime each other across different languages (e.g., Boudelaa & Marslen-Wilson, 2005 in Arabic; Duntildaebeitia, Laka, Perea, & Carreiras, 2009 in Basque; Drews and Zwitserlood, 1995, in both German and Dutch; Frost, Deutsch & Forster, 1997 in Hebrew; Giraud & Grainger, 2000 in French; Rastle, Davis, Marslen-Wilson & Tyler, 2000 in English) and in experimental settings that include multiple control priming conditions (unrelated but also orthographic/phonological and semantic controls in order to neutralize any interference effect). This general result being established, the question of the nature of morphemic units represented in long term memory and their precise role within the lexicon remains unanswered.

Two possible hypotheses of representation have been proposed: either morphemic units stand as access units to word representations, or they organize word representations in morphological families. According to the first hypothesis, morphemic units correspond to concrete pieces of words (i.e., stems and affixes, even letter patterns resembling to morphemes but not functioning as such). Complex words are therefore processed by a decomposition mechanism stripping off the affix in order to isolate the stem. The morphemic nature of the remaining letters is then checked by the system in order to eliminate any procedural error. Access to word representations (i.e., word forms coded in the orthographic lexicon) can then operate via the pre-activation of the constituent morphemes. This mechanism explains why two morphologically related words prime each other, and this view is broadly shared by numerous authors interpreting their data within a sublexical approach (initially developed by Taft in 1994) integrating morphemic representations as access units.

According to the second hypothesis, morphemic units are stored at an upper level of processing, at the interface of word and semantic representations. These intermediate units organize the lexicon in morphological families. Subsequently, each time a complex word is encountered, its recognition triggers the activation of all the word forms that can match it. A competition is then engaged between the pre-activated forms until the right lexical unit reaches its recognition threshold, determined by its surface frequency. However, during the competition phase, competitors send positive activation

to their respective base morpheme that in turn, sends back positive activation to them. Two morphologically related words prime each other thanks to this mechanism of co-activation<sup>1</sup>. Following this supralexicalexical theory (Giraudo & Grainger, 2001), morphologically complex words are not “decomposed” in the proper sense (*viz.* following the same procedure described by the sublexical theory) but can trigger the activation of their constituent morphemes.

Regardless of the differences between sublexical and supralexicalexical approaches of morphological processing, they are both consistent with the idea that separate morphemic units are responsible for priming effects. It is the precise location of these specific units within the architecture of the mental lexicon that specifies their role in word processing (access units vs. organizing units) as well as their nature.

According to the sublexical view, morphemic units play the role of access units since they correspond to concrete letter clusters (i.e., bound stems, free stems and affixes) that constitute words, independently of any grammatical or semantic characteristic of words (i.e., transparency vs. opacity) or to their lexical environment (in terms of orthographic neighbourhood or family size). On the other hand, the supralexicalexical view positions these units above the word forms and before the semantic units. These intermediate units are thus supposed to be more abstract than those contained in words because they have to tolerate form variations induced by the processes of derivation and inflexion (i.e., allomorphy, suppletion, phonological/morphological truncation, haplology). As a consequence, a morphemic unit does not need to exist in the real world in order to be coded in long-term memory but its existence/emergence depends on the interactions between the word and the semantic levels. Such a position also implies that all morphemes of a given language are not necessarily represented within the mental lexicon.

## **2. Pseudo-derivation effects**

Recent studies have explored these issues in order to test the decomposition hypothesis. Using the masked priming paradigm, it was shown that pseudo-derived word primes (e.g., *corner*) as well as pseudoderived nonword primes (e.g., *cornering*) composed of two existing morphemes were able to produce significant priming effects on the recognition times of their base (e.g., *corn*). Moreover, it appears that the quality as well as the magnitude of these priming effects is comparable to the priming effects produced by genuinely derived words (e.g., *banker-bank*). Finally, in order to separate pure morphological effects from form overlap effects, these studies use systematically orthographic control primes (i.e., morphologically simple

forms whose only one part mimics a stem morpheme; such as *brothel* in which *-el* never functions as a suffix in English). Globally, the results demonstrate that the priming effects induced by derived as well as pseudoderived primes differed significantly from these controls, suggesting that these effects resulted exclusively from the surface morphological structure of the primes. For instance, Longtin, Segui and Hallé (2003) demonstrated using French materials that a pseudo-derived word such as *baguette* ('*stick*') (composed with the fragments *bagu-* and *-ette* that correspond to existing morphemes) facilitated the recognition of the target *bague* ('*ring*') while at the same time a comparable orthographic control such as the word *abricot* ('*apricot*') in which only the fragment *abri* can be assimilated to an existing morpheme) did not facilitate the recognition of its pseudobase *abri* ('*refuge*'). These results were replicated by Rastle, Davis and New (2004) who found a strong *corner-corn* priming effect using English materials but no priming effects with the *freeze-free* prime-target pairs. Longtin and Meunier (2005) then explored the "pseudoderivation effect" using pseudowords in order to test the resistance of early morphological decomposition following manipulation of the lexicality of the primes. In their masked priming study, morphologically complex pseudowords (non existing possible words created with two existing morphemes, for instance, the base *sport-* + the suffix *-ation* produce *sportation*) were used as primes. The data revealed that pseudoderived pseudowords (i.e., *sportation*) facilitated the recognition latencies of their base (e.g., *sport*) and did not differ from the facilitation effects obtained using transparent primes (e.g., *sportif* which is a legal and semantically transparent derivation of the base *sport*). More recently, McCormick, Rastle and Davis (2008) manipulated a novel category of derived stimuli that cannot be segmented perfectly into their morphemic components (e.g., *dropper-drop* in which there's a duplicated consonant) in order to test the flexibility of the morpho-orthographic segmentation process described by morpheme-based models. Their results demonstrate the robustness of this segmentation process in the case of various orthographic alterations in semantically related (e.g., *adorable-adore*) as well as in unrelated prime-target pairs (e.g., *fetish-fete*).

Taken together these data strongly support the robustness of a morphological decomposition effect across languages, stimuli and sensorial modalities. A complete review of the literature related to this question was made by Rastle and Davis (2008) and perfectly summarized the results in claiming: "morphological decomposition is a process that is applied to *all* morphologically structured stimuli, irrespective of their lexical, semantic or syntactic characteristics" (p. 949). This conclusion seemed to deliver the

*coup de grace* to any approach (the supralexic model in particular) that would postulate intermediate lexematic units situated above word units. Nevertheless, the very recent study conducted by Crepaldi, Rastle, Coltheart, & Nickels (2010) opened a breach in this wall of certainty. A series of masked priming experiments were carried out on English irregularly inflected forms (viz. allomorphs). Interestingly enough and in total contradiction to their starting hypothesis, the authors found that allomorphs (e.g., *fell*) whose construction enables decomposition, primed their verbal base (e.g., *fall*) more than orthographically matched (e.g., *fill*) and unrelated control words (e.g., *hope*) did. This result had already been found by Pastizzo & Feldman (2002), and discussed enough by morphologists, but it had not been attributed the right importance by the tenants of the sublexical approach because of minor pitfalls in the control conditions (which did not have any incidence on the results, as the results of Crepaldi et al. demonstrate). Crepaldi et al. conceded the “existence of a second higher-level source of masked morphological priming” and proposed a lemma-level composed of inflected words acting “at an interface between the orthographic lexicon and the semantic system”.

However, this double source of morphological priming leads us to differentiate the nature of the coded morphemes. If we turn back to the locus issue that we consider as determining the content of the units reflecting (and explaining) morphological effects, it is important to highlight that more than 90% of the experimental studies manipulated suffixed words or pseudowords. Yet, prefixed and suffixed words show many differences in terms of (1) position relative to the stem, (2) relative number of suffixes and prefixes, (3) grammatical properties (Montermini, 2008; Stump, 2001). To our knowledge, very few experimental studies were dedicated to affix processing representation. Two experimental papers (Colé, Beauvillain, & Segui (1989); Meunier & Segui, 1999) presented data obtained through naming and lexical decision tasks suggesting that the processing of prefixes and suffixes might differ. But masked priming studies conducted on one hand in French (Giraud & Grainger, 2003) and on the other hand in Spanish (Duñabeitia, Perea, & Carreiras, 2008) presented contradictory results. While Giraud and Grainger found that only prefixed primes – but not suffixed ones - produce morphological facilitation on target recognition latencies (e.g., *prénom-préface*, ‘first name’- ‘introduces’), Duñabeitia and coll. get suffix priming (using a slightly different experimental design<sup>2</sup>). Yet one can easily notice that when it comes to the various tests of the decomposition hypothesis ALL the studies were conducted using suffixed words.

The present paper attempts to bring new elements relative to two related but unanswered questions: are pseudoderivation effects observed using prefixed

primes and are prefixes represented in long term memory? Three masked priming experiments were conducted using French materials. In these experiments we selected either morphologically simple targets (e.g., *nom* 'name') or morphologically complex targets (e.g., *surnom* 'surname') and we systematically manipulated three priming conditions: a morphologically related condition (M+), an orthographic condition (O+) and an unrelated condition (M-O-). While the M+ condition used prefixed word primes (e.g., *prénom*), the O+ condition used either pseudoprefixed nonwords in Exp.1 and 2 (e.g., *dénom*, where *dé-* is an existing suffix of French) or nonwords containing a related stem in Exp.3 (e.g., *danom*, where *da-* is not an existing suffix of French).

### 3. Experiments

#### 3.1 Experiment 1

##### 3.1.1 Method

*Participants.* Thirty students at the University of Toulouse (France) participated in the Experiment. In this and the following experiments all participants were native speakers of French and reported normal or corrected-to-normal vision.

*Stimuli and design.* Thirty root words (e.g., *faire* 'to do') were selected as targets. Each target word was tested in three priming conditions defining the three levels of the Prime type factor (prefixed word, prefixed non-word, and unrelated control). Thus each target was primed by the following word primes: (1) a morphologically related prefixed word (e.g., *refaire-faire* 'redo-to do'); (2) a related prefixed non-word (e.g., *infaire-faire*, in which *infaire* is a non-word constructed with the prefix *in-* and the root *faire*) and (3) an unrelated word (e.g., *sergent-faire* 'sergeant-to make'). Targets were 6 letters long on average and primes 8 letters long. Targets had an average printed frequency of 115.82 occurrences per million. Primes were matched in surface frequency and had an average frequency of 9.63 occurrences per million (New, Pallier, Ferrand, & Matos, 2001). Thirty nonwords resembling root words (e.g., *glape* created from *glace* 'ice' by changing one letter) were added for the purposes of the lexical decision task. Each nonword target was primed by either a related affixed word (e.g., *glacon* 'ice cube' – *glape*) or an unrelated word (e.g., *mouton* 'sheep' – *glape*). Examples of materials are presented in Table 1. Three experimental lists were created by rotating targets across the three priming conditions using a Latin-square design, so that each target appeared only once for a given participant, but was tested in all priming conditions across participants. Participants were randomly assigned to one of the three lists.

Table 1: Examples of primes and root targets used in Experiment 1

related words	primes		root targets
	related non-words	unrelated words	
refaire	infaire	sergent	faire
prénom	dénom	sphère	nom
surface	reface	qualité	face
envol	dévol	mégot	vol

*Procedure and apparatus* . The experiment was conducted on a PC computer using the DMDX software (Forster & Forster, 2003). Each trial consisted of three visual events. The first was a forward mask consisting of a row of nine hash marks that appeared for 500ms. The mask was immediately followed by the prime. The prime was in turn immediately followed by the target word which remained on the screen until participants responded. The intertrial interval was 1 second. The prime duration used in this experiment was 50ms. All stimuli appeared in the middle of the screen in lowercase characters in order to preserve stress markers over the appropriate vowels. In order to prevent orthographic overlap being confounded with visual overlap, the size of the font was manipulated (Arial 16 points for targets and 14 points for primes). Participants were seated 50 cm from the computer screen. They were requested to make lexical decisions on the targets as quickly and as accurately as possible, by pressing the appropriate button of the keyboard. After 20 practice trials, participants received the 60 experimental trials in one block.

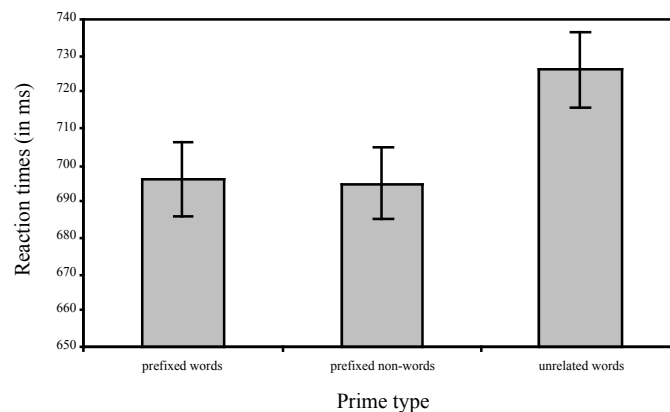
### 3.1.2 Results

Correct reaction times (RTs) were averaged across participants after excluding outliers (RTs > 1500 ms, 1.11% of the data). The results are presented in Graph 1. An ANOVA was performed on the remaining data with prime type (related word, related non-word, unrelated) as within-participant factors. List was included as a between-participant factor in order to extract any variance associated with this variable.

Planned comparisons revealed that both prefixed words and nonwords enhanced significant root priming ( $p > .05$  in both cases), without differing from each other. This first finding suggests that masked morphological priming effects do not depend on the lexicality of primes. The only presence of a prefix + root combination was sufficient to reduce root recognition latencies. One could interpret this result as evidence in favor of the early decomposition hypothesis. However, another explanation could be that because prefixed words are usually less frequent than their root, priming effects could arise from a frequency ratio between primes and targets rather



than the morphological complexity *per se* of related primes. According to a lexeme-based approach (i.e., the supralexical view of morphological representation), masked stimuli (words and nonwords) are indifferently processed during the very early stages of recognition. The letters they contain can equally activate word forms that can match with them. Word forms compete with each other but those with a high surface frequency are activated more quickly than the low frequency ones and thus constitute the strongest competitors in the cohort. That means that when a root target is presented subsequently to a less frequent prime, its recognition will be facilitated due to the strong preactivation of its word form representation and this can explain the priming effects of Experiment 1. We carried out Experiment 2 in order to examine if positive priming effects are still observed when the target is a prefixed word with a surface frequency lower than that of root words.



Graph 1: Mean reaction times on root targets as function of prime type

### 3.2 Experiment 2

#### 3.2.1 Method

*Participants.* Thirty students at the University of Toulouse (France) participated in the Experiment.

*Stimuli and design.* Thirty prefixed words (e.g., *défaire* 'undo') were now used as targets. Targets were 8 letters long on average and had an average printed frequency of 2.56 occurrences per million (New, Pallier, Ferrand, & Matos, 2001). Each target word was tested in the same three priming

conditions used in Experiment 1. Primes and word prime-nonword target pairs were identical to those used in Experiment 1. Examples of materials are presented in Table 2:

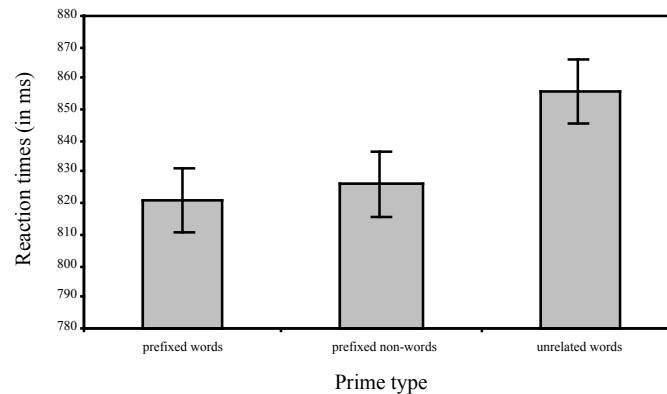
Table 2: Examples of primes and prefixed word targets used in Experiment 2

related words	primes		prefixed word targets
	related non-words	unrelated words	
refaire	infaire	sergent	défaire
prénom	dénom	sphère	surnom
surface	reface	qualité	préface
envol	dévol	mégot	survol

*Procedure and apparatus.* This was the same as in Experiment 1.

### 3.1.2 Results

Correct reaction times (RTs) were averaged across participants after excluding outliers (RTs > 1500 ms, 1.78% of the data). The results are presented in Graph 2. An ANOVA was performed on the remaining data with prime type (related word, related nonword, unrelated) as within-participant factors. List was included as a between-participant factor in order to extract any variance associated with this variable.



Graph 2: Mean reaction times on prefixed word targets as function of prime type

Globally these results replicated those found in Experiment 1. Both prefixed word and nonword primes produced significant priming effects on prefixed

word recognition when compared to unrelated primes. Experiment 2 confirms that the previous priming effects were not due to the higher surface frequency of the root targets. However, these data cannot tell us if the morphological priming effects we observed resulted from a prelexical decomposition of any stimulus composed with a prefix + root combination or from the formal overlap shared by related prime-target pairs. Experiment 3 tested this issue by using orthographic controls. Prefixed non-word primes were then replaced by non-words constructed with a non-prefix and a root (e.g., *onfaire* in which on- does not correspond to a prefix in French).

### 3.3 Experiment 3

#### 3.3.1 Method

*Participants.* Thirty students at the University of Toulouse (France) participated in the Experiment.

*Stimuli and design.* These were the same as in Experiment 1 except for prefixed nonword primes that were replaced by orthographic controls (e.g., *onfaire*). Thus each target was primed by the following word primes: (1) a morphologically related prefixed word (e.g., *refaire-faire* ‘redo-to do’); (2) an orthographic control (e.g., *onfaire-faire* ‘ondo-to do’) and (3) an unrelated word (e.g., *sergent-faire* ‘sergeant-to do’). The word prime-nonword target pairs used for the purposes of the lexical decision task were identical to those of Experiment 1. Examples of materials are presented in Table 3:

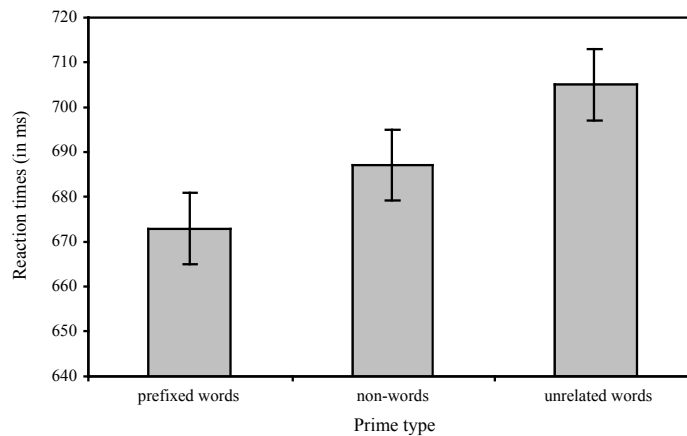
Table 3: Examples of primes and prefixed word targets used in Experiment 3

related words	primes		root targets
	ortho. controls	unrelated words	
refaire	onfaire	sergent	faire
prénom	danom	sphère	nom
surface	béface	qualité	face
envol	gévol	mégot	vol

*Procedure and apparatus.* They were the same as in Experiment 1.

#### 3.3.2 Results

Correct reaction times (Rts) were averaged across participants after excluding outliers (Rts > 1500 ms, 0.34% of the data). The results are presented in Graph 3. An ANOVA was performed on the remaining data with prime type (related word, related non-word, unrelated) as within-participant factors. List was included as a between-participant factor in order to extract any variance associated with this variable.



Graph 3: Mean reaction times on root targets as function of prime type

The results revealed that only morphologically related primes facilitated target recognition. Nonword primes produced a +18 ms facilitation effect that was not sufficient to reach significance. At the same time, the +14 ms difference between prefixed word primes and orthographic primes was not significant either ( $p > .10$ ). Taken together, these data show that the presence of a single root within the prime was not sufficient to produce significant priming while a root associated with a prefix was. However, morphological conditions did not significantly differ from orthographic control conditions, suggesting that we cannot rule out the participation of formal factors operating during priming. On the other hand, morphological priming effects cannot merely be explained in terms of orthographic overlap between related primes and targets since orthographic controls such as *onfaire* did not significantly facilitate target recognition (i.e., *faire*) relative to the unrelated baseline (e.g., *sergent-faire*).

#### 4. Discussion

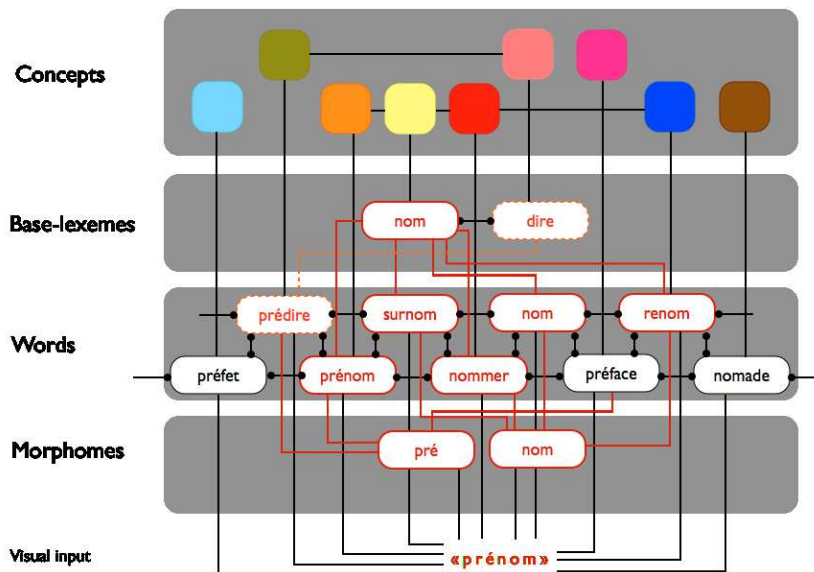
The aim of the present paper was to explore morphological priming effects focusing on the particular case of prefixed words, a category that has not been often taken in account in priming studies. Experiment 1 revealed that both prefixed words and prefixed nonwords enabled root priming without

differing from each other (i.e., *refaire* = *infaire*), Experiment 2 confirmed that this was not due to the higher surface frequency of the root targets. Finally, Experiment 3 showed that the priming effects induced by nonwords (e.g., *infaire*) in Exp. 1 cannot merely be explained in terms of formal overlap between primes and targets since orthographic controls such as *onfaire* did not facilitate processing of the target *faire*. Moreover, this last experiment revealed that if orthographic primes containing a root (but not a prefix) do not sufficiently differ from unrelated primes (a non significant +18 ms difference was found), they also do not differ from morphological primes (a non-significant +14 ms difference was observed). These data suggest that formal overlap is necessary but not sufficient to produce priming while morphological complexity represents a significant advantage for the primes. This finding moderates the idea shared by some psycholinguists, for example Rastle and Davis (2008), according to whom two distinct morphemes are needed to produce priming, given that *on-*, *da-*, *bé-*, *gé* are not prefixes of French. Results of Exp. 3 allow us to consider formal relationships as an intermediate level, given that purely orthographic priming (e.g., *onfaire* – *faire*) is certainly not as efficient as priming from a transparent morphological relative (e.g., *défaire-faire*), but is not significantly different either from morphological or unrelated conditions.

If we turn now to the pseudo-prefixation issue, the present data showed that both prefixed and pseudoprefixed primes produce equivalent facilitation effects on both simple and complex target recognition. These results are in line with those found using suffixed and pseudo-suffixed words (Longtin and coll., 2003, 2005; Rastle and coll., 2004; 2008). In order to integrate pseudo-derivation as well as affix (restricted to prefixes) effects within the same lexical architecture, compatible with the fact that for certain morphologically complex words and particularly those that cannot be decomposed into morphemes, there is a need to represent morphology at a higher level of processing (as suggested by Crepaldi and coll. 2010), we present a new architecture composed of four levels (Figure 1):

- (1) Submorphemic units that only correspond to surface morphemes (i.e. “morphemes” as suggested by Aronoff, 1994). This level captures the perceptive regularity and saliency of morphemes within the language. Accordingly, it automatically detects morphemes independently of the lexicality, semantic transparency or the morphological nature of the input stimuli.
- (2) Word units (i.e. word forms), defining a separate level of processing that constitutes the orthographic/phonological lexicon.

- (3) Base-lexemes, dealing with the internal structure of words, how they are formed according to morphological rules. These units are connected with their family members.
- (4) Concept units containing meaning. They are connected to both word and base lexeme units.



**Figure 1: Hybrid model of morphological processing.** The visual input *prénom* triggers simultaneously the activation of the morpheme level (i.e., the morphemes *pré-* and *-nom* are positively activated and send excitation to the related word forms *prénom, préfet, surnom, renom, prédire, etc.*) and the word level (i.e., orthographic neighbours compete with each other via inhibitory connexions). Then word forms activate their base-lexeme which in turn sends back to them positive activation. The competition between forms belonging to the same morphological family is reduced and the recognition of *nom* is facilitated.

This architecture implies coding of morphological information contained within words according to two dimensions, their surface form and their internal structure. The first level captures the perceptive regularity and saliency of morphemes within the language. It contains the stems and affixes

that can be extracted from words at the end of a simple segmentation process. At this level of coding, morphologically complex words, pseudoderived words and nonwords whose surface structure can be divided into (at least two) distinct morphemes are equally processed. As a consequence, this level cannot be considered as a properly morphological level, in the sense of formation on the basis of morphological rules, but rather as a morpheme level. Contrariwise to the first level, the second level deals with the internal structure of words, i.e. how they're formed according to morphological rules. This level contains lexemes (nouns, verbs and adjectives) abstract enough to tolerate orthographic and phonological variations produced by derivation and inflection. Lexeme representations are connected to morphologically related word representations and the connections are determined by the degree of semantic transparency between the word forms and the lexeme. Semantically transparent complex words are connected both with their constituent lexemes and morphemes. Words with semantically opaque (e.g., *fauvette* 'warbler' that is not related anymore to its free-standing stem *fauve* 'tawny') or illusory morphological structure (e.g., *baguette* 'stick' where *bagu-* is not a stem and has nothing to do with *bague* 'ring') are not connected with their lexeme. Both types of items are nevertheless connected with their constituent morphemes situated at the ortho-morphological level.

Finally, the funding principle of the model is that priming effects depend on the kind of relation the prime entertains with the target (formal and/or semantic) and on the number of activation springs that target recognition implicates:

- a) When the prime is a transparent complex word (e.g., *prénom-nom* 'first name-name'), its perception triggers three springs of excitation: morphemes, word forms and base-lexemes.
- b) When the prime is semantically transparent, complex but not decomposable (e.g., *faisable-faire* 'feasible-to do'), it activates two springs of excitation: word-forms and base-lexemes.
- c) When the prime is semantically opaque (complex or pseudo-complex: *fauvette-fauve* 'warbler-wildcat' or *baguette-bague* 'baguette-ring'), its recognition also triggers two springs of excitation, though not the same as in (b): morphemes and word-forms.
- d) When the prime is neither complex nor decomposable (e.g., *abricot-abri* 'apricot-shelter' or *danom-nom* 'daname-name'), it gives raise to only one spring of excitation: word-forms.

The architecture presented above seeks to provide a satisfactory framework for masked morphological priming data. However, it is important to keep in mind that what we observe as priming effects with exposure durations below 60 ms (in the vast majority of masked priming protocols varying from 40 to

50 ms) corresponds to just a small window of the overall activation of the mental lexicon.

Therefore, in these particular conditions, it's not surprising to observe the following results: *prénom-nom = faisable-faire = baguette-bague > abricot-abri*. And this is exactly what Rastle, Davis, Marslen-Wilson and Tyler (2000) observed when increasing their stimulus onset asynchrony (SOA) from 43ms, to 72ms and 230 ms. At the longest SOA, morphologically related primes (e.g., *departure-depart*) produced priming that significantly differed from both pseudo-morphologically related primes (e.g., *department-depart*) and orthographic controls (e.g., *freeze-free*).

Given the importance of these issues for morphological representation and processing, we think that future research should explore how the different categories of materials we dealt with in this first, exploratory work, behave under different conditions, and particularly the exact time-course of the effects. Future research is projected following this same line of work.

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### Notes

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<sup>1</sup> It's interesting to note that under certain circumstances, a morphologically related word can be unable to facilitate or can even slow down the recognition latency of the target: when lateral inhibition is equal or stronger than excitation sent by the morphemic unit on its family members. This would be the case with prime words characterized by a high number of orthographic neighbours, a small morphological family and a weak root (in terms of its surface frequency).

<sup>2</sup> Giraudo & Grainger examined affix priming effects using two types of affixed words, prefixed and suffixed, and three priming conditions: (1) an affix condition (e.g., *prénom-préface* 'first name-foreword'), a pseudo-affix condition (e.g., *préfet-préface* 'prefect-foreword') and a unrelated baseline condition (e.g., *guitare-préface*). Only prefixed prime-target pairs produced facilitation that differed significantly relative to pseudo-affixed and unrelated primes, suggesting a genuine morphological effect. Duñabeitia and coll. compared suffix priming using two kinds of words: polymorphemic (e.g., *igualdad* 'equality') vs monomorphemic (e.g., *certamen* 'competition') and two priming conditions: related vs unrelated. While they find facilitation effects for polymorphemic words (e.g., *brevedad-igualdad* 'brevity-equality' faster than *plumaje-igualdad* 'plumage-equality'), these effects do not occur for monomorphemic words (e.g., *volumen-certamen* 'volume-competition' equivalent to *topacio-certamen* 'topaz-competition').