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MEASURING MORPHOLOGY: THE TIP OF THE ICEBERG? A RETROSPECTIVE ON 10 YEARS OF MORPHOLOGICAL PROCESSING

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Abstract: Despite the intensive study of morphological effects with various on-line techniques such as masked priming, psycholinguistics did not manage so far to present a consensual framework, and are still divided on the nature and the locus of morphology in the mental lexicon. In this contribution, we propose to focus on three issues related to morphological effects which have not been given the right importance so far: the implications of studying morphology through nonwords, the role of frequency of the lexical items used as materials, and finally the role of a novel variable measuring the influence of formally related but morphologically unrelated word forms on processing, *i.e.* the pseudo-relatives. The experiment presented here provides evidence in favour of these two variables. We propose a revised model of morphological processing, sensitive to lexical (*e.g.* frequency) and exo-lexical characteristics of the stimuli (*e.g.* pseudofamily size), capable to cope with various effects induced by true morphological relatives and pseudorelatives, as well as for surface effects, such as the pseudoderivation effect.

Over the last 40 years, multiple studies have addressed the issue of morphological processing during word recognition, trying to establish how morphologically complex words are analysed and coded in long-term memory. Until 2000, and while morphological effects have been reported in various languages (mostly English, but also Hebrew, Russian, French, Italian, Spanish or Serbo-Croatian), using different paradigms (mainly priming paradigms) and tasks (lexical decision and naming), psycholinguists were divided: on one hand, tenants of the decompositional approach (*e.g.* Taft & Forster, 1975), based on an affix stripping mechanism intervening during the first stages of lexical access and which can be assimilated to the morpheme-based theory of morphology propounded by linguists (*e.g.*, Halle & Marantz, 1993); On the other hand, those who privileged a whole-word-access comparable to the word-based approach (see Chap. 3 in Haspelmath & Sims, 2010). During this period, experimental studies focused on factors determining complex word recognition and influencing processing of their surface as well as their internal structure. Among these factors, the effects of

surface and base frequencies, defining the statistical occurrence of complex words, were extensively studied in languages for which lexical databases were available (*e.g.*, Baayen, Dijkstra, & Schreuder, 1997 for Dutch ; Burani, Salmoso & Caramazza, 1984 for Italian ; Colé, Beauvillain,& Segui, 1989 for French ; Ford, Davis, & Marslen-Wilson, 2010; Taft, 1979; 2004 for English). The fact that recognition latencies depended on both surface and base frequencies was taken as evidence that the reader was sensitive to morphological structure and that a component of morphological processing is related to perceptual sensitivity, suggesting that lexical access strongly depends on whole-word as well as morphemic information.

Priming and masked priming studies went further in examining the role and the representation of morphology within long-term memory. These paradigms are specifically designed to explore the nature of activation transfers from a prime stimulus on target recognition (Forster, 1999) at conscious (long-term priming) and non-conscious (masked priming) levels of processing. The masked priming technique allows for the manipulation of various kinds of relationships between two words, thus rendering it possible to determine the positive or negative effect of a shared linguistic characteristic (phonology, orthography, morphology and semantics). In the case of morphologically related words, it enables the researcher to tease apart the respective part of form and meaning in morphological priming. From the seminal repetition priming study conducted by Stanners *et al.* (1979) to the most recent investigations combining masked priming to brain activity (*e.g.*, Morris, Grainger, & Holcomb, 2013) morphological priming effects have been extensively studied and have systematically revealed strong facilitation effects. Experimental results exhibiting morphological effect (facilitation) differing significantly from formal and meaning relationships, conduced the authors to conclude that independent morphological representations were coded somewhere within the mental lexicon in a similar way as orthographic, phonological and semantic representations.

Taken together, experimental results suggesting various frequency effects on one hand and demonstrating autonomous morphological effects, independent from semantic and orthophonological relationships on the other, led to the three following options described in literature relative to morphological representation and processing: a) the purely sublexical option, in which morphemes stand as access units, implying an obligatory decomposition mechanism that systematically splits off the affix from its base (Taft, 1994);

b) the intermediate sublexical option, postulating a morphemic access route acting in parallel with a whole-word access route (*e.g.*, Caramazza, Laudanna & Romani, 1988) and c) the supralexical option, positing abstract morphemic units at the interface of word-form and meaning representations and organizing word forms in terms of morphological families (Giraudo & Grainger, 2001).

The period from the year 2000 to 2005 was marked by studies focusing specifically on the decomposition vs. nondecomposition issue in order to determine the locus of morphological effects. Even if the priming study carried out by Rastle and colleagues in 2000 historically defines the starting point of a series of masked priming studies, the most striking ones were conducted respectively in French by Longtin, Segui, & Hallé (2003) and in English by Rastle and New (2004). Both manipulated a particular type of word pairs, presenting morphological complexity at their surface form, but which are neither synchronically nor diachronically related (*e.g.*, the English word *corner* cannot be analyzed in corn + er). Using the masked priming paradigm, it was shown that pseudo-derived word primes (*e.g.*, *corner*) as well as pseudo-derived nonword primes (*e.g.*, *corning*) 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, the systematic use of orthographic control primes (*i.e.*, morphologically simple forms for which the first part alone mimics a stem morpheme, such as *brothel* in which -el never functions as a suffix in English) in these studies showed that these surface morphological effects could not be assimilated to mere formal overlap. Consequently, these effects would exclusively result from the surface morphological structure of the primes.

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 *sport-ation*) were used as primes. The data revealed that pseudo-derived 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 'sports'* which is a legal and semantically transparent derivation of the base *sport*). Following the same logic, McCormick, Rastle and Davis (2008) manipulated another 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. Once again 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 supralexical model in particular) that would postulate intermediate lexematic units situated above word units.

It should be noted at this point that, as Giraudo & Voga (2013) notice, a more 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*) for which the decomposition of the surface form is not relevant for stem recovering, 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.* thus 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" (p. 949).

This breach gave rise to numerous experimental studies whose aim was henceforth to reduce the gap between 10 years of research exclusively focused on finding morphological decomposition everywhere and the necessity to consider (or re-consider) data spotlighting that morphology cannot be reduced to the syntax of words. For instance, research on the impact of letter transpositions that arises at a morpheme boundary (*e.g.*, *boasetr* for *boaster*) has yielded conflicting results that are still in debate. Cross-linguistic differences, task limitations or particular characteristics of the materials used might explain why some authors have found an impact of letter transpositions (Christianson, Johnson, & Rayner, 2007; Dunabeitia, Perea, & Carreiras, 2007; Sanchez-Gutierrez & Rastle, 2013) while others have not (Diependaele, Morris, Serota, & Grainger, 2013; Rueckl & Rimzhim, 2011). Nevertheless it is acknowledged that «there is more than one way in which morphology can influence visual word recognition» (Diependaele et al., 2013, p. 1001) implying that decomposition is not the be-all and end-all of morphological processing.

In this contribution, we propose to focus on three, rather neglected but closely related areas of interest in the literature relative to morphological processing: the first one relates to frequency effects, whose study is concomitant with the beginning of psycholinguistic research on lexical access

(ex. the serial model, Forster, 1976) and led to a very important number of published studies. Nevertheless, when it comes to morphological processing, frequency effects do not seem to be attributed the role they should. This overlooks the fact that inflected and derived words also exist as free word forms, and not only as analysable units. The corollary of (base and surface) frequency is the residual activation of units, characterising all lexical items, morphologically simple or complex. In experiment 1, we will illustrate the residual activation and some of its implications, through the manipulation of relative frequencies between primes and targets under masked priming conditions. Residual activation is undoubtedly central to interactive activation (McClelland & Rumelhart, 1981), as well as serial frameworks (Forster, 1976), yet the examination of the relevant literature reveals that this factor remains under-exploited in morphological priming protocols.

The second one relates with the fact that morphological processing and representation is not only studied through existing lexical units, as for example in the studies focusing on frequency effects, but also, and in significant proportions, through nonwords and pseudowords of various kinds, as we saw in the introduction (*e.g.* the abundant literature on pseudo-derivation effects). The reason for studying nonwords in most of the cases resides precisely on their non-lexicality, since nonwords are not supposed to have lexical representation(s) or belong to the cluster of a real word. Nevertheless, taking for granted this idea and using it as a foundation when interpreting nonword effects in morphological terms in order to validate or refute morphological accounts of processing real items, may be problematic from a linguistic point of view, both theoretical and experimental.

The third issue which will be addressed here is related to a larger question we can summarize in the following terms: within the general framework of the lexeme approach (Aronoff, 1994) where morphology is not the "syntax of morphemes" but the extension of patterns of existing systematic form-meaning correspondences (Bybee, 1988; 2001, Booij, 2002) research has great interest on focusing on variables and effects coming from the environment of the word-to-be-identified, and not exclusively from its internal characteristics. Substantial evidence in that sense comes from morphological family size effects in a variety of languages, Germanic or Semitic (Dutch: Schreuder & Baayen, 1997; Bertram, Baayen & Schreuder, 2000; English: De Jong, Feldman, Schreuder, Pastizzo, Baayen, 2002; Hebrew: Moscoso Del Prado Martin, Deutch, Frost, Schreuder, De Jong, Schreuder & Baayen, 2005) and reflects the amount of words that will work as "synagonists" during the recognition process. This functioning may work the other way round: this would mean that formally related but morphologically unrelated words act as antagonists, thus inhibiting morphological processing of the word-to-be-identified. The first experiment we present here provides evidence in favor of a novel variable based on exactly this antagonism, taking place inside the word-level but outside the

word itself. We coined this variable exo-lexical (c.f. the exolexical workshop we organized in the IMM15) in order to emphasize the fact that the locus of these effects resides outside the word under study and its morphemes, exactly as for the morphological family size variable.

1. Lexical frequency and the role of residual activation.

The masked priming technique implies a prime (ex. taught) and a target (teach), the priming benefit being the difference in the time needed to identify the target, compared to an unrelated condition. Given that the most frequently used task for this kind of protocol is the lexical decision task (yes/no) and that above a certain percentage of errors (in most cases 15-20%, words and non-words together) the performance of a particular subject is not acceptable (since it would mean that he/she did not really processed the targets), psycholinguists have begun to habitually present as the target the most frequent item, for example the infinitive for French verbs, the present form for English verbs, or, for the experiments examining morphological effects on non-word processing (ex. Meunier & Longtin, 2007) the stem-only form, for example *sport*. Nevertheless, in interactive activation (McClelland & Rumelhart, 1981) as well as in serial (Forster, 1976) models, the surface frequency of the materials plays an important role, given that it defines the "resting level" or residual activation of a given lexical unit, and consequently, the amount of activation needed to reach the identification threshold. The higher the frequency of the unit, the lower its activation threshold, and consequently, less effort is needed in order to activate it. Masked priming protocols are especially subject to this kind of mechanics, given the very short lapse of time the prime disposes of to activate the target, with SOAs (Stimulus Onset Asynchronies) usually varying between 42 and 57 milliseconds for morphological effects.

What we can observe in the vast majority of masked morphological priming experiments, and this is not surprising, is that the lexical unit taken as the target is the most frequent one, or in the case of morphological effects induced by nonwords, the target is the word and not the nonword. In English protocols, the choice isn't vast: in the verbal system, supposing in a design to study past tense priming, the target can either be the 1st /SG or the 3rd/SG present tense form. In a derivational priming experiment with nonword primes, as the Meunier & Longtin (2007) experiment, the target is the noun sport, a very frequent word, and not a suffixed unit from the great morphological family of sport (ex. *sportif 'sports'*). If the lexical frequency of the prime and target pairs does not play any role, we should admit that all morphologically complex words are decomposed at the entry of the system, independently of their lexical status (word or nonword) and their activation status (frequent or not frequent). This is indeed the option that the greatest part of the psycholinguistic literature took for some years, as discussed in the

introduction and as illustrated by studies as Rastle and Davis (2008) or, more recently, Amenta & Crepaldi (2012, p. 3). Of course things are not so simple, and data suggesting the opposite direction do exist: among the first to be highlighted was Giraudo & Grainger (2000), with French materials, reporting larger effects with high-frequency derived primes than with low-frequency ones, in the same line as Meunier & Segui (1999, with spoken primes).
Our aim here is not to review the data against the decompositional approach, but to insist on a rather surprising lack in the literature: despite the impressive amount of published morphological priming studies, very few of them attempt to reverse the prime and target pair: instead of having the most frequent member of the paradigm (or the morphological family) as target and another less frequent one as the prime, reversing the prime-target pair consists in having the less frequent member as target and the more frequent one as prime. One of the very rare studies operating this inversion is Voga & Giraudo (2009) that we will present here in some detail: as we'll see, manipulating the activation threshold modifies the pattern of effects for real words (verbs).

2. Nonword effects in processing morphology or the distinction between real word and possible word.

Recently, in a paper reviewing the most robust and well-documented morphological priming effects (masked and unmasked), such as the frequency effect as well as the morphological effect on non-word processing, Amenta & Crepaldi (2012) reach the conclusion that "Surely, morphological effects in non-words exclude the possibility that morphological information only comes into play after lexical identification" (p. 9), given that "it is clear that nonwords with a morphological structure are analyzed in terms of their morphemes, thus questioning seriously any theory that suggests morphological processing to kick off upon lexical identification" (p. 7). The experimental effects at stake here concern two types of protocols: a) In simple (unmasked) lexical decision tasks, where the subject has to decide if the stimulus is a word or not, slower rejection times have been observed for pseudo-inflected nonwords with a real suffix compared to pseudo-inflected words with a real stem and a non-suffix or a non-stem and existing suffix (Burani, Dovetto, Thorton, & Laudanna, 1997; Burani & Thorton, 2003; Caramazza *et al.* 1988; Taft & Forster, 1975); b) In masked priming experiments, where the pseudo-inflected real-stem, real-suffix nonword, jumbled words by letter transpositions facilitates the identification of the target (the stem itself) more than other categories of nonwords (Beyersmann, Dunabeitia, Carreiras, Coltheart, & Rastle, 2013; Christianson, Johnson, & Rayner, 2005; Diependaele *et al.*, 2013; Dunatbeitia, Perea, & Carreiras, 2007; 2008; Longtin & Meunier, 2007, Rueckl & Rimzhim, 2011;Sanchez-Gutierrez & Rastle, 2013).

The underlying principle here is that nonwords used in the experiments, including very word-like nonwords, cannot have a lexical representation at all, since they do not exist as words, neither before nor after the experiment, and thus the effect they induce on facilitating the target cannot be due to their lexical representation at the word level, nor to their frequency, since they don't have any (given the non-existence of the lexical unit). Two remarks seem important to us at this point: first, as Amenta & Crepaldi (2012) acknowledge, nonword morphological priming effects are characterized by great inconsistency; to cite an example, Burani *et al.* (2002) obtain no difference between rejection times on suffixed nonwords (*e.g.*, *donnista 'womanist'*) and rejection times on orthographically control nonwords that did not contain any morpheme (*e.g.*, *dennosto* similar to "wemanost" in English); This inconsistency is not found for true morphological effects, we have thus a qualitative difference between the pattern for nonwords and for words. Second, the masked priming technique is nevertheless sensitive to orthographic similarity and this is precisely the reason why an orthographic control is used, at least in studies of type (b), for exemple in Pastizzo & Feldman (2002) or in Giraudo & Grainger (2001). Consequently, one can wonder whether it is acceptable to suppose that the orthographic control created by a real stem and a non-suffix (or a non-stem and an existing suffix) as in Caramazza *et al.* (1988) in order to match a suffixed nonword (*i.e.* with a real stem and a real affix, as for exemple *cantevi*, in the Caramazza study, similar to the English *buyed*) is equivalent to a real-word orthographic control such as those used in real-word morphological masked priming experiments (for exemple in Pastizzo & Feldman (2002) or in Giraudo & Grainger (2001) ? In other words, while *buyed* looks as a real word, the orthographic control to match it does not look as a real word. We cannot answer to what extent this methodological pitfall can change the pattern of results, or whether psycholinguists should banish the use of nonwords for their experiments. Nonetheless, an indirect answer comes from two groups of experimental data: first, from data on interference on lexical identification, and second from data on neighborhood effects on nonword visual processing.

As far as the first type of experimental evidence is concerned, Bowers, Davis & Hanley (2005a) have shown that having participants learn new words (*e.g.*, *BANARA*) that were neighbors of familiar words that previously had no neighbors (*e.g.*, *BANANA*), made it more difficult to semantically categorize the familiar words. This means that interference can also be exerted by items that initially, *i.e.* at the beginning of the experiment, had no lexical status, but acquired it during the experiment. Moreover, as Bowers *et al.* (2005a) show, this interference was greater the day following initial exposure. In other words, within a mental lexicon dealing every day with novelty, productivity and lexical creation, thus attributing, as Bowers *et al.* shows, a (probably temporary) lexical status to an item as *BANARA*, there is no reason to exclude word-like items from the realm of real words, as far as linguistic processing

is concerned. This is especially true for experiments where the subject has received the instruction to push the right button if the stimulus is a word and the left button if it isn't, *i.e.* where the subject has to decide entirely independently the lexicality of the stimuli presented to him/her. (see Grainger & Jacobs, 1996 and Jacobs & Grainger, 1994 for a theoretical account of many empirical findings revealed by lexical decision tasks).

As far as the second type of evidence is concerned, there is substantial work in Italian, a language with shallow orthography that lexical activation is present when processing nonwords. Arduino & Burani (2004) find a facilitatory effect of neighborhood size in naming Italian nonwords (*e.g. greno, tegno, darta*, Exp. 2) and an inhibitory effect of neighborhood frequency in lexical decision with the same nonwords (when neighborhood size and neighborhood frequency were orthogonally varied, Exp. 1). In the naming task of Arduino & Burani, the evidence in favor of the lexical component in reading nonwords is obvious: nonwords with many neighbors were read aloud faster than nonwords with few neighbors, irrespective of neighborhood frequency. This suggests that even in a language as Italian, where the transparency of grapheme-phoneme correspondences should render the non-lexical print-to-sound conversion the privileged path in reading novel words, reading nonwords can benefit from the activation of the lexicon. The facilitatory effect of neighborhood size on nonword naming latencies with no role for the neighbor's frequency is interpreted by the authors as evidence for lexical activation in the case of newly encountered nonlexical stimuli. Even if the results of the lexical decision are in contrast with the results of the naming task, with respect to the role of neighborhood size and neighbor frequency, it is clear that these two factors induce some kind of influence in processing nonwords. The fact that nonwords with a high frequency neighbor required more time to be rejected, interpreted by the authors inside the dual-route (Coltheart *et al.*, 1993, 2001), and the multiple read-out model (Grainger & Jacobs, 1996), results from lexical activation in the word recognition system. Independently of the particular pattern of results for lexical decision and naming in the study of Arduino & Burani (2004), the point we wish to make here is that nonwords are not identified/ read independently and above (or rather below, to illustrate the activations in terms of processing architecture) any participation of the lexicon. Neighborhood size and neighbors' frequency are lexical factors, not pre-lexical.

In light of the above development, it becomes clear that the argument, according to which the sole existence of morphological effects on nonword processing refutes all approaches not based on mandatory decomposition (Amenta & Crepaldi, 2012), seems insufficient. This argument, quite present in psycholinguistic studies demonstrating or reviewing mandatory decompositional effects (Amenta & Crepaldi 2013; Rastle & Davis 2008; Meunier & Longtin 2007) is based on an extremely static view of the mental

lexicon and on a very rigid dichotomy between word and non-word, as if the category of "possible word" did not exist. Assuming that a well-formed, morphologically pseudo-derived or pseudo-inflected nonword such as the pseudo-derived *sportation* of the Longtin & Meunier (2005) study or the *cantevi* of the Caramazza *et al.* study, similar to the English *buyed*, should not induce any priming because it does not have any lexical representation, has little basis. The assumption that a nonword like *buyed* or *sportation* cannot be connected through some kind of link to the stem *buy* or *sport* on the lexical or post-lexical level reveals a disregard for several well established facts: those related to language acquisition where children produce these false yet perfectly intelligible forms (*buyed*, *goed*, etc) as well as those related to productivity (Hay & Baayen, 2003; Plag, 1999; 2004; Lopez-Villasenor, 2012). Finally, such an argument disregards robust experimental effects arguing in favor of a very thin line between units having a lexical status and intermediate type units that do not, but can acquire it, as in the Bowers *et al.* (2005) study.

This question may seem not so central to the issue of morphological processing, given that, according to certain logic, the way in which nonwords are behaving is maybe not as important as the way real world words are behaving. Despite this, however, a close look of the literature reveals that this kind of nonword has been extensively used to study and validate the mandatory decomposition hypothesis. To cite only two examples, with the masked priming technique, Rastle, Davis, Marslen-Wilson, & Tyler (2000) show that pseudo-derived nonword primes (*e.g.*, *corning*) composed of two existing morphemes were able to produce significant priming effects on the recognition times of their base (*e.g.*, *corn*). In French, the pseudo-derivation effect, *e.g. sportation - sport* (Longtin & Meunier, 2005) was found equivalent to the effect induced by semantically transparent true derivations, *e.g. sportif – sport*.

To conclude on morphological priming with nonwords, the question that the literature has to answer is the following: should *cantevi* in Caramazza *et al.* (1988), *donnista* in Burani *et al.* (2002), or *sportation* priming *sport* in Meunier & Longtin (2007) be considered as complete nonwords, deprived of some kind of link to their (very frequent) base form? If we consider this kind of nonwords as *possible words*, linked in some way to the base lexical unit, then the argument according to which nonword effects reflect automatic decomposition loses a lot of its validity. In fact, in this case, the data can very well be interpreted in the opposite way: that the pattern of systematic form-meaning correspondences that we call morphology (Bybee, 1988; 2001, Booij, 2002) is extended to novel words.

3. Exo-lexical variables: the pseudo-family size (Voga & Giraudo, 2009).

The morphological family size variable (Bertram, Baayen & Schreuder, 2000; De Jong, Schreuder & Baayen, 2000) has been shown to influence word processing: complex words with many morphological relatives will be processed faster than those with a poor morphological family, suggesting thus that the locus of morphological effects is not exclusively the word to be processed and that factors outside the word in question intervene on morphological processing. In the case of the morphological family size variable, words from the same family act as synagonists during processing. Nevertheless, in the mental lexicon not only synagonists but also antagonists exist. The role and existence of antagonists are indicated by neuro-psychological (Massol, Grainger, Dufau & Holcomb, 2010) as well as behavioral measures. For example, Grainger, Colé & Segui (1991) have found that orthographic similarity of the prime inhibits lexical access of morphologically complex targets, despite (or because of) the absence of any morphological relation between them, *e.g.* the prime "mûrir" (ripen) inhibits the target "MURAL" (wall) and this inhibition reaches 27ms for words that share their initial letters. This inhibition is accounted for in terms of "preactivation of lexical representations during the processing of the prime, which interferes with the processing of the target" (Grainger, Colé & Segui, 1991, p. 380).

Coltheart's N (Coltheart, Davelaar, Jonasson, & Besner, 1977), another well documented effect related to word processing, refers to the number and relative frequency of neighbors, *i.e.*, words differing by a single letter (such as BANISH and VANISH); Evidence from this type of research has not always given consistent results, and reviewing them is beyond the scope of this paper. However we stand by the remark of Bowers, Davis & Hanley (2005b) relative to the fact that in competitive network models like Interactive Activation Models (McClelland & Rumelhart, 1981) and SOLAR models (Self-Organizing Lexical Acquisition and Recognition, Davis, 1999) the critical contrast is between words that have no neighbors ("hermits") and words that have one or more neighbors. As noticed by the same authors, (Bowers, Davis & Hanley, 2005b) it is important to have a psychologically accurate definition of what is a neighbor and considering as such only words of the same length that differ by one letter (Coltheart's N) is rather based on simplicity than on perceptual similarity.

Given that morphological processing is dependent on the characteristics of the morphological family, whose members act as synagonists, it is possible that morphological processing also depends on the number and nature of neighbors. These neighbors, when they exist, act as antagonists, leading to interference in target identification, thus delaying morphological processing. Voga & Giraudo (2009) present two experiments exploring a novel variable, coined "pseudo-family size", which is the opposite of the morphological family size. Voga & Giraudo (2009) examined inflectional priming for two kinds of stimuli: verbs coming from big pseudo-families and verbs coming

from small or inexistent pseudo-families, *i.e.* what Bowers *et al.* 2005b call "hermits".
By "pseudo-family size" we mean a word as "portons" (meaning "we carry", where "port-" is the stem and "-ons" is the conjugation mark). When this word is presented to the lexical processing system as a prime, it can potentially activate (at least) all words that share its initial letters, *i.e.* the letters of the stem. In other words, *portons*, has numerous "pseudo-relatives" at the lexical level : *portail (portal), porte (door), port (harbour), portier (porter), portion (portion), portique (porch), portrait (portrait), portière (door), portugais (portuguese)*, but also the actual neighbor, in the sense of BANISH-VANISH, *postons* (*we mail*). The working hypothesis in Voga & Giraudo (2009) is that all these pseudo-relatives will behave like competitors at the lexical level. On the other hand, a verb like *mourir* (infinitive form of the verb *die*) is almost a hermit, since the only pseudo-relative it has is the rare *mouron* (*scarlet pimpernel*), and therefore it will receive a very small amount of competition on the lexical – orthographic level. A word can belong to the pseudo-family of another word even if they don't share their stem: for example, *portugais* (*portuguese*), under our definition, is a pseudo-relative of *portons* because the stem of *portons* is a part of the superset *portugais*. The decision to include this type of pseudo-relative in the computation of pseudo-family size was based on previous studies emphasizing the role of the beginnings of words in lexical access (Humphreys, Evett & Quinlan, 1990; Grainger, O'Regan, Jacobs & Segui, 1992), as well as on studies on lexical co-activation (Bowers, Davis & Hanley, 2005b). Consequently, this measure of pseudo-family should not be assimilated to stem homographs, such as those of Laudanna, Badecker & Caramazza (1989), ex. colpo – colpa (blow – guilt). In short, we can say that our definition of the pseudo-family size of a lexical entry is the sum of neighbors in the classic sense (Coltheart's N) and of all words sharing their stem with that entry, even if what remains once the stem is removed is not really an affix (*e.g.*, *porter – portugais*). Following this logic, we considered "*mourir*" as a hermit, according to our pseudo-family variable. In the experiment briefly reported below, we oppose inflectional effects obtained with words having no pseudo-family to those obtained with words coming from big pseudo-families, where the prime will activate a legion of lexical competitors.

4. The Experiment

The first experiment briefly reported here (for the complete version, see Voga & Giraudo, 2009) was designed to jointly investigate the role of the pseudo-family size as well as the influence of the relative frequencies of primes and targets. As stated in section 1, what the majority of masked priming studies report as morphological effects is the facilitation induced by a morphologically related prime on the base form target, *i.e.*, the member of the

morphological family that already has the greatest residual activation because of its frequency, generally higher than that of other morphologically related forms. As can be seen in Table 1, Experiment 1a studied the classic configuration, where the target is the easiest-to-activate member of the paradigm, while experiment 1b took as targets less frequent inflections, thus reversing the typical design described above. Table 1 provides a global description of the two experiments (1a and 1b).

4.1 Method

4.1.1 Participants. 62 undergraduate students from the University of Aix-en-Provence who reported normal or corrected-to-normal vision participated in the experiment.

4.1.2 Stimuli and design. Fifty-six French words and fifty-six nonwords were used as targets. Targets were always the infinitive form of French verbs, from 4 to 9 letters long (mean: 5.6 letters) with an average frequency of 66.17 occurrences per million (New, Pallier, Ferrand, & Matos, 2001) and consisted of1) 28 verbs, 4 to 9 letters long (mean: 5.6 letters), that had large pseudo-families, and 2) 28 verbs, 4 to 7 letters long (mean: 5.75 letters) that were "morphological hermits", *i.e.* with no or an insignificant pseudo-family (a pseudo-family consisting of marginal frequency items). These two categories of target word represent the two levels of the pseudo-family size factor (PsFam) that was estimated with the help of a French dictionary (Petit Robert) by exhaustive inspection. Each target was given four types of prime: a repetition prime, two morphologically related primes, and an unrelated prime. These primes define each one of the four experimental conditions for every type of verb, PSFam+ verbs and PsFam- verbs. The two conditions of morphologically related primes were a frequent inflection and a much less frequent one. Table 2 provides examples and prime-target orthographic overlap for each one of the 8 experimental conditions tested in Experiment 1a. 56 French nonverbs were created respecting the orthotactic constraints of the language and were matched for length with the real verbs. The nonword primes were primed in the same way as word primes. Four experimental lists were created by rotating targets across the four 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 four lists.

Table 1. Examples of stimuli and frequencies (in occurrences per million) for materials used in experiments 1a and 1b: targets and morphologically related primes [frequent inflections (F+) and non-frequent inflections(F-)] for the two types of verbs, large pseudo-family size verbs (PsFam+) and small pseudo-family size verbs (PsFam).

	Targets Exp. 1a	(Primes) Infl. F+	Infl. F-	**Targets Exp. 1b**	Infl. F+	Infl. F-
PsFam + verbs	**monter** 115.4	monté 144.08	montais 4.16	**montons** 6.27	monté 144.08	montais 4.16
PsFam- verbs	**sentir** 78.4	senti 95	sentiront 2.39	**sentons** 4.64	senti 95	sentiront 2.39

4.1.3 Procedure and apparatus. The experiment was conducted on a PC computer using the DMDX software (Forster & Forster, 2003). Subjects were requested to make lexical decisions on the targets as quickly and as accurately as possible, by pressing the appropriate button of the gamepad.

Table 2. Stimuli sample and degree of prime-target orthographic overlap (letters, percentage) for the repetition, the two morphologically related (frequent and non-frequent inflection) and the unrelated conditions for the two types of target (large pseudo-family size PsFam+ verbs, low-pseudo-family size PsFam- verbs) tested in Experiment 1a.

	Primes						
Word	**Targets**	Rep.	Freq. Infl.	Orth. ovrl.	Non freq. infl.	Orth. ovrl.	Unrel.
PsFam+ verbs	monter (climb)	monter	monté (climbed)	3.75 lt. (64 %)	montais (I was climbing)	3.75 lt. (66 %)	perdre
PsFam- verbs	sentir (feel)	sentir	senti (felt)	4.07 lt. (69 %)	sentiront (they'll feel)	4.21 lt. (69 %)	appeler

	Primes						
Non word	**Targets**	Rep.	Pseudo-infl.	Orth. ovrl.	Pseudo-infl.	Orth. ovrl.	Unrel.

Pseudo -verbs	dainier	dainier	dainions	3.71 (65%)	deniais	3.79 lt (67 %)	taunnie
Pseudo -verbs	vlâmir	vlâmir	vlâmé	3.68 (67%)	vlâmmais	3.7 lt (69 %)	sténon

4.2 Experiment 1b

Experiment 1b was identical to experiment 1a, except that targets were not the infinitive forms of French verbs and French-like pseudoverbs, but their 1st/PL inflection. The aim of this manipulation was to modify the relative frequency between prime and target. For a language like French, where infinitive forms tend to have a higher surface frequency than conjugated forms, this means that (conjugated) targets will have a surface form frequency that is lower or equivalent to that of their inflections (see Table 1 for comparative frequencies of the materials used in Experiments 1a and 1b). 32 subjects from the same subject pool participated in this experiment.

4.3 Results. Correct response times (RTs) were averaged across participants after excluding outliers (300 > RTs > 1300ms). The results for word stimuli for experiments 1a and 1b are presented in Table 3. An ANOVA was performed on the remaining data with prime type (repetition, frequent inflection, less frequent inflection, unrelated) and verb category (large pseudo-family size, small pseudo-family size) as within-participant factor. We report only Fs by subjects, since our Latin Square design permits us to remove all F2 analyses (Raaijmakers, Schrijnemakers and Gremmen, 1999) which would be very conservative for this type of design.

Table 3. Reaction times (RT in milliseconds) for lexical decisions to targets in the repetition (R), frequent inflection (F+), non-frequent inflection (F-) and unrelated (U) prime conditions for the two categories of verbs, large pseudo-family size (PsFam+) and small pseudo-family size verbs (PsFam-) tested in Experiments 1a and 1b. Net priming effects are given relative to the unrelated prime condition.

Words	Rep. (R)	Freq. infl. (F+)	Non freq. infl. (F-)	Unrel. (U)	Net Priming Effects		
Exp. 1a	RT	RT	RT	RT	U–R	U – F+	U – F-

PsFam+ verbs	602	617	633	634	32*	16*	1
PsFam- verbs	593	597	624	633	40*	36*	9
Exp. 1b	RT	RT	RT	RT	U-R	U-F+	U-F-
PsFam+ verbs	638	663	629	652	14	-11	23
PsFam- verbs	594	618	622	644	50*	26*	22*

4.3.1 Experiment 1a. There was a significant main effect of prime type, $F1(3, 366) = 19.86$, $p<.001$. The main effect of pseudo-family size was not significant ($F1<1$), neither was the interaction between the two main factors, $F1(3, 366) = 1.01$.
Planned pair-wise comparisons show significant repetition priming for both types of verbs, $F1(1, 61) = 12.79$, $p<.001$ for PsFam+ verbs and for PSFam- verbs, $F1(1, 61) = 33.22$, $p<.001$. Facilitation induced by frequent inflections was significant for large, $F1(1, 61) = 5.75$, $p<.05$, as well as for low PSF-size verbs, $F1(1, 61) = 33.25$, $p<.001$. Priming induced by non-frequent inflections was not significant, either for PsFam+ verbs, $F<1$, or for PsFam- verbs, $F1(1, 61) = 1.61$. The two morphological prime conditions did not differ between them for PsFam+ verbs, $F1(1, 61) = 3.27$, but did for PsFam- verbs, where the difference of 27ms between frequent and non-frequent inflections was significant $F1(1, 61) = 11.81$, $p<.001$. Repetition did not differ from frequent inflection conditions, either for PsFam+ verbs, $F1(1, 61) = 3.29$, or for PsFam- verbs, $F1<1$, but they did differ from non-frequent inflexions, both for PsFam+ verbs, $F1(1, 61) = 12.99$, $p<.001$, and for PsFam- verbs, $F1(1, 61) = 25.13$, $p<.0001$. The frequent inflections did not differ from non-frequent ones for PsFam+ verbs, $F1(1, 61) = 3.27$, but they did for PsFam- verbs, $F1(1, 61) = 11.81$, $p<.001$.

4.3.2 Experiment 1b. The same type of analysis was conducted separately for the results of experiment 1b. Again, the main effect of prime type was significant, $F1(3, 186) = 6.50$, $p<.001$, and the main effect of pseudo-family size was not significant, $F1(1, 62) = 1.99$. Contrary to experiment 1a, the interaction between these two factors was significant, $F1(3, 186) = 3.58$, $p<.05$. Planned pair-wise comparisons show significant repetition priming for small PsFam size verbs, $F1(1, 31) = 28.62$, $p<.001$ but not for large PsFam size verbs, $F1(1, 31) = 1.43$. Morphological priming due to frequent inflections is significant for small PsFam size verbs, $F1(1, 31) = 11.24$, $p<.001$ but not for large ones, $F1<1$, and priming due to non-frequent inflections follows the same pattern, $F1(1, 31) = 4.92$, $p<.05$, and $F1(1, 31) = 3.49$ respectively. Morphological priming between frequent and non-frequent

inflections did not differ for PsFam- verbs, F1<1 whereas it did differ for PsFam+ verbs, F1(1, 31) = 6.13, p<.05, which is the opposite situation of the one observed in experiment 1a. The robust repetition priming (50ms) obtained for PsFam- verbs differs significantly from morphological priming, F1(1, 31) = 6.42, p<.05 for frequent and for non-frequent inflections F1(1, 31) = 9.02, p<.001, whereas morphological and repetition conditions do not differ for PsFam+ verbs, either for frequent inflections, F1(1, 31) = 3.45, or for non-frequent ones, F1<1. The frequent inflections differed from non-frequent ones for PsFam+ verbs, F1(1, 61) = 6.13, p<.05, but they didn't for PsFam- verbs, F1<1.

4.4 Discussion for Experiment 1a and 1b.

The main outcome of this study concerns the role of the pseudo-family size jointly with frequency: under the circumstances of Exp. 1a, only primes that are frequent inflections of the infinitive targets facilitate processing, whereas non-frequent inflections fail to induce any facilitation. The fact that lexical frequencies of the primes influence processing of the targets provides another experimental demonstration that lexical frequency plays a role in morphological processing (*e.g.* for French, Giraudo & Grainger, 2000 with the masked priming technique; Meunier & Segui, 1999 with spoken primes). In other words, in the classic configuration we tested in Exp. 1a, we obtain the classic morphological priming effect induced by frequent inflections, which does not differ from repetition priming. This first result cannot be integrated in any kind of mandatory decomposition approach given that both inflections, frequent and non-frequent ones, are equally decomposable, there is therefore no reason for the frequent ones to prime and the non-frequent ones not to do so.

In experiment 1b, where the relative frequencies between primes and targets are modified comparatively to Exp. 1a, and where the disposition between primes and targets is the opposite of what the literature usually examines, we observe that the pattern of results changes radically: only small Pseudo-family size verbs, with no antagonists at the word-form level induce repetition and morphological facilitation, which for these verbs is equivalent (arithmetically and statistically) for both frequent and non-frequent inflections. In experiment 1a, repetition priming is equivalent to morphological priming, as in the majority of similar experiments examining repetition and morphological effects, in which the target is the easiest-to-activate member of the paradigm. The fact that in Exp. 1b repetition differs considerably from morphological priming probably suggests that we are not looking at inflection effects through the same window as in the majority of studies. There is also a second reason orientating us towards the interpretation that, under the circumstances of Exp. 1b we observe masked morphological effects through a different window: the fact that frequent inflections of PsFam+ verbs fail to prime, despite having exhibited

significant inflectional priming in Exp. 1a. At the same time, we observe that as soon as relative frequencies between primes and targets have been modified, thus broadening our observation window, word-forms lacking antagonists (PsFam- verbs) induce very important repetition priming and significant inflectional priming, equivalent for frequent and for non-frequent inflections.

In conclusion, the experiments presented here provided an experimental demonstration for two important effects: the first one is that not only does lexical frequency of the word-forms influence morphological processing, but relative frequencies between primes and targets also influence inflectional processing. Making the hypothesis that the lexical variable that we call frequency leaves morphological processing unaffected would be equivalent to denying these data, along with other data demonstrating this same thing (*e.g.* Giraudo & Grainger, 2000). The second effect is that of the PsFam size, an exo-lexical variable influencing inflectional processing. This influence is substantiated through inhibition exerted from primes which are pseudo-relatives of targets, *i.e.* word-forms similar in form to the target but morphologically unrelated to it. This inhibition of the pseudo-family size points towards the idea we will develop in the general discussion, namely that morphological processing effects are the sum of various kinds of activation and inhibition.

5. General discussion: Towards a revised model of morphological processing.

The literature clearly points out a number of constraints stemming from experimental data which have to be taken into account by any model of morphological processing: 1) positive priming effects produced by pseudo-derived forms suggest that the cognitive system is highly sensitive to the decomposability of linguistic stimuli; (c.f. introduction of the present contribution and section on nonword effects); 2) masked morphological priming effects do not really depend on the semantic relatedness shared by prime-target pairs and differ significantly to semantic priming (c.f. the pseudo-derivation effect); 3) masked priming effects observed between allomorphs (inflected and derived) and their base requires us to consider an upper level of processing containing bases (*e.g.* Pastizzo & Feldman, 2002); 4) masked morphological priming effects are sensitive to lexical frequency (*e.g.* Giraudo & Grainger, 2001, as well as Exp. 1a of the present contribution); 5) morphological effects are sensitive to morphological family size : members of the morphological family will act as synagonists (*e.g.* Schreuder & Baayen, 1997); 6) masked morphological priming effects can be modulated when manipulating the relative frequencies between primes and targets (Exp. 1a and 1b); 7) under the conditions where the target is not the easiest-to-activate member of the paradigm, word-forms (primes) which are

formally similar but morphologically unrelated to it, will function as antagonists, thus inhibiting the processing of the target (Exp. 1b).
Points (1) & (2) suggest that in the early stages of identification, each time a decomposable form (a regular word or non-word) is processed, it triggers the activation of its morphemic parts. This activation depends neither on semantics nor on lexicality, given that the pseudo-derived item does not have to be an established lexical unit, nor does it need to have a meaning (as we saw in section 2). We can then logically make the hypothesis that these effects take place at a sublexical level situated before the word level (*i.e.*, the orthographic lexicon). Given that facilitation can be obtained with non-words (composed by two morphemes) as well as with semantically opaque words (*e.g. corner*), the units coded within this sublexical level do not necessarily have anything to do with morphemes properly[1]. The kind of units, thanks to which the pseudo-derivation effect (*corn-corner*) arises, cannot be considered as *morphemes*; despite this, these units bring to the fore the high saliency of morphemes across languages, in terms of statistical frequency and productivity. Consequently, we should consider these sub-units as pure surface realizations. We propose to call them *morcemes* as this label translates well the fact that these units, situated before the word units, are of orthographic nature but capture morpheme regularity in the language. Point (3) implies that some semantically transparent units organize the orthographic lexicon in morphological families. However, morphological variations and constraints realised in a given language such as allomorphy, suggest that these units have to be abstract enough. Moreover, because the function of these units consists of organising words in morphological families, they have to correspond, according to our logic, to base-lexemes (*i.e.*, nouns, verbs and adjectives). Point (4) does not need to be described in a very detailed way: it suffices to bear in mind that lexical frequency is a variable relevant for word-forms, not for sublexical units, even if statistical occurrences of bigrams, trigrams or other kinds of sublexical units may indeed affect processing. Given the well documented fact that lexical frequency influences processing, and given that in masked priming protocols two different lexical frequencies intervene, (the prime's and the target's), the manipulation of the frequency ratio between them (point 6), leads to a slight removal of the prism through which we perceive morphological effects : from the classic configuration which displays perceptual saliency between primes and targets (ex. the pseudo-derivation effect) to a situation where we enable ourselves to observe finer effects, such as the role of the pseudo-family size highlighted in point 7. Points (5) and (7) stress the role of the

[1] According to Aronoff and Fudeman (2005), morphemes correspond to "the smallest linguistic pieces with a grammatical function. (…). A morpheme may consist of a word, such as *hand*, or a meaningful piece of a word, such as the *–ed* of *looked*, that cannot not be divided into smaller meaningful parts" (p.2)

environment of the word-form itself: this environment can be morphologically-friendly, as for the words issued from a large morphological family. Inversely, it can be morphologically hostile, *e.g.* for members of big pseudo-families, *i.e.* similar on form but morphologically unrelated, which will act as antagonists and exert inhibition on processing the target. As experiment 1b showed, targets that are word-forms with no pseudo-family (hermits) thus having nothing to compete with at the word-form level, will directly benefit from their inflectional primes, whether they are frequent or non-frequent.

Taken together, these constraints converge towards a hybrid model of morphological processing integrating four levels of coding. As we can see in figure 1, two of them are dedicated to morphology given that morphologically complex words are coded according to two dimensions, their surface form and their internal structure.

INSERT Figure 1

The first level captures the perceptive regularity and the saliency of morphemes within the language. It contains stems and affixes that have been extracted during word acquisition. Accordingly, during language acquisition, the most salient perceptive units (*i.e.*, recurrent and regular) will be caught and coded by the cognitive system as lexical entries. At this level of coding, morphologically complex words, pseudo-derived words and nonwords whose surface structure can be divided into (at least two) distinct morphemes, are equally processed. As a consequence, this level cannot properly be considered to be a morphological level, but rather as a level containing *morphomes* in the sense defined by Aronoff (1994). Morphomes stand as access units that speed up word identification each time an input stimulus activates one of them. Therefore, there is no need to assume, at this stage, a process of *morphological* decomposition; this would be unnecessary.

Contrary to the first level, the second level deals with the internal structure of words, their formation according to morphological rules. This level contains base-lexemes, units abstract enough to tolerate orthographic and phonological variations produced by the processes of derivation and inflection. Base-lexeme representations are connected to morphologically related word representations and these connections are determined by the degree of semantic transparency between word forms and base-lexemes. Semantically transparent morphologically complex words are connected both with their morphemes and their base-lexeme. Words with a semantically opaque structure, as for example, *fauvette 'warbler'* (not related anymore to its free-standing stem *fauve 'tawny'*) or with an illusory structure, as for example *baguette 'stick'* in which *bagu-* is not a stem and has nothing to do with *bague 'ring'*, are not connected with a base-lexeme. These two types of items are only connected with their *surface morphemes* situated at the

morphome level. Indeed, the model makes the fundamental assumption that base-lexeme representations are created in long-term memory according to a rule that poses family clustering as an organizational principle of the mental lexicon. This rule stipulates that as soon as two words share both form and meaning, a common abstract representation emerges; this representation is then fed by all the incoming forms respecting this principle. In the course of language acquisition and learning family size grows and links are continually being strengthened.

The model is intended to provide an interface framework for both psychological and linguistic phenomena. On the psychological side, the current debate among psycholinguists revolves around the manner in which the lexicon is organized in terms of structural units, and the manner in which these units interact with each other during lexical access. After almost ten years of studies focusing on this issue, in particular through the manipulation of morphemes and pseudo-morphemes within masked priming experiments, two antagonistic approaches, the first one based on a mandatory morphological decomposition mechanism (Taft, 1994; Marslen-Wilson & Tyler, 2007; Rastle & Davis, 2008) and the second one on whole-word access activating intermediate morphemes (Diependaele, Sandra, & Grainger, 2005; Giraudo & Grainger, 2000) still remain.

It is interesting to note that the same antagonism remains in linguistics. On one hand, the morpheme-based approach considers that morphemes are the basic structural units of the lexicon (Halle & Marantz, 1993) and consequently word forms are analyzed as arrangements of morphemes. On the other hand, the defenders of a lexeme-based approach argue that morphology is primarily a set of systematic correspondences between word forms and meanings, and that the source of morphology is the network of paradigmatic relations between words existing in a language (Aronoff, 1994; Bybee, 1988; 2001, Booij, 2002; to appear).

From a psycholinguistic perspective, the hybrid model we propose accounts for a large part of psycholinguistic data and can make very precise predictions about morphological priming effects. According to the model, priming effects depend on the kind of relation the prime entertains with the target (formal and/or semantic) and consequently, on the number of excitation springs that target recognition triggers: a) when the prime is semantically transparent and complex M+O+S+ (like in the pairs *banker-bank or hatched-hat*), its perception gives birth to three springs of excitation (SoE), from morphomes, word forms and base-lexemes; b) when the prime is semantically transparent, complex but not decomposable M+O-S+ (like in the prime-target pair *fell-fall*), it activates two SoEs, from word forms and base-lexemes; c) when the prime is semantically opaque M+O+S- (it concerns complex or pseudo-complex words like *apartment-apart* or *corner-corn*), its recognition triggers two SoEs, from morphomes and word-forms;

d) when the prime is not complex and not decomposable M-O-S- (like *freeze-free*), it gives raise to only one SoE, from word-forms.
The masked priming data collected until now stated the following results: *banker-bank=corner-corn* > *freeze-free* about derivation (see Rastle and Davis, 2008 for a review) and *hatched-hatch* > *fell-fall* > *teach-taught* about inflection (Pastizzo & Feldman, 2002; Crepaldi *et al.*, 2010). The predictions derived from the hybrid model we present above provide a more nuanced picture: *banker-bank* (3 SoEs) > *corner-corn* (2 SoEs) >*freeze-free* (1 SoE). Nevertheless, the role of psycho-physical characteristics of the protocol should not be completely discarded. In most masked priming studies, prime exposure duration ranges from 48ms to 60ms. In this case, and with the particular design discussed in section 1, what we observe as priming effects corresponds to a small window of the overall activation, as we demonstrated through the experiments presented here. This characteristic could explain why data revealed a *banker-bank* effect which was equal to the *corner-corn* effect. When increasing the SOA, the advantage that morphologically, semantically and orthographically related prime-target pairs have over morphologically (very opaque)[2] and orthographically related but semantically unrelated pairs, emerges (see Rastle, Davis, Marslen-Wilson, & Tyler, 2000).

6. Conclusions

Previous models of morphological processing, and in particular those claiming that morphological information has to be represented at a sublexical level of processing, make, in our view, an error in that they confuse the morphemic unit as a subpart of a word with its linguistic function. Starting from the general postulate that cognitive models of information processing are coding external information from basic and primary features (*e.g.*, letter features) to the most complex characteristics (*e.g.*, concepts), the morpheme, a unit perceptively smaller that the word, has been implicitly classified at a lower level on the scale of information complexity. Experimental studies examined morphological processing through various explicit manipulations of morphemes: within non-words or complex words showing their determinant role in reading, between prime-target pairs demonstrating the earliness of morphological processing and the

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[2] It is interesting to note here that in a significant proportion of psycholinguistic studies, as in the studies cited here, the category of semantically opaque items mixes morphologically complex words, whose structure is opaque as a result of complex etymology but remains relatively accessible synchronically (e.g. *fauvette*), with morphologically simple words whose surface can be segmented into morpheme-like sub-units (e.g. *corn-er,* in the Rastle 2000 study, *chant-ier,* in the Meunier 2005 study), without making any difference between them.

need to represent morphology as a separate level of processing, and finally within simple words and non-words emptying the morpheme of its linguistic functions. A non negligible part of the psycholinguistic literature has, little by little, lost sight of the linguistic function of morphology to focus only on surface information. From a linguistic point of view, morphology is not only reduced to a surface form or a word's subpart. Base-lexemes refer to a semantic field that is common to all their derivations and inflections. There's no need to explicitly state that the French word *écolier* (which means *'pupil'*) and *scolaire* (wich means *'scholar'*) both derive from the Latin base *schola* to convince the native speaker of their morphological link. Moreover, this link is not perceived as being only semantic in nature. Even in Hebrew, which doesn't have a linear morphological structure (the consonants of the root are intertwined with the word-pattern phonemes), Velan and Frost (2011) recently demonstrated that native speakers processed Hebrew words with a Semitic structure (with an internal structure) differently to Hebrew words borrowed from Indo-European languages (without any internal structure).

Our conclusion is that the above considerations, along with a great deal of experimental data stemming from various techniques, and especially masked priming, strengthen the idea that the readers' morphological representation plays a determinant role in the organization of their mental lexicon. The role of perceptive saliency of surface morphemes is certainly very important, yet it constitutes merely "the tip of the iceberg". Bringing out the organisational functions at the interface of form and semantics, which constitute its hidden part, requires us to include variables related to the lexical status of items, as well as paradigmatic relations and factors outside the word-to-be-studied.

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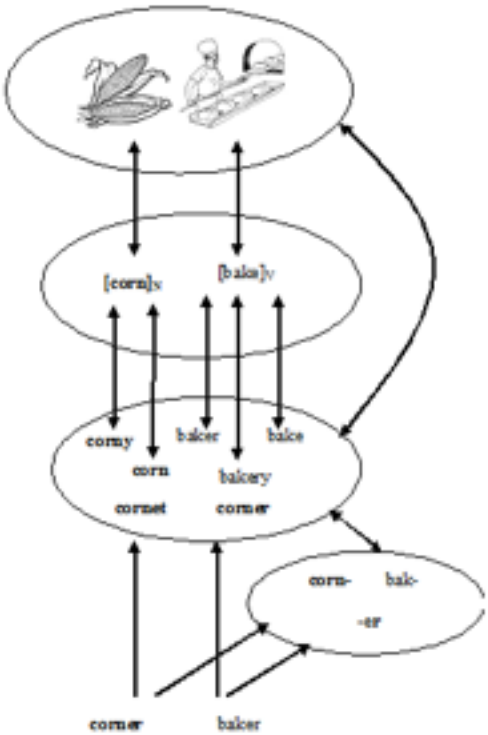
Figure 1: The Base-Morceme-Word Model (BMWm)



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