Chapter 16

Much ado about morphemes

Hélène Giraudo

CLLE, Université de Toulouse, CNRS, Toulouse, France

Most of the psycholinguists working on morphological processing nowadays admit that morphemes are represented in long-term memory and the predominant hypothesis of lexical access is morpheme-based as it supposes a systematic morphological decomposition mechanism taking place during the very early stages of word recognition. Consequently, morphemes would stand as access units for any item (i.e., word or nonword) that can be split into two morphemes. One major criticism of this prelexical hypothesis is that the mechanism can only be applied to regular and perfectly segmentable words and, more problematic, it reduces the role of morphology to surface/formal effects. Recently, Giraudo & Dal Maso (2016) discussed the issue of morphological processing through the notion of morphological salience – as defined as the relative role of the word and its parts – and its implications for theories and models of morphological processing. The issue of the relative prominence of the whole word and its morphological components has indeed been overshadowed by the fact that psycholinguistic research has progressively focused on purely formal and superficial features of words, drawing researchers' attention away from what morphology really is: systematic mappings between form and meaning. While I do not deny that formal features can play a role in word processing, an account of the general mechanisms of lexical access also needs to consider the perceptual and functional salience of lexical and morphological items. Consequently, if the sensitivity to the morphological structure is recognized, I claim that it corresponds to secondary and derivative units of description/analysis. Focusing on salience from a mere formal point of view, I consider in the present contribution how a decompositional hypothesis could deal with some phonological endings whose graphemic transcriptions are various. To this end, a distributional study of the final sound [o] in French is presented. The richness and the diversity of the distributions of this ending (in terms of type of forms, size and frequency) reveal that paradigmatic relationships are more suitable to guide morphological processing than morphological parsing as suggested by the lexeme-based approach of morphology (see Fradin 2003).

1 Introduction

In the domain of linguistics, morphological analysis is conceived according to two antagonistic approaches. On the one hand, the morpheme-based approach (exemplified by

Hélène Giraudo. Much ado about morphemes. In Olivier Bonami, Gilles Boyé, Georgette Dal, Hélène Giraudo & Fiammetta Namer (eds.), *The lexeme in descriptive and theoretical morphology*, 401–421. Berlin: Language Science Press. DOI:10.5281/zenodo.1407017

the theoretical framework of Distributed Morphology, see Halle & Marantz 1993, 1994) integrates morphology with syntax and considers morphemes as basic minimal forms. On the other hand, the lexeme-based approach postulates that words are the first units of analysis (e.g. Corbin 1987, Aronoff 1994, Fradin 1996) . Psycholinguistic research aiming to understand the cognitive processes underlying word processing has broadly explored the effects of morphological processing on the underlying processes of lexical access. Whereas it was widely admitted that morphological information plays a crucial role during word processing, its representation is still controversial. Nowadays most psycholinguists support a decompositional view of morphological processing (see Rastle & Davis 2008 for a review) that can be linked to the morpheme-based hypothesis, while a few of them defend an opposing view according to which words are recognized holistically. This last procedural hypothesis, which is clearly in line with the lexeme-based approach, is tested in the present chapter through a qualitative and quantitative study of words ending in [o]. The distribution of this ending is so diverse that it would cause a huge number of procedural errors of morpheme decomposition. Conversely, the lexeme-based/holistic approach to morphology seems to be much more appropriate to encompass the diversity.

2 Studying morphological processing

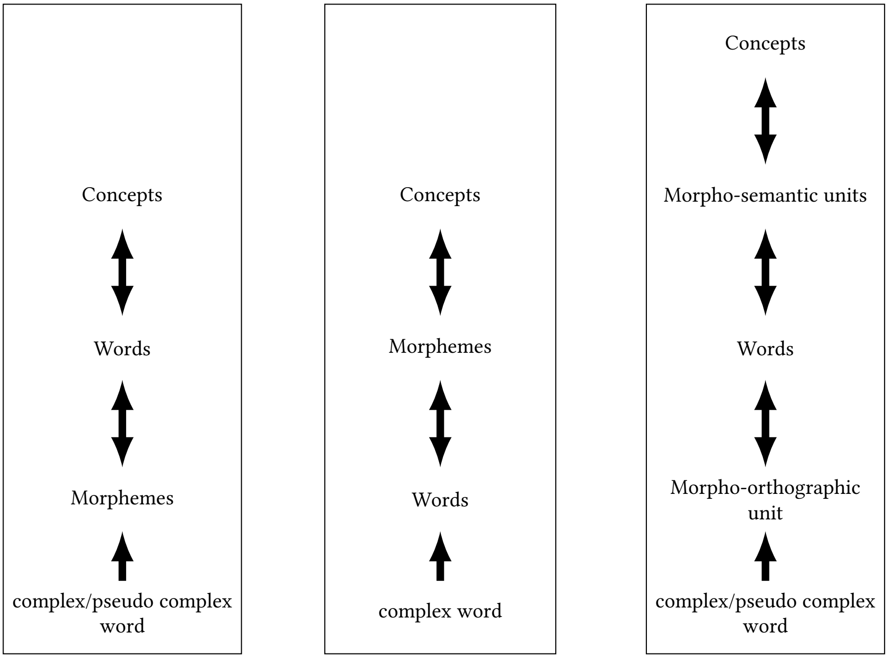
In a seminal experimental study carried out by Taft & Forster (1975) on the recognition of nonwords, the idea of morphological decomposition was first introduced. They showed that 1) nonwords (e.g., *juvenate*) corresponding to an English stem induced longer rejection latencies than nonwords that were not stems (e.g., *pertoire*) and 2) prefixed nonwords constructed with an English prefix and stem (e.g., *dejuvenate*) took longer to be classified compared to morphologically simple control items (e.g., *depertoire*). Longer decision latencies were interpreted as reflecting a pre-lexical mechanism of morphological decomposition by which all the words (real or possible) would be accessed via the first activation of their stem. Forty years of experimental research have been focused on testing this decomposition hypothesis by manipulating the characteristics of morphologically complex words and nonwords (i.e., their form in terms of decomposability and interpretability, their lexical frequency and more rarely their lexical environment) in various perceptual tasks (with a large dominance of the lexical decision task which consists in a word/nonword discrimination) and numerous languages (most studies focusing on English, however). Most of the results have been interpreted as supporting the decompositional view (see the reviews of Amenta & Crepaldi 2012, Diependaele et al. 2012) without really questioning the linguistic processes underlying the construction of complex words. An overview of the tested hypotheses and the materials used to explore complex word recognition indeed reveals a lack of consideration of the paradigmatic characteristic of words for understanding the cognitive mechanisms underlying lexical access. Numerous studies mainly focused on the formal properties of the word and extended the morphological sensitivity effects observed with complex nonwords to complex words (e.g. Taft & Forster 1976, Caramazza et al. 1988, Laudanna et al. 1997, Crepaldi et al. 2010) failing to consider semantic aspects of morphological complexity. Many experimental reports examined morphological processing using the masked priming paradigm (Forster & Davis 1984) that is supposed to reflect the automatic and nonconscious processes engaged in the very early stages of word recognition. In this paradigm, two visually related items are presented successively and participants are asked to perform a lexical decision indicating whether the second item is a word or not. However, because the prime word is presented masked and very briefly, the reader is not even aware of its presence before seeing the target item.[1] Hence, the paradigm allows examination of the effects of the unconscious processes of the prime processing on the target recognition (see Kinoshita & Lupker 2004 for a review on masked priming) . Many masked priming studies demonstrated that when two words are morphologically related (e.g., *singer–sing*), the prior presentation of the prime shortens the recognition latency of the target relative to both a baseline condition in which the prime is completely unrelated to the target (e.g., *baker–sing*) and an orthographic condition that uses a prime that is only formally related to the target (e.g., *single–sing*). Accordingly, morphological priming effects do not result from the mere formal overlap shared by prime–target. Other studies showed that semantic priming effects (e.g., *cello–violin*) only arise when the prime duration is sufficiently high (i.e., > 72 ms, see Rastle et al. 2000 for a comparison between morphological, orthographic and semantic priming effects using different Stimulus–Onset Asynchronies). This general result suggests that priming effects result from morphological relationships shared by prime–target pairs and that morphologically related words are connected by some kind of excitatory links. Most of the models of lexical access have tried to account for these morphological effects.

3 Psycholinguistic models of morphological processing

The architecture of psycholinguistic models of word recognition is mostly based on symbolic interactive activation models (e.g. McClelland & Rumelhart 1981). This type of model is organized in hierarchical levels of processing containing symbolic units. Each level corresponds to a linguistic characteristic of words, from letter features to semantics. During word recognition, activation spreads from the lowest to the highest levels. Within-level units are connected by inhibitory links whereas inter-level units are by excitatory links. Consequently, the model functions according to a principle of competition between within-level units that is compensated by both bottom-up and top-down excitations. The independence of the morphological effects relative to mere formal and semantic effects being established, morphological information was usually represented as a separate level of processing. However, its locus relative to the formal level (phonological and orthographic descriptions of the words) and the semantic level is still controversial. Morphological units have been situated variously: before the formal level and stand as access units to the mental lexicon (see Figure 1a depicting the sublexical model, Taft 1994), at the interface of the formal and the semantic level, organizing the word representations in morphological families (see Figure 1b, the supralexical model, Giraudo

[1] The *Stimulus Onset Asynchrony* is usually less than 50 milliseconds, it corresponds to a subliminal processing.

& Grainger 2001) or at either places, before and after the formal level (see Figure 1c, the hybrid/dual route model, Diependaele et al. 2009 ; see also Diependaele et al. 2013).



(a) Sublexical model (b) Supralexical model (c) Hybrid model

Figure 1: Alternative hierarchical models of morphological processing.

These three options nevertheless assume morpheme representations and by extension, propose a decompositional view of morphology. The sublexical and the hybrid models of morphological processing actually state very clearly that complex words are systematically decomposed into morphemes during lexical access. This decomposition mechanism is reflected by the obligatory activation of morphemes to gain the word representations coded within the mental lexicon. Each time a complex or a pseudo complex word (i.e., a word with a surface morphological structure like for example the word *corner* which comprises a surface stem *corn-* and a surface suffix *-er*) is processed by our cognitive system, it triggers the activation of its constituent morphemes that successively activate the wordforms containing it. Moreover, the hybrid model supposes that "In a priming context, opaque morphological relatives will only be able to prime each other through shared representations at the morpho-orthographic level, whereas transparent items will also be able to do this via shared representations at the morpho-semantic level" (Diependaele et al. 2009: 896). Even if the authors claim that morphological representations *per se* are not simply represented at both levels – the first being orthographically constrained and the second semantically constrained – these two levels actually correspond to surface morphemes at least as far as the contained units are concerned. In these two frameworks (sublexical and hybrid models), morphological priming effects result from the pre-activation of the morpheme shared by the prime and the target before accessing the word representations. These morphemic units pre-select in a way the wordforms that can potentially match with the target to be recognized. Lexical access takes place via the obligatory activation of surface morphemes.

One major criticism of the prelexical hypothesis is that this mechanism can only be applied to regular and perfectly segmentable words. Even more problematic is the fact that it reduces the role of morphology to surface/formal effects. This is certainly why Diependaele and colleagues proposed a second level of representation for morphology, as numerous experimental studies showed that two morphologically related but orthographically unrelated words (e.g., *bought–buy*) prime each other. However, this solution only considers morphology from its syntagmatic dimension: that is according to the word internal structure. Therefore, nothing is said about the influences of family and series[2] on word representations.

The original version of the supralexical model (Giraudo & Grainger 2001) also integrated morphemes even though it did not suppose a decomposition mechanism by which word representations are decomposed properly in order to activate their semantic representations. On the contrary, the morphological level contained "emerging" base morphemes, that is, morpheme representations resulting from the acquisition of complex words that are derived from the same base or the same series. Accordingly the morphological node organizes the word level in paradigms (i.e., morphological families and series), morphologically related words being connected together thanks to a supralexical node. Concretely, when the system processes a complex word, it first activates all the word representations that match formally with it while at the same time the complex forms activate their common nodes that feed back positively these forms. As all units belonging to the same level compete with each other, the activated formally related words inhibit each other, but those which are also morphologically related receive facilitation from their shared node. Words from the same family are then less inhibited than the other representations at the word level. In masked priming, the morphological facilitation between two morphologically related words observed relatively to two unrelated words is explained in terms of a reduced inhibition effect compared to a regular inhibition effect for unrelated items.

4 The benchmark effects: lexicality, frequency, regularity

Among the factors that have been manipulated in order to better understand the nature of morphological relationships and the locus of morphological priming effects within the mental lexicon, one can cite *lexicality*, *frequency* and *regularity*. Starting from the dominant hypothesis according to which words are first decomposed before accessing

[2]The term 'series' was, to our knowledge, first introduced by Hathout (2005, 2008) and refers to groups of words sharing the same affix.

the mental lexicon, some authors used the masked priming paradigm to study the influence of lexicality (i.e., comparing the processing of existing words coded in the mental lexicon relative to non-existing but morphologically structured items) in word recognition. A series of masked priming studies examined the effect of complex nonword primes during the early processes of lexical access. For example, Longtin & Meunier (2005) have tested the effects of nonwords constructed using legal and illegal combinations of existing stems and suffixes in French (e.g., legal: *infirmiser–infirme ‘disabled+er’–‘disabled’*; illegal: *garagité–garage ‘garage+ité’–‘garage’*) and found that both types of nonwords produced facilitation relative to orthographic control primes (e.g., *rapiduit–rapide, ‘fast+uit’–‘fast’*), that did not induce any significant effect on word recognition (see also, McCormick et al. 2009, Morris et al. 2013 for English materials). Giraudo & Voga (2013) replicated these results using French prefixed nonwords (e.g., *infaire–faire, ‘un-do’–‘do’*) suggesting that these effects apply to all affixed items. Andoni Dunabeitia et al. (2008), focused on affix priming in Spanish and showed that isolated suffixes (e.g., *dad–igualdad, ‘ity’–‘eguality’*) and suffixes in neutral context (e.g., *#####dad–igualdad*) were also able to induce positive priming effects (see also Crepaldi et al. 2016 using English suffixed related nonword pairs like *sheeter–teacher*). Finally, Crepaldi et al. (2013) examined reversed compounds like *fishgold–goldfish* and observed facilitation within related prime–targets pairs.

Taken together these studies suggest that in the early stages of word recognition – in masked priming conditions in which primes are presented less than 50-60 ms – lexicality does not impact lexical access as far as complex nonwords are considered. Moreover, none of these studies found priming effects using orthographic nonword primes (e.g., *blunana–blunt* tested by McCormick et al. 2009) suggesting a pre-lexical morphological analysis of the primes, blind to lexicality. However, even if these data seem to strengthen the pre-lexical decomposition hypothesis, results obtained using nonword primes created by letter transpositions have to be considered. Following, the discovery in Cambridge University according to which “*it deosn’t mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae… it doesn’t matter in what order the letters in a word are, the only important thing is that the first and last letter be at the right place*” (see *http://www.mrc-cbu.cam.ac.uk/personal/matt.davis/Cmabrigde/*), a series of masked priming experiments aimed to explore this effect. Some studies showed that reading comprehension of jumbled words are more or less costly (as demonstrated for example by Rayner et al. 2006), this effect still constitutes a challenge for the decompositionalists. It indeed contradicts the hypothesis according to which lexical access takes place via the obligatory decomposition of complex words into morphemes. Masked priming experiments explored repetition priming effects (i.e., the same stimulus is presented as prime and target, like in *table–table*) and morphological priming effects using jumbled primes and Beyersmann et al. (2012) first found that relative to unrelated primes, both repeated simple primes (e.g., *wran–warn*) and morphological primes (e.g., *wranish–warn*) reduced the latencies of target word recognition (see also Christianson et al. 2005, Duñabeitia et al. 2007 for Spanish and Basque). However, when orthographic primes (e.g., *wranel–warn*) were manipulated, no facilitation priming was observed highlighting the need for priming effects to keep the morpheme boundary intact. Then, a series of experiments compared of primes with Transposed Letters (TL) at the morpheme boundary (e.g., *speaekr–speak*) vs. outside the morpheme boundary (e.g., *spekaer–speak*). Only one experiment in the literature reported a benefit for TL primes when the transposition fell within the morpheme; no benefit was observed when the transposition fell across the morpheme boundary (Duñabeitia et al. 2007 , using Spanish materials). Subsequent investigations in both English and Spanish failed to replicate these findings (Beyersmann et al. 2012, 2013, Rueckl & Rimzhim 2011, Sánchez-Gutiérrez & Rastle 2013) and obtained equivalent facilitation when the transposed letters appeared within a stem or across a morpheme boundary.

Because TL benefit is not affected by the position of the TL relative to the morpheme boundary, I consider this result as a strong challenge for any decompositionalist model. If morphologically complex stimuli are indeed systematically decomposed into morphemes before gaining the mental lexicon, the main predictions of such models is that when the morphemes boundary is disrupted, no priming effect is expected since the cognitive system cannot parse the item into potential morphemes.

Diependaele et al. (2013) furthermore investigated the TL effect by comparing semantically transparent vs. opaque complex primes. Their first experiment showed that relative to formal primes, both transparent and opaque primes induced positive priming (e.g., *banker–bank* = *corner–corn* > *scandal–scan*). However, when morphological primes with TL were used, the transparent ones produced priming while the opaque ones did not (e.g., *baneker–bank* > *corenr–corn* = *scandal–scan*). A second experiment manipulated derived nonword primes in order to examine the effect of lexicality on the TL effect. Materials were selected from Longtin & Meunier's 2005 study and the authors found, on the one hand, that relative to unrelated primes, both intact derived word primes and intact derived nonword primes facilitated target recognition equally (e.g., *garagiste–garage* = *garagité–garage* > *diversion–garage*). On the other hand, when comparable morphological primes with TL were manipulated, a different pattern of priming emerged: only derived primes induced priming (e.g., *garaigste–garage* > *garaigté–garage* = *diverison–garage*). According to the authors, these data are line with the predictions of their hybrid/dual route model of morphological processing (presented above in Figure 3) in which complex items are automatically parsed within two morphological levels: morpho-orthographically and morpho-semantically, reflecting two sources of morphemic activation in word recognition. Morphological complex words (e.g., *banker*) are actually supposed to be processed twice at both morphemic levels, and pseudo-complex words (e.g., *corner*) once at the morpho-orthographic level, letter transposition across the morpheme boundary should interfere more with morpho-orthographic than morpho-semantic processing. Accordingly, transparent words and nonwords with TL are supposed to resist letter transpositions thanks to the morpho-semantic activation while opaque words and nonwords with TL did not because the morphemic activation at the morpho-orthographic level would be skipped.

According to me, the dual route model and the way masked priming effects are interpreted in this study are far from being convincing. "The key prediction of this account is that fast-acting effects of morphology are not only morpho-orthographic in nature, but also morpho-semantic, and most importantly, that these effects reflect two separate sources of morphemic activation in word recognition" (p. 989).

If genuine complex words benefit from two sources of activation (morpho-orthographic and morpho-semantic) and pseudocomplex words from one only (morpho-orthographic), words like *banker* should be more efficient primes than *corner*. Nevertheless, their results (experiment 1) and the ones obtained so far in the literature demonstrate on the contrary that prime-target pairs like *banker-bank* and *corner-corn* produce equivalent priming effects (cf. surface morphology effects, see Rastle & Davis 2008 for a review). When TL effects are considered, it has been shown that primes with TL at the morpheme boundary (e.g., *banekr–bank*) and within the stem (e.g., *bakner–bank*) both induce equivalent facilitation effects. If the morpho-orthographic level is much more sensitive to letter order than the morpho-semantic level is, then one should have observed greater priming effects when the morpheme boundary of the prime is intact (e.g., *bakner–bank*) because two sources of activation could operate while for jumbled morpheme boundary (e.g., *banekr–bank*) only one source is active. The results obtained so far did not show any difference between these two types of primes, neither in the present paper, nor in the literature. Moreover, Diependaele et al. (2013) found in their experiment 2 that TL letter derived primes (e.g., *banekr–bank*) produced faster reaction times than intact primes (e.g., *banker–bank*). This surprising result is also very problematic for a decompositional account since the letter recoding for the TL primes that is necessary to activate morphemic representations should have delayed lexical access, therefore reducing priming.

Word processing is also closely linked to input frequency. This factor that has been broadly studied in the psycholinguistic literature on word recognition showing a strong and very robust correlation between lexical frequency and recognition latencies: the higher the frequency, the shorter the reaction time (see Ellis 2002 for a review). Generally, these experimental studies oppose derived or inflected words of comparable surface frequency, but crucially differing in their stem frequency (high vs. low). In this kind of study, when reaction times (RTs) were found to be a function of the stem frequency, this is considered as evidence of the fact that word recognition implies the activation of the stem. For example in Italian, Burani & Caramazza (1987) investigated derived suffixed forms (verbal roots combined with highly productive suffixes such as *-mento, -tore, -zione*) by opposing stimuli matched for whole word frequency, but differing in root frequency (experiment 1), to stimuli matched for root frequency but differing in whole word frequency (experiment 2). Their results indicated that reaction times were influenced by both root and whole word frequencies (faster RTs were obtained for items containing a high frequency root in experiment 1 and for higher whole word frequency items in experiment 2), the authors suggested that the access procedure crucially operates with both whole word and morpheme access units. Frequency effects have been observed also in French by Colé et al. (1989), who similarly considered derived words matched for surface frequency but differing in their cumulative root frequency (e.g., *jardinier 'gardener'*, containing a high frequency root, vs. *policier 'policeman'*, containing a low frequency root). Since a clear cumulative root effect was observed only for suffixed words but not for prefixed ones, Colé and colleagues suggest that only the former are accessed through decomposition via the root.

More recently, Burani & Thornton (2003) conducted a study on the interplay between the frequency of the root, the frequency of the suffix and the whole word frequency in processing Italian derived words. More precisely, in experiment 3, they considered low frequency suffixed words that differed with respect to the frequency of their morphemic constituents. As expected, the results showed that lexical decisions were faster and more accurate when the derived words included two high-frequency constituents (e.g., *pensatore* 'thinker') and slowest and least accurate when both constituents had low frequency (e.g., *luridume* 'filth'). Interestingly, when the derived words included only one high-frequency constituent (either the root or the suffix), the lexical decision rate was found to be a function of the frequency of the root only, irrespective of suffix frequency. The authors conclude that access through activation of morphemes is beneficial only for derived words with high frequency roots, while lexical decision latencies to suffixed derived words are a function of their surface frequency when they contain a low frequency root.

To sum up, frequency effects have been considered as a diagnostic for determining whether an inflected or derived form is recognized through a decompositional process that segments a word into its morphological constituents or through a direct look-up of a whole word representation stored in lexical memory. Frequency has therefore played a crucial role in the debate which opposed full parsing models, which assume a prelexical treatment of the morphological constituents with a consequent systematic and compulsory segmentation of all complex words (Taft & Forster 1975, Taft 1979), and full listing models, which defend a non-prelexical processing of the morphological structure and a complete representation of all morphologically complex words (see McClelland & Rumelhart 1981).

Despite the importance of the frequency for lexical access (the more frequent a word, the faster its recognition, see Solomon & Postman 1952) and the number of priming studies focused on its impact for word recognition (see Kinoshita 2006 for a review), very few studies manipulated frequencies using masked morphological priming. In a paradigm such as masked priming in which the prime is presented for a very brief duration, frequency is nevertheless a crucial factor since it determines the access speed to lexical representations. Moreover, clear opposite predictions can be derived for the two main approaches of morphological processing. According to the decompositional approach, only the root/stem frequency should interact with morphological priming effects since complex words are supposed to be accessed via the activation of their stem. The holistic hypothesis predicts no stem frequency effect but that surface frequency strongly determines masked morphological priming effects because lexical access takes place on the whole word. Giraudo & Grainger (2000) investigated the interaction of both frequencies with morphological processing through a series of masked priming experiments conducted in French. They manipulated the surface frequencies of derivatives used as primes for the same target (high frequency primes like *amitié–ami* 'friendship'–'friend'; low frequency primes like*amiable–ami* 'friendly'–'friend'). They found an interaction between priming effects and the prime surface frequency (experiment 1), but no effect for the base frequency. Experiments 1 and 3 demonstrated that the surface frequency of morphological primes affects the size of morphological priming: high surface frequency derived primes showed significant facilitation relative to orthographic control primes (e.g., *amidon–ami* 'starch'–'friend'), whereas low frequency primes did not. The results of experiment 4 revealed, conversely, that cumulative root frequency does not influence the size of morphological priming on free root targets. Suffixed word primes facilitated the processing of free root targets with low and high cumulative frequencies. These data suggest that during the early processes of visual word recognition, words are accessed via their whole form (as reflected by surface frequency effects) and not via decomposition (since the base frequency did not interact with priming).

Another piece of evidence against the decompositional hypothesis comes from the study conducted by Giraudo & Orihuela (2015), which considered the effects of the relative frequencies of complex primes and their base target opposing the configuration with high frequency primes/low frequency targets to the configuration with low frequency primes/high frequency targets in French. Their results revealed that, relative to both the orthographic and unrelated conditions, morphological priming effects emerged only when the surface frequency of the primes is higher than the surface frequency of the targets (see also Voga & Giraudo 2009 for a similar conclusion). Again, these data contradict the prediction of the classical decomposition hypothesis, according to which the reverse effects would be expected.

The interpretation of frequency effects with respect to psycholinguistic models, however, remains very controversial. McCormick, Brysbaert, et al. (2009) defend a completely opposite position, in favour of an obligatory decomposition of all kinds of stimuli (even for the non-morphologically structured ones). They carried out a masked priming experiment manipulating the frequency of the primes, thus comparing high frequency, low frequency and nonword primes. Their hypothesis was that if morphological decomposition was limited to unfamiliar words, as predicted by the horse-race style of dual-route models, then priming should be limited to the last two conditions. On the contrary, if morphological decomposition was routine, an obligatory process applying to all morphologically structured stimuli should occur in all three conditions. The results showed that the priming effect observed with high frequency primes was equivalent to the one observed with low frequency primes and with nonword primes. Such findings seem to confirm the claim that a segmentation process is not restricted to low frequency words or nonwords, as assumed by horse-race models.

Very recently, the masked priming study carried by Giraudo et al. (2016) on Italian materials explored the role stem frequency in morphological processing even more deeply. They focused on the surface frequencies of base targets (comparing high vs. low surface frequency targets, e.g., *trasfire* 'to transfer' vs. *motivare* 'to motivate') primed by either the same base (e.g., *trasfire–trasfire*), a derivation of the base (e.g., *trasferimento–trasfire* 'transfer'–'to transfer'), an orthographic control (e.g., *trasparenza–trasfire* 'transparence' –'to transfer') and an unrelated control (e.g., *sacrificio–trasfire* 'sacrifice'–'to transfer). The data showed that full morphological priming effects were obtained whatever the frequency of the targets (high or low). Accordingly, the frequency of the base contained in the derived primes (e.g., *trasferire* in *trasferimento*) did not interfere with morphological facilitation: primes whose base had a high frequency did not induce stronger facilitation than primes with a low frequency base. As a consequence, contrary to the predictions of a decompositional approach of lexical access to complex words, the prior presentation of a complex prime whose stem had a high surface frequency did not accelerate the access to its lexical representation relative to primes whose stem frequency was low.

Taken together, the frequency effects obtained using masked priming suggest that lexical access depends much more on the lexical frequency of the prime (that determines its activation threshold) than on its the stem frequency. Stem frequency does not seem to interfere with the access to the mental lexicon and morphological priming effects reveal instead that, as soon as a lexical representation is activated within the mental lexicon, such a representation automatically triggers the activation of all its family members. The result of the overall activation of the morphological family is revealed in those LDT experiments in which it has been observed that both the lexical and the base frequencies determine the recognition latencies of suffixed words. Only models that consider the word as the main unit of analysis, be it morphological (e.g., Giraudo & Voga 2014) or not (e.g., Baayen et al. 2011), are able to account for these findings.

Finally regularity is another factor from which opposite predictions can be drawn by the two views of morphological processing. In the psycholinguistic literature, this issue is intimately linked with the ease with which a complex word can be segmented into morphemes. Most of these studies consider morphology under the single angle of the word internal structure and the reported experiments carried out with irregular words aimed to test the predictions of decomposition hypothesis according to which parsability should interact with the magnitude of morphological priming effects. Regularity has been mainly tested with irregular materials like the irregular verbs in English (e.g., *bought–buy*) and with complex words containing various orthographic alterations (e.g., *bigger–big*). Pastizzo & Feldman (2002) carried a series of masked priming experiments on English irregular verbs (viz. allomorphs). They 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. Contrary to the predictions of the decompositional hypothesis, non-segmentable complex words then induce priming effects that cannot be attributed to the formal overlap between prime–target pairs but depend on the morphological relationships they share. These results have been replicated later by Crepaldi et al. (2010; see also the MEG study carried by Fruchter et al. 2013 leading to the same pattern of data) who were forced to admit 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).

McCormick et al. (2008) manipulated another category of derived stimuli that cannot be segmented perfectly into their morphemic components (for example, missing 'e' (e.g., *adorable–adore*), shared 'e' (e.g., *lover–love*), and duplicated consonant (e.g., *dropper–drop*) 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*). The same authors then addressed the same question using morphologically structured nonword primes (McCormick et al. 2009). To this end, they created nonword primes with a missing <e> at the morpheme boundary (e.g., *adorage-adore*) and compared it to orthographically related prime-target pairs (e.g., *blunana-blunt*). The observed data showed that morphologically structured nonword primes facilitated the recognition of their stem targets, and that the magnitude of these priming effects was significantly larger than for orthographic control pairs. They interpreted this result as supporting their previous conclusions on word primes (2008) according to which stems that regularly lose their final <e> may be represented in an underspecified manner (i.e., absent or marked as optional). But far to call the decomposition mechanism into question, they claimed that the process of morphological decomposition was robust to regular orthographic alterations that occur in morphologically complex words.

According to me, these results could be interpreted on the contrary as being totally incompatible with the hypothesis of a mandatory decomposition process based on the surface morphology because this mechanism is only based on a minimalist condition of having two surface morphemes. If not, the decompositionalist approach needs to explain to how/on which criteria these words are actually decomposed. So far, the decompositionalists only proposed the idea of fast acting morphological effects (see Diependaele et al. 2013) without specifying on what visual/perceptual base these effects could actually operate. Recently, Giraudo & Dal Maso (2016) discussed this issue through the notion of morphological salience and its implications for theories and models of morphological processing. More precisely, the impact of the salience of complex words and their constituent parts on lexical access was questioned in light of the benchmark effects reported in the literature and the way they have been unilaterally interpreted. The issue of the relative prominence of the whole word and its morphological components has been indeed overshadowed by the fact that psycholinguistic research has progressively focused on purely formal and superficial features of words, drawing researchers' attention away from what morphology really is: systematic mappings between form and meaning. While I do not deny that formal features can play a role in word processing, an account of the general mechanisms of lexical access also needs to consider the perceptual and functional salience of lexical and morphological items. Consequently, the existence of morphemes is then recognized, but we claimed that it corresponds to secondary and derivative units of description. I hold that results obtained on the basis of masked priming are in line with holistic models of lexical architecture in which morphology emerges from the systematic overlap between forms and meanings (Baayen et al. 2011)[3] and for which the lexeme is the first unit analysis for the cognitive system. In such models, salience is not only a matter of internal structure, but also results from the organization of words in morphological families and series. As a consequence, not only syntagmatic,

[3]And also to abstractive approaches assuming that "the lexicon consists in the main of full forms, from which recurrent parts are abstracted" (Blevins 2006: 537).

but also paradigmatic relationships contribute to morphological salience. Certainly, the notion of salience refers primarily to formal aspects, because the perceptual body of the morpheme is necessarily the starting point of the processing mechanism. However, the notion of salience makes sense for complex word processing only if the form it refers to is associated with a meaning or function. Salience, in other words, is a property of the morpheme (i.e., a stable association of form and meaning), not simply of a phonetic or graphemic chain.

5 The final sound [o] in French

Focusing on salience from a mere formal point of view leads to consider how a decompositional hypothesis could deal with some phonological endings whose graphemic transcriptions are various.

I present a distributional study of the final sound [o] in French suggesting that paradigmatic relationships are more suitable to guide morphological processing than morphological parsing. The data have selected from Lexique 3 database (New 2006).

In French, the final sound [o] can be written in 9 different ways:

(1) *-au* as in:
noyau, préau, tuyau, bestiau
'core', 'courtyard', 'pipe', 'cattle'

(2) *-aud* as in:
noiraud, rougeaud, crapaud, nigaud
'black+aud', 'red+aud', 'toad', 'idiot'

(3) *-aut*, as in:
quartaut
'quarter+aut

(4) *-eau* as in:
poireau, grumeau, tableau, drapeau
'leek', 'lump', 'board', 'flag'

(5) *-od* as in:
pernod
'pernod'

(6) *-op* as in:
galop, sirop, trop
'gallop', 'syrup', 'too much'

(7) *-os* as in:
gros, dos, enclos, chaos
'big', 'back', 'pen', 'chaos'

(8) *-ot* as in:
bistrot, cachot, chiot, jeunot
'pub', 'dungeon', 'puppy', 'youngster'

(9) *-o* as in:
auto, ado, mécano, fluo
'car', 'teenager', 'mechanic', 'fluo'

Among these words, one can distinguish semantically transparent complex words (e.g., *drap-eau*) M+, semantically opaque complex words (e.g., *crap-aud*) M−, simple words (e.g., *trop*) O and clippings (e.g., *ado* from *adolescent*) C, whose distributions in terms of size, i.e., number of different words sharing the same ending (N) and cumulative frequencies of these words (F) are sometimes very heterogeneous. Tables 1 and 2 present these different distributions.

Table 1: Number of different words having the same ending.

Ending	Distribution of the Size				
	Transparent complex words (M+)	Opaque complex words (M−)	Simple words (O)	Clippings (C)	Total N (M+, M−, O)
-au	2	3	13	5	18
-aud	20	15	11	35	46
-aut	0	1	22	1	23
-eau	74	47	74	121	195
-od	0	0	1	0	1
-op	0	0	4	0	4
-os	0	0	179	0	0
-ot	43	46	130	89	221
-o	18	8	430	26	581
Total	157	120	864	277	1089

As one can see above, among the 9 possible transcriptions of the sound [o], 6 can correspond to suffixes (i.e., *-au, -aud, -aut, -eau, -ot, -o*). It means that 66% of these endings can correspond to a suffix. Moreover endings in [o] are globally carried by a larger number of simple words (864 for O vs. 277 for M), and these simple words are much more frequent than complex words (13280 occ./million for O vs. 870 occ./million for M).

If we examine the size distributions of the different transcriptions, it appears that *-o* represents more than a half of the overall endings (581 words in *-o* for a total of 1089 words ending in [o]). The ending *-eau* dominates among the other endings (121/277 = .44) and only *-eau* (121 complex words for 74 simple words) and *-aud* (35 complex words for 11 simple words) show a morphological probability higher than an orthographic probability (p(M-*eau*) = 121/195 = .62; p(M-*aud*) = 35/46 = .76). All the other endings are dominated by

Table 2: Cumulative frequencies of words having the same ending.

Ending	Distribution of the cumulative frequency				
	Transparent complex words (M+)	Opaque complex words (M−)	Simple words (O)	Clippings (C)	Total N (M+, M−, O)
-au	6.55	34.86	5350.20	41.41	5391.61
-aud	2050.73	67.31	184.53	108.04	292.57
-aut	0	0	2009.41	0.20	2009.61
-eau	169.35	300.23	1559.39	427.10	1986.49
-od	0	0	4.73	0	4.73
-op	0	0	868.94	0	868.94
-os	0	0	1596.89	0	1596.89
-ot	1.80	4.05	1002.49	263.69	1493.18
-o	1.17	1.05	703.47	29.48	1037.39
Total	2229.60	407.50	13280.05	869.92	14681.41

simple words. This means that even if 66% of [o] endings can function as suffixes, their morphological probability is very low (p(M) = 227/1084 = .21). Therefore, morphological decomposition would conduct to a procedural deadlock in 81% of the cases. Finally, when the N distributions of M+ words are compared to M− words, we can see that M+ globally dominates M− (157 vs. 120) but when each ending is examined it appears that except for *-eau* (74 vs. 47) and *-o* (18 vs. 8) it is more a 50/50 ratio than a clear dominance. It suggests than even when the cognitive system encounters a complex word, morphological decomposition is semantically useless in 50% of the cases.

If one turns now to the details of frequency distributions, the cumulative frequencies of simple words are systematically higher than those of complex words, the highest value being associated with simple words ending in *-au* (5350 occurrences per million). As for the N distributions, the cumulated frequencies of the suffixed words ending in *-eau* dominates the other suffixed words (427 occ./million for a total of 870 occ./million). M+ words are much more frequent than M− words (2230 occ./million vs. 407 occ./million) but this dominance is explained by the cumulated frequencies of M+ suffixed words in *-aud* (2051 occ./million). When the data of *-aud* are removed, the cumulated frequency of M− words (340 occ./million) becomes almost twice as high as the one of M+ words (179 occ./million). Altogether, this suggests that simple words and semantically opaque complex words ending in [o] should be accessed more rapidly than the semantically transparent complex ones.

To sum up, the reported study of the 9 possible transcriptions of [o] according to the size and the cumulative frequency reveals that the probability for this phonological ending to correspond to a suffix is low. More importantly, the cumulative frequency of suffixed words bearing a semantically transparent construction is weak relative to the non-suffixed words. Consequently, a decomposition hypothesis according to which any item bearing a structured morphological surface is first decomposed into morphemic constituents would lead to numerous useless prelexical mechanisms.

6 Something is rotten in the state of the decomposition hypothesis

In the present paper, I reviewed results from masked morphological priming reported in the literature and I highlight the shortcuts made by the decompositionalist to interpret some data, in particular those related to formal effects, forgetting the semantic and the paradigmatic aspects of morphology. Although I do not deny that morphology plays a role during lexical access, I doubt that fast morphological effect can operate under masked priming conditions (i.e., within a window of a 50–60 ms). In addition, I propose an alternative interpretation of its role within the mental lexical

Recently, Giraudo & Voga (2014) proposed a revised version of the supralexical model. This new model is sensitive to both lexical (e.g. frequency) and exo-lexical characteristics of the stimuli (e.g., family size) and capable to cope with various effects induced by true morphological relatives (e.g., *singer–sing*) and pseudo relatives (e.g., *corner–corn*). According to the model, morphological relationships are coded according to two different dimensions: syntagmatic and paradigmatic. The first level captures the perceptive regularity and the salience 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 very early level of processing, 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 morcemes (from French *morceau* ‘piece’). Morcemes correspond to word pieces standing 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 wordforms 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 morceme 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 organisational principle of the mental lexicon. This rule stipulates that as soon as two words share form and meaning, a common abstract representation emerges; all the incoming forms respecting this principle then feed this representation. In the course of language acquisition and learning, family size grows and links are continually being strengthened.

Finally, if we turn back to priming effects, the model postulates that it depends on the kind of relationships the prime entertains with the target (formal and/or semantic) and consequently, on the number of excitation sources 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 sources of excitation, from morcemes, wordforms 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 sources of excitation, from wordforms 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 sources of excitation, from morcemes and wordforms; d) when the prime is not complex and not decomposable MO−S− (like *freeze–free*), it gives raise to only one source of excitation, from wordforms.

In our view, much work still needs to be done on morphological processing, but within the framework of a lexical network that codes word representations as the result of both syntagmatic and the paradigmatic influences. Separating form from meaning, words from their family and series within experimental paradigms like the masked priming paradigm that exclusively focuses the attention of the readers on visual formal aspects, leads to a confirmation bias and reduces the notion of morphology to form only. It is indeed very important to consider that masked priming effects do not only correspond to the early processes of lexical access as suggested by numerous authors, but to a picture of lexical access that takes place at a given time within an ocean of complex relationships.

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