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On the interplay between family and series effects in morphological masked priming

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Abstract The aim of our research is to further investigate the role of suffixes in morphological processing and to verify whether morphological series (i.e., paradigms of complex words sharing the same suffix) play a role in lexical representation and processing, as suggested by paradigm-based approaches (Bybee 1988, 1995; Booij 2010). The premise of our study is that, while the relationship between words belonging to the same morphological family has been extensively confirmed by psycholinguistic research, experimental studies on the relationship between words belonging to the same morphological series have been scarce so far and produced inconsistent results. On such premises, we carried a series of masked priming experiments on Italian, which consider truly suffixed words with respect to words with non-morphological endings (it. *inquina-mento* ‘pollution’–*cemento* ‘cement’) and we focused on series which display different degrees of internal consistency. Crucially, in order to facilitate the emergence of the series effect, we used a semantic categorization task associated with the masked priming technique, instead of the traditional lexical decision (LDT). Our results show that when the masked priming effects are not inhibited by formal factors (as happens with LDT), the facilitation induced by the words organization in series emerges more easily, although it is affected by series consistency in different ways. Firstly, while the series effect approaches significance for consistent series, it fails to emerge for non-consistent ones (Exp. 1). Secondly, the base effect is more robust and clear-cut in consistent than in non-consistent series. Thirdly, in more consistent series the interference of formal/orthographic factors is absent or reduced, while it significantly affects processing in less consistent series (Exp. 2). All in all, our results demonstrate that the paradigmatic effects are inherently graded as they crucially depend on series internal consistency and that they crucially interact with family effects during word access.

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1 Introduction: morphological series in a paradigmatic perspective

The aim of our research is to further investigate the role of morphological series in lexical processing and more precisely to verify whether words belonging to the same series (i.e., sharing the same suffix, e.g. *darkness*, *kindness*, *happiness*, *sadness*, etc.) prime each other in the same way as words belonging to the same morphological family (i.e., words sharing the same base, e.g. *kind*, *kindness*, *unkind*, *kindly*, *kind-hearted*, etc.). According to paradigm-based approaches (specifically Bybee's 'Network Model' and Booij's 'Construction Morphology'), morphological series¹ are conceived as sets of words which display a (varying) degree of formal and semantic similarity, alongside with general morpho-syntactic properties. Because morphological series express predictable properties, they clearly play a fundamental role both in understanding existing complex words, and in indicating how new ones can be coined. However, another and crucial function which is ascribed to morphological series in paradigm-based approaches is to give structure to the mental lexicon; i.e., to organize complex words in lexical paradigms, although such paradigms might differ significantly in terms of internal consistency. The aim of our research is precisely to provide psycholinguistic evidence of such a paradigmatic organization of the mental lexicon. More specifically, our research questions are: does lexical organization in series affect word processing and access? Does this organization impact word processing and access in the same way as lexical organization in morphological families, although these two kinds of paradigms rely on clearly different principles? How does lexical organization in series show up in psycholinguistic terms? In order to find an answer to this kind of questions, we will conduct two masked priming experiments on Italian derived words which belong to morphological series with different degrees of internal consistency (Sect. 2).

Priming (generally associated with lexical decision, Sect. 3) is, as a matter of fact, one of the mostly reliable on-line techniques used to investigate morphological effects during processing. The basic assumption on which this experimental paradigm relies is that the recognition of a visually presented word (the target; e.g. *hunt*) is facilitated, and therefore faster, when it is preceded by a (morphologically) connected word (the prime, e.g. *hunter*), with respect to conditions where it is preceded by an unrelated word (e.g. *fruit*) or a word which is formally/orthographically similar but not semantically connected (e.g. *hunger*). A facilitation in the recognition of the target word (which corresponds to reaction times significantly shorter in the morphological condition, *hunter-hunt*, than in the unrelated and orthographic condition) is generally interpreted as the result of a pre-activation of the target word induced by the connected prime. Morphological effects, therefore, are thought to be generated by the activation of the connections established among lexical items in the speaker's

¹The term 'series' has been introduced by Hathout (2009) and it will be used here accordingly.

mental lexicon; in Forster's words "the cortical representation of the prime and the target are interconnected or overlap in some way such that the representation of the prime automatically activates the representation of the target word" (Forster 1999:6). In the most recent developments of the research, the 'masked' technique has been preferred to simple repetition priming because it prevents the subject from developing any predictive response strategy or metalinguistic reasoning on the relationship between the prime and the target during the recognition task. This is assured by the fact that participants do not consciously perceive the prime since it appears on the screen for a very short period (generally under 60 ms) but nonetheless is able to induce a facilitation or an inhibition on the recognition of the target. For this reason, such a technique is considered as particularly suited to explore the automatic and unconscious processes occurring in the speakers' mind during word processing and has been chosen for the present research.

Although the masked priming is generally acknowledged to be an effective methodology to observe the processing of morphologically complex words, the theoretical assumptions which have driven the experimental studies with this technique are far from been univocal. Specifically, the majority of the experimental research has adopted what can be defined as a 'syntagmatic perspective' (Voga and Giraudo 2017), i.e., is focused on the internal structure of complex words and on the linear relationship between the 'superficial' morphological components (stem + affix).² Within such a syntagmatic framework, the aim is to assess whether morphologically complex words are accessed through their morphological constituents, which are 'extracted' through a compulsory decomposition process, or as whole forms retrieved from the lexical memory.³ In a syntagmatic view, therefore, a facilitation in the morphological condition would be due to the activation of the stem or of the affix which compose the complex word and which are both stored as entries in the lexicon.

By contrast, adopting a 'paradigmatic perspective' entails taking into consideration, beside the characteristics of the word to be recognized, its lexical environment as well, i.e., the complex network of formal and semantic relationships in which the word participates and the distributional and quantitative properties of the paradigms it is part of. Although these 'beyond-the-word-properties' have revealed to significantly affect processing, the most recent developments of psycholinguistic research have substantially neglected this dimension and preferred a syntagmatic one (see Voga and Giraudo 2017 for a discussion on the topic).

Thus far, experimental evidences of the effectiveness of the paradigmatic organization of the mental lexicon concern primarily morphological families, whereas evidences for the effect of morphological series are more controversial. The clearest

²An 'extreme' consequence of this view of the processing of morphologically complex words is represented by the morpho-orthographic hypothesis and by the so-called 'corner effect' (Rastle et al. 2004; Longtin and Meunier 2005 and Rastle and Davis 2008), according to which all forms which present a 'superficial' complex structure (e.g. *corn-er*) would be decomposed in early stages of visual processing, despite the fact that they are not in fact morphologically complex. For a discussion, see Giraudo and Dal Maso (2016) and Voga and Giraudo (2017).

³The success of such a syntagmatic approach in psycholinguistic research (an of the decomposition hypothesis to which it is connected) is also due to fact that the masked priming technique is acknowledged to be particularly sensitive to the formal characteristics of the word to be recognized, especially when used in association with lexical decision tasks, as it is almost always the case.

confirmation of the psychological reality of morphological families is represented by two specific effects which emerge quite systematically with lexical decision tasks in different languages, i.e., the ‘family size effect’ and the ‘entropy effect’. The first one refers to the fact that words with a large number of morphological relatives are recognized faster than words with a limited number of morphological relatives (i.e., Schreuder and Baayen 1997; De Jong et al. 2000; De Jong et al. 2002; Bertram et al. 2000; Pykkänen et al. 2004; Juhasz and Berkowitz 2011; Mulder et al. 2014). Within families, frequencies play a role as well, as demonstrated by the fact that words with equally frequent morphological relatives are processed faster than words whose morphological family is characterized by few very dominant members, which obscure the others (e.g., Moscoso del Prado Martín et al. 2004). This effect is known as entropy effect. Both the family size and the entropy effects prove that morphological processing is not determined simply by the properties of the word to be recognized but also, and crucially, by properties lying beyond it, at the level of lexical organization, and which affect processing *in absentia*.

As we mentioned, evidences of the series effect are, on the other hand, still scarce and highly controversial. This is partly due to the fact that only a limited number of experimental studies investigated the suffix effect *per se*; generally, the suffix is controlled as a factor in the experimental design (i.e., it is kept constant across sets of derived words), but the focus of attention is the base effect. This is the case for instance for Bradley (1979), Vannest and Boland (1999), Ford et al. (2010) and, more recently, Vannest et al. (2011) which basically show that the base frequency effect (i.e., shorter RTs for derivatives with high-frequency bases/stems) emerges more clearly when complex words have frequent, productive, semantically and phono-tactically transparent suffixes. On the contrary, RTs for the recognition of derivatives with less frequent, less productive, semantically and phono-tactically opaque suffixes correlate with the whole-word frequency, i.e., the surface frequency. In other terms, in these studies a suffix effect emerges, although it is not the focus of the investigation. However, when it is specifically manipulated, the effect of the suffix is shown to interact with the effect of the root and, more precisely, to stand out less clearly than the effect of the base. This is suggested by Burani and Thornton (2003), which conducted a word recognition experiment in Italian, exploiting the frequency effects. In a series of lexical decision experiments, they showed that true words with high-frequency roots yielded quicker and more accurate lexical decision responses, irrespective of suffix frequency. On the contrary, words with low-frequency roots, independently from the suffix frequency, did not differ from non-derived words. The authors concluded that the main factor responsible for lexical decision performance is root frequency, with only a marginal role for affix frequency. These results are, however, again interpreted within the storage *vs.* computation dichotomy, in what we described as a syntagmatic perspective: “access through activation of morphemes is beneficial only for derived words with high-frequency roots. By contrast, suffixed derived words that did not include any high-frequency constituent, or only included a high-frequency suffix, did not show any processing advantage with respect to derived words of similar low-frequency” (Burani and Thornton 2003:188).

If we draw now our attention on results coming from the masked-priming research, we have to acknowledge that the efficacy of the suffix on processing is even more

doubtful: Duñabeitia et al. (2008), Lázaro et al. (2015) on Spanish and Crepaldi et al. (2016) on English found a significant effect of the suffix, whereas no facilitation emerged in Giraudo and Grainger (2003) on French and in Giraudo and Dal Maso (2016) on Italian. Again, it is worth underlying that Duñabeitia et al. (2008), Lázaro et al. (2015) and Crepaldi et al. (2016) mainly verified the role of the suffix in a syntagmatic perspective, as a morphological component with its own lexical representation. An important methodological implication of this approach is the fact that in their experimental design the prime mainly used is the suffix presented in isolation (e.g., Span. *dad* - *IGUADAD* in Duñabeitia et al. (2008)), the suffix used at the end of a non-linguistic string (e.g., Span. %%%*dad*-*IGUALDAD* in Duñabeitia et al. (2008)) or the suffix in non-words (e.g., Engl. *sheeter*-*TEACHER* in Crepaldi et al. (2016)). We recently discussed the theoretical and methodological implications of using bound morphemes in isolation in recognition tasks, in much the same way as if they were free items (Giraudo and Dal Maso 2016) and we will not go into further details here. However, it has to be highlighted that presenting a morphological component in isolation as a prime is clearly incompatible with paradigmatic approaches which are word-based, rather than morpheme-based, and which focus on the effect of morphological schemas, rather than on the effect of discrete morphological components. In fact, according to Construction Morphology, suffixes are morphemes which are not listed in the lexicon as autonomous lexical items and whose existence is bound to their occurrence in schemas: affixes “have no independent existence outside complex words” (Booij 2010:19).

Having said that, in experiments where suffixed words were used as primes for other suffixed words, morphological effects did not clearly emerge, i.e., Giraudo and Grainger (2003) on French (Fr. *fumet* ‘smoked aroma’ did not significantly prime *muret* ‘low wall’, with respect to an orthographic condition) and Giraudo and Dal Maso (2016) on Italian (It. *pescatore* ‘fisher’ did not significantly prime *traditore* ‘traitor’, with respect to an unrelated condition). Interestingly, however, morphological series with different salience and orthographic consistency did seem to induce different priming patterns. This was suggested by Giraudo and Dal Maso (2016), which opposed series with a high degree of salience and orthographic consistency (___tore series, e.g. *pescatore* ‘fisher’), to series with a lower degree of salience (___ico, e.g. *ironico* ‘ironic’) and orthographic consistency (___etto series, e.g. *pezzetto* ‘small piece’).⁴ Specifically, series’ orthographic consistency, operationalized as the ratio between suffixed and non-suffixed words in a series of words ending with a given letter string,⁵ seemed to play a role. Results indicated that with consistent series a strong effect of the base (*pescare* ‘fish’-*pescatore* ‘fisher’) was found as expected according to the literature, whereas within inconsistent series (*pezzo* ‘piece’-*pezzetto*

⁴The adoption of a paradigmatic perspective in this work is made clear by using a specific graphic notation: a sequence of underscores before the suffix (e.g. ___tore) will be used to indicate the morphological schema, while the traditional hyphen (e.g. *-tore*) will indicate the suffix as a morphological component in a syntagmatic perspective.

⁵In Italian, the ___tore series is highly consistent as 78,38% of the items ending with that string of letters is genuinely morphologically complex (86,15% if we consider the token frequency), whereas the ___etto series is much less consistent, as only 39,47% of the items is genuinely suffixed (16,78% if we consider the token frequency); moreover, the most frequent words are not truly suffixed (e.g., *progetto* ‘project’, *effetto* ‘effect’, *oggetto* ‘object’, *letto* ‘bed’, *aspetto* ‘aspect’, etc.).

‘small piece’) even the base effect failed to emerge. Moreover, the error rate for the less consistent series was higher than for the more consistent ones, especially in the morphological condition. These results seem to be in line with what found by Bradley (1979), Vannest and Boland (1999), Ford et al. (2010) and, more recently, Vannest et al. (2011) and eventually indicate that, although a direct effect of the series could not be observed, the morphological processing is nonetheless sensitive to the characteristics of the series. In paradigmatic terms, we suggested that when the representation of the morphological schema is stronger, as it is the case for consistent series, the effect of the base can stand out more clearly. On the other hand, within inconsistent series, the weaker morphological structure prevents the base to emerge. Thus, a weaker representation and activation of the morphological schema makes the discrimination between truly suffixed and pseudo-suffixed words fuzzier for the speaker. Our hypothesis is, therefore, that there is a deep and complex interplay between the paradigms in which the words participate: morphological families and series.

To sum up, the results obtained in Giraudo and Dal Maso (2016) seem to point towards the hypothesis that series (in)consistency does indeed affect the processing of suffixed words, although a direct priming effect was not observed in that first study. In the present development of the research, therefore, we will further investigate the series effect by: i) opposing more clearly consistent and inconsistent series (Sect. 2); ii) using an experimental design which is more sensitive to ‘deep’ and less formal priming effects, i.e., the semantic categorization task (Sect. 3).

2 Series’ consistency

As we discussed in Sect. 1, assuming a paradigmatic perspective implies considering the features of series as morphological schemas, mainly in terms of quantitative and distributional features, degrees of morpho-semantic and morphotactic transparency, degrees of functional and perceptual salience, etc., as it will be outlined below. When we consider the interaction of all these factors, we observe that morphological series are extremely heterogeneous and we might expect that their representation in the mental lexicon varies accordingly; consistent series (i.e., frequent, productive, salient and contingent series) are expected to have a stronger representation than less consistent ones (i.e., less frequent, less productive, less salient and less consistent series). Therefore, morphological effects should emerge more likely for consistent than for less consistent series. Ultimately, opposing series with different degrees of consistency is a way which could allow us to observe any series effect. For this reason, in our experiments we opposed series which display significantly different characteristics at the morpho-semantic, morpho-tactic and quantitative level. Specifically, we selected:

- i) ___*mento* (e.g., *ragionamento* ‘reasoning’) and ___*tore* (e.g., *viaggiatore* ‘traveller’) for the most consistent series;
- ii) ___*ellola* (e.g., *fornello* ‘cooker’) and ___*inola* (e.g., *cestino* ‘little basket’) for the less consistent series;
- iii) ___*olola* (e.g., *bestiola* ‘small biest’) for the non-consistent series.

It is worth underlying that our aim is not to assess which specific feature (productivity, frequency, morpho-semantic or morpho-tactic transparency) is responsible for a certain processing mechanisms or priming patterns, as has often been done in traditional behavioral research. In the same line with Vannest et al. (2011), we will rather oppose series which are substantially different because of the clustering of several features. The rationale for our choice is that the distinction between some of the properties, although theoretically clear, is very difficult or even impossible empirically. This is the case, for instance, for suffix numerosity and suffix frequency, as observed also by Burani and Thornton (2003), which are found to systematically correlate and cannot therefore be disentangled. Similar observations can be made for the relationship between productivity and transparency, transparency and perceptual salience and also for morpho-semantic and morphotactic transparency. From a more theoretical point of view, our choice is grounded on the assumption that none of these factors in isolation is a reliable predictor of a morphological effect in priming but that they rather interact in defining series consistency and representational strength. Therefore, if any series effect emerges, this will be the result of the convergence of different features, which bundle differently in order to create graded and non-discrete degrees of representational strength.⁶

Let us now have a look at the criteria we considered in defining series' consistency. What we considered as consistent series are larger (i.e., have higher type frequency) and more frequent (i.e., higher token frequency); according to the It.ten.ten Corpus the ___*mento* series is made up of 807 lexical items and its token frequency is 7.505.393; the ___*ino* series is composed by 545 words and its token frequency is 1.291.307; whereas the ___*olo* series comprises 51 types and 1270 token. Likewise, more consistent series are more prone to be enriched by new elements, whereas non-consistent series, as ___*olo*, are synchronically non-productive (Grossman and Rainer 2004). In selecting series, we also considered orthographic ambiguity, i.e., the proportion between the number of truly affixed and non-affixed words containing the same orthographic ending (see the notion of 'affix confusability' applied by Laudanna and Burani (1995) to the Italian prefix system). Orthographic ambiguity differs significantly among the series we selected: 93,6% of words ending in *-mento* are truly suffixed, but only 38,4% of words ending in *-olo* are.⁷ Again, if we consider the token frequency, the difference between series appears even more strikingly as, while the proportion for the consistent series remains quite stable (around 90% for ___*mento*), the percentage of truly suffixed words drops drastically for the non-consistent series (3% for ___*olo*).

⁶This choice is also compatible with the observation that speakers' perception of morphological complexity has revealed to be substantially non-discrete but rather intrinsically graded, as observed by Hay and Baayen: "People's behavior in experimental tasks is anything but categorical. Individuals can rate affixed forms consistently on a scale from unaffixed to affixed, and can assess which member of a pair of complex words is more complex (e.g. *settlement* is reported as 'more affixed' than *government*). This suggests that morphological complexity is not a binary category" (Hay and Baayen 2005:343).

⁷The ratio between suffixed and pseudo-suffixed words is calculated only with respect to the category of nouns, which means that, for instance, in the *-ello* series we considered the proportion between suffixed nouns as *cestello* 'small basket' and pseudo-suffixed nouns as *ruscello* 'stream, brook', but not adjectives as *bello* 'beautiful' or pronouns, as *quello* 'that one', which however display high frequencies. This data could potentially be interesting, but will not be developed here because of lack of space and will be the object of further research.

As for the semantics, we firstly considered the number of meanings carried by a given suffix (on the concept of semantic coherence, see Aronoff 1976, Baayen 1992 and Ellis's notion of 'contingency', Ellis 2006). Again, while, *-mento* exhibits almost invariably the semantic outcome of either event or result nouns, a suffix such as *-ino* presents a much more fragmented spectrum of meanings, ranging from diminutive (e.g., *tavolino* 'small table'), ethnic (e.g., *marocchino* 'Moroccan'), agentive (e.g., *spazzino* 'street sweeper') and instrumental (e.g., *accendino* 'lighter'). Semantically, then, the ___*ino* series is much less uniform than the ___*mento* one and possibly less easily recognizable. A closely related issue which is also claimed to be responsible for the series consistency, is the semantic bleaching that some affixed words might have undergone, either as a whole (e.g., *broccolo* 'sprout' from *brocco* 'stick') or in their original diminutive value (e.g., *bracciolo* 'arm rest', not 'little arm' from *braccio* 'arm'). In our vision, a morphological series with a high number of semantically opaque suffixed words might be more difficult to be perceived by speakers, as the semantic connections with the respective stems and with the other members of the series is severely weakened.

The functional stability of the derivational base has also been considered as a factor which possibly affects the way in which the series is perceived. According to this criterion, we opposed the ___*mento* series, which always selects verbal bases, to the ___*ino* series which, on the other hand, selects both verbal (e.g., *imbianchino* 'white-washer' from *imbiancare* 'to whitewash') and nominal bases (e.g., *nasino* 'little nose' from *naso* 'nose'). As for the nominal stems, series might also differ in relation to the stability of the gender of the base, e.g., *-ino* selects both feminine and masculine nominal bases (e.g., *spazzolino* 'toothbrush' from *spazzola* 'brush' (fem.) and *quadernino* 'little notebook' from *quaderno* 'notebook' (masc.); on gender changing suffixes see Merlini Barbaresi 2004).

Finally, the relationship between morphological series and the orthographic series (involving stress patterns) has been taken into account in order to define series' consistency. This perspective is particularly suited when we consider Italian with respect to languages with less transparent writing system. As Italian has a relatively transparent writing system (a 'shallow system' in the sense of Katz and Frost 1992), Italian does not exhibit the kind of morphographic spellings which is found in languages with opaque writing systems ('deep systems' in Katz and Frost's terms), as English for instance. As Aronoff et al. (2016) point out, in writing systems with complex phoneme-grapheme correspondences, affixes are generally spelled in a consistent way. For this reason, these writing systems are defined as morphographic. On the contrary, in shallow systems (as Italian, but also German and Spanish) the spelling is mainly phonographic (rather than morphographic); the spelling of affixes is therefore less 'unique'. As Aronoff et al. (2016) state: "languages differ with respect to their spelling in that English and French are fairly morphographic, while German and Spanish exhibit more ambiguities with respect to their spelling of affixes and non-affixes. As a result, affix stripping might be more pronounced in the salient contexts of the former two languages, and less so for the latter" (p. 180). This kind of observations is particularly important when we deal with early processing stages, as it is the case when we use the masked priming technique. We might in fact suppose that these early stages are more deeply influenced by the formal/orthographic information and that, for that reason, languages with shallow and deep writing systems

might induce different effects (i.e., greater effects for morphographic systems than for phonographic spelling systems). For all these reasons, it is crucial to introduce in the experimental design an orthographic control (Sect. 4) in order to control to which extent the pure formal factor interacts in the recognition process.

The fact of considering all these criteria allowed us to distinguish series with different degrees of consistency. Our aim is therefore not to determine to which extent each feature discussed above determines the emergence of the morphological series and affects morphological processing, but rather to investigate how they all converge in defining morphological series with different degrees of consistency, which possibly affects processing. Our hypothesis is in fact that the emergence of each morphological series is shaped by its relative degree of consistency.

3 Masked priming technique combined with semantic categorization task

As we explained in Sect. 1, in recent psycholinguistic research, processing mechanisms have been investigated mainly by means of the masked priming experimental technique (Forster and Davis 1984), traditionally associated with a lexical decision task (LDT), i.e., subjects are exposed to visually presented stimuli (which appear in different priming conditions, as explained before) and are asked to discriminate between real words (the critical items, e.g., *hunter*) and non-existing words (the distractors, e.g., *fleng*). Ultimately, the recognition of an item depends on participants having a mental representation of the word's form/orthography, therefore his/her decision focuses on external formal aspects and might not entail (or might precede) a (complete) access to semantics: “[i]n a typical lexical decision experiment subjects [...] are not told to respond only when they know exactly what the word is, or only when they know exactly what the non-word is” (Kinoshita and Norris 2012:3).

Starting from the acknowledgment that masked priming effects are modulated by the tasks they are associated with (Kinoshita and Norris 2012), in the present development of our research, we aim at verifying whether the lack of series priming effects observed in Giraudo and Grainger (2003) (on French) and later in Giraudo and Dal Maso (2016) (on Italian) could be due to the fact that LDT is a quite formal-focused task. If this were the case, the emergence of the series effect might be induced by varying the task associated with the masked priming technique, since, as argued by Kinoshita and Norris (2012): “[t]he same pairing of primes and targets can produce different patterns of priming in different tasks. Priming is not an automatic function of the relation between prime and target but depends critically on the nature of the experimental task” (Kinoshita and Norris 2012:1).

It cannot be excluded that in previous research the series effect might have been obscured by the fact that participants' attention was largely focused on the orthographic representation of the word to be identified because of the LDT, since the discrimination between words and non-words can indeed simply rely on low-level formal properties. This hypothesis is supported by recent studies which, using semantic priming, have questioned whether semantic access for words is truly automatic and suggested that in fact it requires participants be involved in some lexical-level task

(Mari-Beffa et al. 2000). In other terms, semantic priming seems to occur with tasks which entail the attention to be directed to high-level properties of words (such as semantic properties), while it is reduced (or even absent) when attention is addressed to the formal level.

In the light of these considerations, we aimed at verifying whether the ‘functional meaning’ carried by the suffix and the strength of morphological schemas (and of connections between words in paradigmatic relationships) could be more easily captured by an experimental task that taps onto deeper, more semantically related phases of the word recognition process. For these reasons, in the present research, we decided to use the masked priming technique in association with a semantic categorization task in which participants are exposed, besides to the critical items (target words in different priming conditions, e.g., *hunter–hunt* or *hunter–hunger*), to distractors which refer to a homogeneous category (e.g., animals). In semantic categorization tasks, the subjects are asked to decide whether the word they are exposed to (e.g., *squirrel* vs. *hunt*) refers to an exemplar (a congruent item) of that category or not. This kind of discrimination necessarily implies semantic processing because the decision process to give a response needs to consider the semantic features of the target words rather than their shape: “The semantic categorization task necessarily requires semantic processing, as the decision is whether the target word has the semantic features of a category exemplar” (Kinoshita and Norris 2012:5).

To sum up, in such a design, the critical items are always the target words in different priming conditions (e.g., *hunter–hunt* or *hunter–hunger*, etc.), but in the recognition process they will ‘compete’ against words (i.e., distractors) which belong to a homogeneous semantic category. In other terms, in our experiment we will manipulate the relationship between the critical items and the distractors.

4 The present study

On such premises, we decided to carry two masked priming experiments on Italian, which consider suffixed words with respect to words with non-morphological (or opaque) endings. Our main hypothesis is that the degree of consistency of the series should influence the recognition process of Italian suffixed words and, therefore, we expect to obtain stronger morphological priming effects for consistent (e.g., ___*mento*) than for less consistent (e.g., ___*ello*) series.

4.1 Experiment 1: Suffixed target words primed by suffixed and pseudo-suffixed words of the same series

4.1.1 Participants

27 native speakers of Italian (mean age: 29.7) participated to our experiments. All of them reported normal or corrected-to-normal vision. They were all high school or university educated and participated to the experiment on a voluntary basis.

Table 1 Experimental design of Exp. 1

	Consistent series		Inconsistent series	
	Prime	Target	Prime	Target
(a) Base condition	<i>ragionare</i> '(to) reason'	<i>ragionamento</i> 'reasoning'	<i>forno</i> 'oven'	<i>fornello</i> 'burner'
(b) Suffix condition	<i>inquinamento</i> 'pollution'		<i>granello</i> 'grain'	
(c) Pseudo-suffix condition	<i>cemento</i> 'cement'		<i>cammello</i> 'camel'	
(d) Unrelated condition	<i>incarico</i> 'role'		<i>fervore</i> 'fevor'	

4.1.2 Stimuli and design

As explained in the previous sections, in Exp. 1 we considered prime and target words belonging to the same morphological series and we opposed consistent series (*__mento* and *__tore*) to less consistent ones (*__ello/a* and *__'olo/a*). We selected 28 items as target words for both the consistent and inconsistent series (globally 56 items). More precisely, we selected 17 items for the series in *__tore*; 11 items for the series in *__mento*; 22 items for the series in *__ello/a* and 6 items for the series in *__olo/a*.

In our experimental design (summarized in Table 1), the target words appeared in four priming conditions, our experimental condition being the suffix condition where the target word is preceded by a prime word displaying the same suffix (e.g., *inquinamento*–*ragionamento*; *granello*–*fornello*). The experimental condition is compared to the base condition (e.g., *ragionare*–*ragionamento*), which, according to the literature, is expected to yield the fastest reaction times, and to an unrelated condition (e.g., *incarico*–*ragionamento*) which, on the contrary, is expected to yield the smallest facilitation effect and thus the longest RTs. Crucially, we introduced a further condition, namely a pseudo-suffix condition, i.e., prime words which end with the same orthographic sequence but are not indeed suffixed (e.g., *cemento*–*ragionamento* and *cammello*–*fornello*). This experimental design allows us to directly compare the priming effect of a suffixed word and of a pseudo-suffixed word on the same target, namely two primes with the same word ending but in one case a morphological one and in the other a non-morphological one. Moreover, we could verify the effects of a suffixed prime and of a pseudo-suffixed prime for consistent and non-consistent series.

The rationale of this experiment is the following: if the series priming facilitates the responses to complex words but not to pseudo-suffixed, simple words, then we can defend a transfer of excitatory activation from the prime to the target, which could be due to the fact that the morphological schema has been pre-activated by the connected suffixed prime (e.g., *inquinamento*–*ragionamento* 'reasoning'–'pollution') but not by the pseudo-suffixed prime (e.g., *cemento*–*ragionamento* 'cement–reasoning'). In this case, we expect more consistent series (*__mento*) to induce stronger effects than less consistent series (*__ello*). Otherwise if the priming benefits both suffixed

and pseudo-suffixed words to the same extent, we can interpret this as the result a purely formal overlap between the prime and the target, triggered by the morpho-orthographic structure of a suffixed and pseudo-suffix word, regardless of the existence on any morphological schema. In the latter case the results would suggest that the segmentation process takes place during processing independently from the presence of any base or stem (as claimed by the morpho-orthographic hypothesis, Rastle et al. 2004).

Primes and targets were as matched as possible in number of letters (8.8 letters for primes and 10.9 letters for targets in consistent series and 7.8 letters for primes and 9 letters for targets in non-consistent series). However, because of the reduced number of pseudo-suffixed words found among the series we selected (especially for the consistent set), it was not possible to match primes in the different conditions for frequency. On average, words in the pseudo-suffix condition had higher frequency than words in the suffix condition.⁸

For the purpose of the semantic categorization task, 56 nouns designating animals were also selected. Distractor words were as matched as possible for frequency and length.

Four experimental lists, each composed of 112 priming-target pairs (half suffixed words, half words designating animals) 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.

4.1.3 Procedure and apparatus

The experiment was conducted on a PC computer using the DMDX software (Forster and Forster 2003). Each trial consisted in three visual events. The first was a forward mask (a row of hash marks) that appeared for 500 ms. The mask was immediately followed by the prime which, in its turn, was followed by the target word. The target word remained on the screen until participants responded. The prime duration used in this experiment was 60 ms. Participants were seated in front of the computer screen and were asked to perform a semantic categorization task (“does the word that you are seeing refer to an animal?”), as quickly and as accurately as possible, by pressing the appropriate button of the keyboard. Participants were unaware of the presence of a prime since the duration would prevent conscious identification.

4.1.4 Results

For the statistical analysis in the present experiment, as well as in the next one, we chose to perform an ANOVA instead of the more recently popular multiple regression analysis, mainly because our hypotheses were based on differences between prime

⁸The stress pattern of prime words was clearly constrained in the base, suffixed and pseudosuffixed conditions. In the unrelated condition, it has not been controlled, which represents a potential flaw in the experimental design, as suggested by one of the reviewers. Although in Giraudo and Dal Maso (2016) the stress pattern of primes (which participated in the definition of perceptual salience) did not seem to affect priming effects, such a point would certainly deserve a closer inspection in future research.

types and between consistency types of the series we manipulated. As explained by Howell, “the analysis of variance is a special case of multiple linear regression, which in turn is a special case of what is commonly referred to as the general linear model” (Howell 2010:574). Moreover, Howell points out that “the analysis of variance tells us that three treatments (T1, T2, and T3) have different means (X_i). Multiple regression tells us that means (Y_i) are related to treatments (T1, T2, and T3), which amounts to the same thing. Furthermore, the analysis of variance produces a statistic (F) on the differences among means. The analysis of regression produces a statistic (F) on the significance of R. [...], these Fs are (nevertheless) equivalent” (p. 580). According to us, these claims can certainly justify our statistical choice.

Correct response times (RTs) were averaged across participants after excluding outliers (RTs > 1500 ms, 0.34% of the data). Results are presented in Table 2. The ANOVA was performed on the remaining data with prime type factor (stem, suffix, pseudo-suffix and unrelated primes) and series type (consistent and non-inconsistent) as within-participant factors. List was included as a between-participant factor in order to extract any variance associated with this variable. A Latin Square design was used in the present experiment, therefore as recommended by Raaijmakers and Phaf (1999), we did not perform separate subject and item analyses but only a F1 test statistic.

The main effects of the prime type factor ($F(1,3,87) = 7.04, p < .001$) and the series type factor ($F(1,29) = 112.05, p < .0001$) were significant. The interaction between these two factors was not significant ($F(1,3,87) < 1$), however a significant partial interaction between the two main factors was found only for consistent series ($F(1,3,87) = 4.14, p < .05$; for inconsistent series: $F(1,3,87) = 2.08, p > .10$). Planned pairwise comparisons were carried separately for consistent and for non-consistent series.

For consistent series, the effect of the prior presentation of a base prime (*ragionare–ragionamento*) was significant relative to all the other three priming conditions (vs. suffix: $F(1,29) = 5.21, p < .00$; vs. pseudo-suffix: $F(1,29) = 5.38, p < .05$; vs. unrelated: $F(1,29) = 18.15, p < .0001$). This means that in this set the base is the most efficient prime to reduce target recognition latencies. As for the effect of the suffixed prime (*inquinamento–ragionamento*), it only reaches a tendency to significance relative to the unrelated primes ($F(1,29) = 2.97, .05 < p < .10$), whereas the pseudo-suffixed primes (*cemento–ragionamento*) is not significantly different from the RTs obtained in the unrelated condition.

This suggests that the fact of belonging to the same morphological series reduces quantitatively the target recognition latencies (as we can see on Table 2, the suffix priming condition was 17 ms faster than the unrelated condition), although it is not sufficient to induce a statistically significant priming effect (the effect of suffix primes did not differ significantly from pseudo-suffix primes ($F(1,3,87) < 1, p > .10$)).

For non-consistent series, base primes (*forno–fornello*) induced significant priming effect relative to unrelated primes ($F(1,29) = 8.45, p < .006$), but did not differ from suffix primes (*granello–fornello*) ($F(1,29) = 2.04, p > .10$) and show a tendency to significance with pseudo-suffix primes ($F(1,29) = 3.04, .05 < p < .10$). However, suffix primes did not induce any significant facilitation effect relative to the unrelated condition ($F(1,29) = 1.04, p > .10$) and were not more efficient than pseudo-suffix primes ($F(1,29) = 0.10, p > .10$). These results show that for non-consistent series only base primes are able to significantly facilitate target recognition

Table 2 Reaction times (RT, in ms) and % of errors for targets in the Base (Base), Suffix (Suf), Pseudo-suffix (Ps) and Unrelated (Un) prime conditions for the two categories of series (Consistent, Non Consistent) tested in Exp. 1. Net priming effects are given relative to the unrelated prime condition (* indicates a significant priming effect and ** a tendency to significance)

	Primes				Net priming effects		
	Base	Suffix	Pseudo-suffix	Unrelated	Un-Base	Un-Suf	Un-Ps
	Consistent	621 (0.004)	638 (0.005)	645 (0.005)	655 (0.05)	34*	17**
Non-consistent	687 (0.018)	706 (0.021)	710 (0.024)	719 (0.036)	32*	13	9

latencies. Moreover, as we can see in Table 2, targets in consistent series were globally recognized significantly faster than non-consistent series (in average 640 ms vs. 705 ms), but this difference can be attributed to the frequency differences between targets from consistent series and those from non-consistent series.

Therefore, as summarized in Table 2, the clearest priming effect which emerges even when masked priming is associated with a semantic categorization task is the one produced by the base, which is significant for both the consistent and non-consistent series. This indicates that the facilitation induced by the organization of words in morphological family is robust and emerges independently from the task used in the experimental paradigm (although here it emerged even for non-consistent series, whereas with a lexical decision task it failed to be observed for non-consistent series, Giraudo and Dal Maso 2016). However, it is worth highlighting that even if the effect of the base emerges in both the consistent and the non-consistent series, it cannot be considered as qualitatively equivalent. In the consistent series set, the base priming effect is significant relative to the other three priming conditions (i.e., suffix, pseudo-suffix and unrelated), whereas in the non-consistent series condition, the base priming effect is observed only relatively to the unrelated baseline. Specifically, the base is clearly an efficient prime only when compared to the baseline condition (i.e., the unrelated primes for which no priming effect is expected since there is neither a formal overlap nor a semantic similarity in prime-target pairs), but its effect does not significantly differ from other primes which have a morphological relationship (i.e., suffix condition) or a formal overlap (i.e., pseudo-suffix) with the target. This seems to suggest that, as we already hypothesized in Giraudo and Dal Maso (2016), the base stands out more clearly in consistent series, which have stronger and more entrenched representations. Eventually, the findings obtained using a semantic categorization associated with the masked priming are in line with what previously found by Bradley (1979), Vannest and Boland (1999), Ford et al. (2010) and Vannest et al. (2011) in that they show that series consistency does play a role in morphological processing, as it induces the base to stand out.

As for the series effect, which is the main focus of the present research, our results indicate that it emerges rather weakly even when we make use of an experimental technique which is acknowledged to be less focused on formal features and better suited to capture semantic and deeper effects, as those produced by lexical organi-

zation in paradigm. Nonetheless, while with traditional methods it failed to surface (at least in the 'paradigmatic perspective' adopted), here it approaches significance. What is more interesting, however, is the fact that such a tendency to significance is obtained only for consistent series (i.e., for *inquinamento*–*ragionamento*, but not *fornello*–*granello*), which points toward the fact that not only consistency plays a role in the processing of morphologically complex words but also, and crucially, that series *tout court* are responsible for processing mechanisms. Indeed, if series did not play a role at all, we should have observed the same pattern of results (i.e., no suffix effect) in both kinds of series, which is clearly not the case here, despite the statistical weakness of our suffix effect. We take this as evidence of the fact that series are involved during processing, but also that series priming does not surface as a discrete 'yes-or-no' effect, but rather as an inherently graded one. Once again, experimental studies which directly compare the facilitation induced by a word of the same family and of the same series on the same target, reveal a very complex interplay of these two dimensions of lexical organization during processing. The fact that the base priming effect emerges independently of the experimental task, whereas the suffix effect critically depends on the nature of the task used, indicates that the activation of morphological families and series is sensitive to different factors. According to us, this would mean that the organization of complex words in morphological families and series is not driven by the same principles and that could respond to different processing mechanisms. However, the question of how much activation is needed in order to induce series priming effect as well as the question of how such an activation can be captured experimentally needs further research. As a matter of fact, the nature of the effect we recorded in the suffix condition is still ambiguous, not only because suffix effect only approaches significance, but also because it does not significantly differ from the one obtained in the pseudo-suffixed condition, i.e., when the prime is a word displaying the same orthographic word ending although a non-morphological one (e.g., *cemento*–*ragionamento*). Therefore, in order to clarify the nature of the effect we observed in the suffix condition and to better understand the interplay between morphological and formal effects, we ran a second experiment, which focused on the formal overlap between orthographically (but not morphologically) related prime-target pairs. Again, we considered series with different degrees of consistency, in order to observe a possible graded effect.

4.2 Experiment 2: pseudo- or opaque suffixed target words primed by pseudo- or opaque suffixed words

In Exp. 2, we considered prime and target word which belong to the same word-ending series but are not morphologically complex (or are highly lexicalized and morpho-semantically opaque) and cannot therefore be considered as part of the same morphological series. The aim of this experiment is twofold. First, it allows us to observe whether words with the same orthographic word-endings prime each other in the same way as suffixed words do. This of course would mean that the effect yielded in the previous experiment in the suffix condition is not morphological in nature. Secondly, by opposing consistent and less-consistent series it is possible to verify whether the priming effects induced by formal similarities are modulated by series characteristics.

Table 3 Experimental design of Exp. 2

	Consistent series		Less consistent series			
	Prime	Target	Prime	Target	Prime	Target
Pseudo-suffix condition	<i>argomento</i> 'argument'	<i>segmento</i> 'segment'	<i>destino</i> 'fate'	<i>giardino</i> 'garden'	<i>pericolo</i> 'danger'	<i>diavolo</i> 'devil'
Unrelated condition	<i>torrente</i> 'stream'		<i>profilo</i> 'profile'		<i>rivale</i> 'rival'	

4.2.1 Participants

They were the same as Exp. 1

4.2.2 Stimuli and design

For Exp. 2, we considered simple words or highly lexicalized words with the same orthographic (and phonetic) word-ending sequence. Specifically, we selected 10 prime-target pairs for each kind of series, namely consistent series (e.g., ___*mento*); less consistent series (e.g., ___*ino*) and basically inconsistent series (e.g., ___*olo*). The experimental condition (i.e., the pseudo-suffix condition) is compared with a base line condition represented by a formally and semantically unrelated prime for which we do not expect any kind of priming effect. Primes and targets were matched as closely as possible in mean number of letters (respectively 7.9 and 7.3 letters) and in frequency (Tab. 3).

4.2.3 Procedure and apparatus

They were the same as Exp. 1

4.2.4 Results

Correct response times (RTs) were averaged across participants after excluding outliers (RTs > 1500 ms, 0.56% of the data). Results are presented in Table 4. An ANOVA was performed on the remaining data with prime type factor (pseudo-suffix and unrelated primes) and series type (consistent, low consistent and inconsistent) as within-participant factors. List was included as a between-participant factor in order to extract any variance associated with this variable. A Latin Square design was used in the present experiment, therefore as recommended by Raaijmakers and Phaf (1999), we did not perform separate subject and item analyses but only a *F*1 test statistic.

The main effect of the prime type factor ($F(1,19) = 2.73, .05 < p < .10$) tends to significance whereas the series type factor does not reach significance ($F(2,38) = 1.97, p > .10$). The interaction between these two factors was not significant ($F(1 < 1)$); however, the prime type factor was significant for inconsistent series ($F(1,19) = 5.37, p < .03$), while it was not for consistent series ($F(1 < 1)$) and for low consistent series ($F(1 < 1)$). It means that only in inconsistent series, pseudo-suffix primes can

Table 4 Reaction times (RT, in ms) and % of errors for semantic categorization to targets in the Pseudo-Suffix (Ps) and Unrelated (Un) prime conditions for the three categories of formal overlaps tested in Exp. 2. Net priming effects are given relative to the unrelated prime condition

	Pseudo-suffix	Unrelated	Net priming effects Un-Ps
Consistent series	681 (0.003)	689 (0.03)	+8
Less consistent series	652 (0.03)	666 (0.00)	+12
Inconsistent series	674 (0.03)	707 (0.03)	+33*

significantly reduce target recognition latencies relative to unrelated primes (RTs are reduced by 33 ms).

The results obtained in Exp. 2 and summarized in Table 4 are quite straightforward, as the priming effect induced by the (purely formal) word-ending is significant for the inconsistent series (e.g., *pericolo* ‘danger’–*diavolo* ‘devil’), but it is crucially not significant in less consistent series (e.g., *destino* ‘fate’–*giardino* ‘garden’) and in consistent series (e.g., *argomento* ‘argument’–*segmento* ‘segment’). In other words, formal overlap induces significant facilitation only in inconsistent series, whereas the stronger the series is, the less formal priming effects emerge. According to us, these results are particularly interesting as they indicate that the more consistent a morphological series is, i.e., the stronger its mental representation for the speaker, the less the formal overlap affects the processing mechanism. It seems therefore that the morphological strength of the consistent series blocks the orthographic/formal interference. On the contrary, the ‘ambiguity’ of the word-ending sequence in inconsistent series allows for purely formal effects to emerge.

5 General discussion and conclusions: the complexity of the morphological series effect and the interplay with family effects

In this study, we focused on the role of series in morphological processing and lexical organization in order to verify whether words belonging to the same series prime each other as expected according to paradigm-oriented models of the mental lexicon. We addressed this specific issue because previous studies using the masked priming technique and dealing with real words (i.e., Giraudo and Grainger 2003 and Giraudo and Dal Maso 2016) failed to systematically observe such an effect (but Duñabeitia et al. 2008, Lázaro et al. 2015 on Spanish and Crepaldi et al. 2016 on English obtained it, even though with different experimental materials and design). On the other hand, the experiment conducted by Giraudo and Dal Maso (2016) on Italian suggested that the emergence of the series effect could be indeed influenced by paradigmatic properties (specifically series’ consistency) and that, in a sort of ‘rebound effect’, even the effect of the morphological family was weakened in non-consistent series. For these reasons, we aimed at clarifying the complex interplay between morphological families and series by adopting a clearly paradigmatic approach (Sect. 1). We therefore

investigated the effect induced by morphological schemas, rather than by morphological components, how is often done in 'syntagmatic approaches' which restrain their attention on the relationship established *en presence* between the base and the affix comprised in a complex word (see the large number of experimental studies on word decomposition and on the morpho-orthographic hypothesis, as reviewed by Rastle and Davis 2008). In order to observe series' impact on processing, for our experiments we selected morphological series with different degrees of consistency, defined basically in terms of distributional features, morphosemantic and morphotactic transparency (Sect. 2). On the basis of the clustering of such properties, we opposed highly consistent series (e.g., ___*mento*), which are assumed to have a stronger representation within the speaker's mental lexicon, to low-consistency series (e.g., ___*'ola*) which, on the contrary, are assumed to have a weaker lexical representation. We did not intend to single out which specific series' properties determine processing (whether frequency, productivity, contingency, etc.), as is done in the majority of the behavioral research; we rather aimed at verifying whether different degrees of consistency, which are determined by the clustering of such properties, correspond to different degrees of representational strength which possibly affect word processing. Moreover, in order to boost the series effect, which emerges less systematically than the family effect, we decided to use a different experimental task in association with the masked priming technique. Thus, instead of using a traditional lexical decision task, which focuses on formal aspects, as it entails word (*vs.* non-word) recognition and discrimination (without a necessary access to the word meaning), we employed a semantic categorization task. With this task, participants' attention is focused on the semantic features and on high-level word properties, rather than on formal characteristics (Sect. 3).

Results from Exp. 1 show that, using such an experimental task, a priming suffix effect which approaches significance is yielded for consistent series (e.g., *inquinamento*–*ragionamento*), but no significant effect is observed for less consistent ones (e.g., *granello*–*fornello*). This result, although statistically weak, indicates that words belonging to series which display different quantitative characteristics and varying degrees of morphotactic and morpho-semantic transparency are not processed in the same way. Ultimately, this also means that morphological series do indeed play a role during the processing of morphologically complex words as, if series were not involved, we should not observe any difference between consistent and inconsistent primes. Thus, our results points towards a possible impact of series during processing, depending on their consistency and representational strength. It has to be acknowledged, however, that although the use of a different task associated with the masked priming paradigm has allowed us to observe a 'relative' series effect (for consistent series but not for inconsistent ones), its emergence is still weak in absolute terms. This elusiveness can of course be attributed either to the role of the series during word processing or to the capacity of the experimental technique to capture it. In any case, it is undeniable that series effects are less systematic and consistent than family effects. More interestingly, our data indicate that series effect can be interpreted only in its deep and complex interaction with morphological families. In this respect, we remind that, in our experimental design the same target word (e.g., *ragionamento*) was primed by both a word with the same base (e.g., *ragionare*) and

a word with the same suffix (e.g., *inquinamento*), providing us with a direct comparison of two morphologically related primes on the same target. This has allowed us to observe that even the emergence of family effects, although more easily captured experimentally, is modulated by the series' consistency. As a matter of fact, in Exp. 1 the base effect is significant relative to the unrelated condition for both consistent and less consistent series, but only in the consistent set it is significant compared with all the other three priming conditions. This indicates that, in line with what suggested in Girauo and Dal Maso (2016) and previously found by Bradley (1979), Vannest and Boland (1999), Ford et al. (2010), the base stands out more clearly in consistent morphological series, which have stronger representations, than in non-consistent series.

More generally, as far as the interplay between family and series effect is concerned, it has to be highlighted that morphological family effects emerge systematically in a large number of languages, notwithstanding for the experimental task, whereas morphological series effects are clearly more elusive, controversial, and, as we demonstrated, sensitive to the nature of the task used. This leads us to believe that the mechanisms underlying the processing of stems and suffixes are substantially different and that the priming mechanisms within morphological families and morphological series are driven by different principles. Words belonging to the same morphological series share only general categorial properties, but limited semantic information, especially within non-consistent series (Booij 2010; Hathout 2009). This might be one of the reasons underlying the different priming patterns observed for morphological families and series. However, semantic and functional information might not tell the whole story about family and series relationships. An interesting suggestion to interpret our data comes from researches which make use of Temporal Self-Organizing Maps (THSOMs), a semantic-blind model of artificial neural network whose simulations can shed light on the dynamics between word activation (in short-term memory) and storage or learning (in long-term memory) and on the morphological organization of stored word forms (i.e., topology). Specifically, Ferro et al. (2010) run a THSOM simulation using 66 Italian present indicative forms. Although the study focused on inflected forms, results provide us with interesting insights about word alignment, a central issue to clarify the interplay between morphological family and series effects. They observe the activation patterns induced by two kinds of input strings: on the one hand inflected forms with the same stem (such as *crediamo* 'we believe' and *credo* 'I believe') and, on the other, forms belonging to the same inflectional paradigm (such as *crediamo* 'we believe' and *vediamo* 'we see'). In the case of inflected forms of the same verb (*credo* and *crediamo*), shared morphological structures are directly mirrored by shared chains of activation on the map (which are defined as Best Matching Unit, BMU). By contrast, BMU chains which are fired by the same suffixes (be they inflectional or derivational morphemes) are not identical, as they unfold independently, running in parallel through the same map areas: "Paradigmatically homologous forms such as *vediamo* 'we see', and *crediamo* 'we believe' are represented as activation chains on the map. The BMU chains are fairly clearly separated on the roots *cred-* and *ved-* but tend to converge as soon as more letters are shared by the two input forms. Eventually the substring *-iamo* leaves two BMU chains that run in parallel through the map at a very

short topological distance. We take this to mean that the two substrings are recognized by the map as two instances of the same type of inflectional ending. Note that the substring *-iamo* takes different positions in the two forms, starting from the fourth letter in *vediamo* and from the fifth letter in *crediamo*. [...] As the chains unfold, pre-node distance progressively narrows down. In morphological terms, topological convergence expressed shared morphological structure” (Ferro et al. 2010:231). In other terms, when the base is shared by a series of words (i.e., in families), not only the formal overlap is generally larger, but it is also perfectly aligned. The trace for the morphological schema (stem___) is expected to be, therefore, more easily entrenched. For words which share the same morphological ending, on the contrary, the overlap is reduced and, more importantly, not aligned. The chain activated by the suffix (___suffix) run in fact in parallel at a short topological distance, but crucially does not overlap. Moreover, the authors underline the fact that parallel chains (i.e., morphological series) are considerably more general morphological structures than shared chains (i.e., morphological family), as they extend over a significantly larger number of forms. If we agree with the authors, according to whom bundles of parallel chains represent the closest possible correlate to the notion of morphological formative (i.e., affix) in a THSOM, we might take this to represent the fact that morphological schemas are less easily entrenched than morphological families.

Although artificial neural network simulations are useful tools for investigating the family vs. series interpretation, they clearly cannot give any insight about the role of consistency, which crucially involves also semantic aspects. Particularly, the issue of the different nature of the facilitation induced by pseudo-suffixed (*cemento*) and truly suffixed primes (*inquinamento*) on a target word with the same word-ending (*ragionamento*) and the issue of the weight of different degrees of series consistency (___mento vs. ___ello) go beyond purely quantitative data and can hardly be simulated in a map. Unfortunately, these issues remain open in Exp. 1, since the suffix and pseudo-suffix conditions do not significantly differ and the only difference observed concerns consistent series (where pseudo-suffixed primes do not significantly reduce recognition latencies with respect to unrelated conditions, while suffixed words in consistent series do). In order to verify the morphological nature of the effect recorded in Exp. 1 and to exclude that orthography was responsible for that result, we conducted a second experiment in which, crucially, both the prime and the target words were pseudo-suffixed or semantically opaque. This allowed us to further investigate the relationship between morphologically complex words and monomorphemic words with the same endings. Again, we compared strongly consistent, less consistent and inconsistent series (e.g., *argomento* ‘argument’–*segmento* ‘segment’; *destino* ‘fate’–*giardino* ‘garden’; *pericolo* ‘danger’–*diavolo* ‘devil’ respectively) and observed whether the degree of consistency correlates significantly with RTs. Results for Exp. 2 reveal that such an interaction does in fact emerge since a purely formal effect has no effect in strongly consistent series (i.e., *argomento* does not prime *segmento*), while it plays a role for non-consistent series (i.e., *diavolo* primes *pericolo*). We interpret this outcome as a hint of the fact that consistent series, because of their stronger and more entrenched representations, block the interference of a purely formal factor and prevent it from having an effect. By contrast, with non-consistent series, the interference of the formal aspects is definitely stronger and is inversely

proportional to the representation strength and degree of entrenchment. The fact that the series effect varies depending to their degree of consistency demonstrates that morphological effects are substantially non-discrete and inherently graded. This result supports, in our view, approaches which assume morphological complexity not as a binary category, but rather describes it as a continuum defined by the clustering of different kinds of properties (Hay and Baayen 2005). Moreover, the different patterns of facilitation observed for consistent and non-consistent series show that processing does not rely only on the activation of 'superficial' components extracted through a parsing mechanism (as claimed by morpho-orthographic hypothesis), but rather implies the activation of morphological paradigms which differ significantly for their representational strength.

Because our experiments employed a kind of task (semantic categorization) which is not traditionally associated to the masked priming technique, it is impossible to draw comparisons between our results and the ones previously obtained and discussed in the introduction. Results on Italian should be particularly reliable as in this language there is no orthographic difference between a morphological and a non-morphological word ending and consequently there is clearly a strong ambiguity between them. For this reason, the emergence of a difference between morphological and non-morphological endings in the priming patterns should be considered as particularly conclusive.

To conclude, the results of our experiments show that the series effect is elusive and emerges only under specific experimental conditions which 'boost' it or, at least, do not inhibit it by focusing on formal factors. Although in absolute terms, the effect is still weak, the fact that its emergence depends on the series' consistency ultimately reveals that series do play a role during processing. However, series effects can be understood only in their deep and complex interplay with family effects, as series consistency also determines the emergence of the base effect (as we obtained a more robust and clear-cut effect in consistent than in non-consistent series). Finally, series consistency significantly affects the interaction between morphological and formal factors, since it has been demonstrated that the more consistent a series is, the less formal elements interfere. All in all, our results indicate that the processing of morphologically complex words (and pseudo-complex words) is determined by paradigmatic competing effects (namely family vs series effects) and that series effects are more prone to interfere with formal/orthographic factors than morphological family ones.

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