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Reading units in Italian children: experimental evidence from morphological, orthographic and semantic word features

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Abstract

This dissertation investigated the morphological, orthographic and semantic word features involved in the reading process of Italian primary-school children and, at the same time, the processing units which young readers are able to rely on. Aim of this dissertation was to show how Italian children are able to rely on both large and small units during the reading process, and how the assumption of processing units as simple linguistic elements (graphemes, phonemes, semantic features) connected in networks is the most representative in the word recognition processes. In Chapter 1, an overview of the more or less recent theoretical issues presented in the literature has been proposed together with the complex scenario of results emerging from several studies on both adults and children. In the following chapters, psycholinguistic experiments assessed different types of reading units which Italian children rely on. In Chapter 2, a pseudoword reading task has been carried out by Italian children in order to provide evidence for a lexical reading based on whole-word representations, despite the transparency of the Italian orthography. In Chapter 3, we aimed at presenting morphological-oriented coding schemes of reading errors performed by Italian children in morphologically complex words reading. This analysis showed reliability on morphemic structure when children are reading morphologically complex words, and their ability to use morphemes as intermediate grain size reading units. Chapters 4 and 5 presented the Orthography-Semantics Consistency (OSC), a new measure first tested in English language that quantifies the consistency of the orthographic and semantic information carried in words and reveals more or less consistent orthographic-semantic associations within words. English children in Chapter 4 and Italian children in Chapter 5 have showed to be affected by OSC. When children are coming across sublexical consistent and inconsistent orthographic-semantic patterns, they are facilitated by consistent patterns that correspond to higher values of OSC. Although further researches are needed, effects of a distributional property of language such as OSC indicate that children are able to grasp orthographic-semantic associations as processing units after repeated exposure to written texts. Orthographic-semantic associations, not morpheme-mediated, play a crucial role in word reading process and highlight the limits of the consolidated 'morpheme-as-unit' assumption. Indeed, morphology seems to be connoted as an age-related emergent aspect of written word processing, exploited by children mostly in order to overcome their reading difficulties. Our experimental evidence supported a new connotation of morphology (Marelli, Traficante, Burani, *in press*): a more general learning mechanism, experience-acquired, that exploits orthographic-semantic consistencies of the language system.

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CHAPTER 1

General Introduction

In linguistics, morphology is a branch that investigates the internal framework of words and the connections between form's changes and meaning's changes of the words themselves (Thronton, 2005). Two or more morphemes, i.e., the smallest meaningful linguistic pieces with a grammatical function, make up morphologically complex words through compounding (*snow-man*), derivation (*art-ist*), and inflection (*tell-ing*) word formation processes.

The study of morphologically complex word processing has been centered on the notion of morphemes as processing units, and evidence from psycholinguistics and cognitive neuropsychology has suggested that morphemes are represented at the lexical level, on a par with words. Indeed, literature on the morphological processing in both adult and young readers has been guided by the hypothesis that morphemes and/or complex words are stored as representational units within the mental lexicon. An long-debated experimental question in literature has been whether morphemes are accessed or not in visual word recognition. On this issue, early debates provided two main views: *full-parsing* theories and *full-listing* theories. According to *full-parsing* theories, first theorized by Taft and Forster (1975), morphologically complex words are totally segmented during word recognition through automatic morphological parsing, and hence morphemes are represented and accessed in the mental lexicon. In this perspective, morphemes are clearly processing units and an early procedure is applied to segment the complex word into its morphological constituents, which are in turn used to compute the whole-word representation (parsing-and-recombination procedure) (Taft, 2004; Rastle, Davis, & New, 2004). On the other hand, according to the *full-listing* theories (Butterworth, 1983) an explicit representation for any morphologically complex form (derived, inflected, or compound) takes place in the mental lexicon. This perspective conceives separate lexical entries for each single inflected, derived or compound word-form. Thus, separate units for *drive*, *drives*, *driving*, *driver, driveway*, etc. are represented in the mental lexicon and, morphology would not emerge as a direct consequence of explicit morphemic access, rather it would depend on reliable and stable form-meaning relations between independent lexical units (*drive*, *drives*, *driver*). In this way, the processing of *driver* will not be characterized by morphological effects as the *–er* suffix is stripped from its stem (Taft, & Forster, 1975); rather, morphological effects will depend on the orthographical, phonological, and semantic overlap between *driver* and *drive*. It is worth noting that *full-listing* models do not completely exclude morpheme-based processes, rather relegating them to infrequent contexts (e.g., novel complex words). A third position has proposed an intermediate point of view between the two former proposals. In these *mixed* or *dual-route* models both morphological parsing and whole-word access are possible, whom efficiency is depending on many factors such as psycholinguistic features of words or kind of readers. Examples of this position are the Augmented Addressed Morphology (AAM) model (Burani and Caramazza, 1987; Caramazza, Laudanna, & Romani, 1988) and parallel dual-route models such as Race Model by Schreuder and Baayen (1995) and dual-route approach to orthographic processing by Grainger and Ziegler (2011).

Evidence for the role of morphemes in word processing has been mostly provided by primed lexical decision experiments. In this priming paradigm, a *prime* word is more or less briefly presented before the *target* item on which a response is requested to the participants. Primes and targets are morphologically complex words semantically related (i.e. transparent condition) and, when the association between a complex prime and its associated stem target is not also sustained by semantic similarity (i.e. opaque condition), morphological priming effects can or cannot emerge. An orthographic condition (e.g., *scandal-scan*) is usually added as control condition to assess whether morphological parsing, on the base of morphemic constituents such as base (e.g. *farm-*) or pseudobase, (e.g. *corn-*), and suffix (e.g. *–er*), is involved in complex word recognition. Priming effects are expected in transparent and/or opaque morphological conditions, whereas priming effects are not expected in orthographic conditions as any kind of morphological relation exists between prime and target.

Feldman (2000) demonstrated that morphological priming effects are significantly greater than the sum of effects observed in purely semantic (*pledge-vow*) and orthographic conditions (*vowel-vow*). This supports the hypothesis that morphological relatedness is distinct from the composite effects of semantic and orthographic similarity, further sustaining the idea of representational units for morphemes in the mental lexicon.

If morphological representations are stored in the mental lexicon, how and when are they accessed in word processing? In the psycholinguistic literature, two approaches are debated: *sublexical* and *supralexical* (or morpheme-based *vs*. lexeme-based, Aronoff 1994) approach. The sublexical approach (Taft, 2004; Rastle, et al., 2004) ideally follows from the traditional full-parsing models, positing that complex words are automatically parsed and the resulting morpheme representations lead to lexical access (either through recombination or via spreading activation). On the contrary, in supralexical approach (e.g., Giraudo and Grainger, 2000) morphological access occurs after word activation and depends on an abstract representation level at which lexemes are organized in morphological families. In the sublexical approach a word like *darkest* and a word like *corner* are both parsed in (pseudo)-morphemes; whereas in the supralexical approach a word like *darkest* is parsed but a word like *corner* is not parsed.

To investigate the early phases of morphological processing, *masked priming* with lexical decision paradigm has been designed, where the prime, subliminally processed by participants, is presented more or less briefly between a forward mask (######) and the target. In opposition to orthographic word pairs (e.g., *scandal-scan*), morphological parsing effects were observed for both (semantically and morphologically) transparent word pairs (e.g., *killer-kill*) and opaque word pairs whose morphological complexity is only apparent (e.g., *corner-corn*) and there is no morphological or semantic relation between prime and target (see studies in French: Longtin, Segui, and Halle, 2003; in English: Rastle et al., 2004; in Russian: Kazanina, Dukova-Zheleva, Geber, Kharlamov, and Tonciulescu, 2008; in Italian: Marelli, Amenta, Morone, and Crepaldi, 2013). These results provide evidence for a kind of semantically blind and form-based parsing: complex words are parsed into morphological constituents irrespective of consideration about their possible meanings and, the involved procedure is not influenced by the lexicality of the complex form (Taft 1994, 2003). In this case, both *darkest* and *corner* are parsable in (pseudo)-morphological constituents (*dark-est*; *cor-ner*). However, semantics has been re-introduced in morphological parsing by other models. On the one hand, *form-then-meaning* accounts (Crepaldi et al., 2010; Rastle et al., 2004) consider an early morpho-orthographic parsing with semantics playing a role only at later stages. On the other hand, *form-with-meaning* accounts (Feldman, O'Connor, and Moscoso del Prado Martin, 2009) proposed a kind of morpho-semantic parsing, highlighting an early involvement of word and morpheme meanings (lexical and semantic level), with semantics influencing the ease of morpheme processing. In this case, *darkest* is parsed in morphological constituents, whereas *corner* is not parsed.

Evidence for the crucial role of morphemes in word recognition has been provided by effects of morphological structure in word processing, even with non-lexical orthographic strings (see Taft and Forster, 1975 for English; Burani, Dovetto, Thornton, and Laudanna, 1997; Burani, Marcolini, and Stella, 2002 for Italian). More recently, Crepaldi, Rastle, and Davis (2010) have shown that a string having an acceptable morphological structure is more word-like than a string lacking this property, that is, *shootment* is slower to be rejected as a non-word than *shootmant* because a suffix is expected to be found at the end of a word; whereas no difference is observed between *mentshoot* and *mantshoot*. These results provide strong support to the hypothesis that morphemes play a role in written word processing.

Recently, Marelli and Baroni (2015), investigating the role of semantics in morphological processing, moved the research focus from the "morpho-orthographic decomposition vs. morpho-semantic decomposition" debate to understanding which type of semantics influences morphological effects at different processing levels. In their model, a morphological priming effect might be shown also for opaque words at early processing stages not because semantics is not important, as thought in morpho-orthographic parsing accounts, but because an erroneous meaning is automatically computed. Masked priming tasks would limit information uptake so that no lexical knowledge about the whole-word meaning could be accessed. Consequently, morphemes would be automatically combined in a productive way, generating an erroneous whole-word meaning that will be semantically related to its stem even for opaque words (e.g., corner as someone who corns, irony as made of iron, etc).

In addition, neuropsychological studies support the hypothesis that morphemes are represented in the mental lexicon. Morphological errors performed by neuropsychological patients in reading morphologically complex words show that morphemes play an important role in word processing (Badecker, 1997; Badecker, & Caramazza, 1987; De Bleser, & Bayer, 1990; Castles, Coltheart, Savage, Bates, & Reid, 1996; Funnell, 1987; Joanisse, & Seidenberg, 1999; Job, & Sartori, 1984; Luzzatti, Mondini, & Semenza, 2001; Patterson, 1980; Plaut, & Shallice, 1993; Rastle, Tyler, & Marslen-Wilson, 2006).

However, some studies concerning the role of morphology in word processing have attempted to move outside the idea of morphemes as reading units providing results that are more complex to interpret (Marelli, Amenta, Morone, & Crepaldi, 2013; Tsang and Chen, 2014; Amenta, Marelli, & Crepaldi, 2015). Morphemic access is not purely form-based, morpho-orthographic, and reflects complex semantic operations. Marelli et al. (2013) found that, when participants are asked for semantic questions in a lexical decision task, priming effect will emerge in the transparent condition only (i.e., significant facilitation for driver-drive but not for either corner-corn or scandal-scan). The semantic contribution emerges early during processing, and these task-dependent effects are problematic for accounts based on obligatory morphological decomposition. Amenta, et al., (2015) showed that, in Italian natural language-processing situations, the same opaque word (e.g., *fruitless*) is characterized by inhibitory stem-frequency effects on reading times when presented in sentences prompting their opaque meaning (*fruitless* as without results), as opposed to facilitatory stem-frequency effects when embedded in sentences prompting the potential transparent meaning (*fruitless* as without fruits). In this perspective, morphologically complex words are parsed irrespective of their transparency and morpheme meanings are accessed even if their semantic contribution is not helpful for computing the complex word meaning, as in opaque words. The segmentation process may be semantically blind, but the morpheme activation is semantically connoted.

The distributional properties of both complex words and their morphemic constituents (e.g., morphological entropy and orthography-semantics consistency) play crucial role in word reading processes, in both adult and young readers. Literature on morphological entropy effects in word reading have disproved the morphological decomposition theory, rather redefining morphology in an information-theoretical framework (Milin, Kuperman, Kostic, and Baayen, 2008). The basic assumption of this approach is that words are organized in paradigms and morphology is reflected in this paradigmatic organization. Entropy provides a convenient way to measure the information carried by a given paradigm, quantifying the amount of predictability of the word system. The less predictable is a paradigm, the more is the carried information, and the larger is the associated entropy. Baayen, Wurm, & Aycock, 2007 showed that both inflectional entropy (i.e., entropy computed on the set of possible inflected forms with a given stem) and derivational entropy (i.e., entropy computed on the set of possible derived forms with a given stem) have facilitatory effects in lexical decision latencies: the more informative is the associated paradigm, the faster are the responses to the target word. On the contrary, in Milin, Filipovic-Durdevic, and Moscoso Del Prado Martin's (2009) study, response times resulted to be negatively associated with relative entropy: the larger the relative entropy (i.e., the more deviant the paradigm of a given noun), the longer are the response times. Moreover, Baayen, Milin, Filipovic-Durdevic, Hendrix, and Marelli's (2011) study further showed that relative entropy modulates priming effects in masked conditions. Taken altogether, results on the effects of morphological entropy speak more in favor of paradigms than morphemic units salient in word reading, and let form-meaning patterns play a role in language processing. Once these orthographic-semantic relations, which are non-morphological relations, are taken into account as affecting word reading processes, it is more difficult to consider morphemes as fundamental and well-defined reading units.

In Marelli, Amenta, and Crepaldi's (2015) study, lexical recognition is influenced by the orthography-semantics consistency (OSC) of the considered word target. This research moved from a permanent effect found in priming studies performed by English-speaking adult readers: stems from transparent sets elicit faster responses than stems from opaque sets, irrespective of the prime preceding them, and even if the item sets are carefully matched for a number of variables. This effect may be explained in terms of OSC: stems from transparent sets (e.g., *widow*) are orthographic strings that only appears in words that are related to the correspondent meaning (e.g., *widower, widowed, widowhood*), whereas stems from opaque sets (e.g., *whisk*) are orthographic strings appearing also in words unrelated to the correspondent meaning (e.g., *whisker, whiskey, whisky*). Therefore, it can be supposed that response times in morphological priming tasks are not modulated by the morpho-semantic transparency of the experimental condition, rather by OSC values: the higher the OSC value, the faster the response time. Words as *widow* are, throughout the whole lexicon, reliable orthographic cues for their own meanings, whereas words as *whisk* provide unreliable information in these regards. In other words, words as *widow* are better linguistic *symbols* than words as *whisk*. OSC, computed as the frequency-weighted average semantic-similarity between a word and its orthographic relatives, provides an efficient estimate of this reliability-as-symbol, and represents a new example as to how distributionally based form-meaning associations, over and above morphological considerations, are central to word reading. In chapters 4 and 5 of this thesis, we are going to provide evidence for OSC affecting also English and Italian children word recognition processes. In conclusion, distributional properties of language as well seem to highlight the limits of the morpheme-as-processing unit assumption.

The attitude of children to use morphemes as reading units in processing complex words has been largely observed in languages with different orthographies varying by orthographic depth and morphological richness (e.g., Verhoeven & Perfetti, 2011). Data from different languages suggest that children learn to detect and to use frequent and stable chunks of letters corresponding to morphemes and shared by several words. In this way, they improve fluency and accuracy in decoding new and unfamiliar words. Children often find new complex words as far as they go on through school grades and the opportunity of recognizing known morphemes embedded in strings of letters can help them to read aloud and understand the meaning of the derived or compound words they come across. However, the advantage taken from morphological structure varies according to the features of their language. Transparent orthographies like Italian and French present a quite consistent grapheme-to-phoneme correspondence that allows children to reach a good level of accuracy also by using small grain-size units in decoding new words (see the grain-size theory by Ziegler & Goswami, 2005). The opportunity of detecting morphemic units (both stems and affixes), that are larger than single graphemes, can allow them avoiding the time-consuming grapheme-to-phoneme procedure, gaining overall in fluency. On the contrary, in languages with opaque orthography like English, children are cannot trust on small grain-size units, so they have to memorize the association between orthographic and phonological representations of the whole words as soon as possible to reach a good level of accuracy and fluency. In order to process a long complex word, learning to detect affixes and stripping them away to isolate the base word (very often base words are stems in English) might be a good strategy. In this way, the probability of a correct pronunciation, if the stem/base word is a known word, increases in comparison to the strategy of reading through smaller units. In Byrne's (1996) study, pre-literate English children tend to grasp the grapheme-to-morpheme transcription (e.g., the plural /s/ in 'cats') more easily than the grapheme-to-phoneme correspondence (e.g., the phonemic /s/ in 'bus'), showing their ability to map the English orthography into morphemes learnt in language acquisition. Thus, the relation between orthographic patterns and morphemic units seems to be grasped by children before formal teaching has been provided to them.

The role of morphological structure in reading acquisition has been proved by Mann and Singson (2003), who found that morphological awareness increases its role from third grade English children, when the number of new complex words in the school texts increases. In particular, children decoded derived words with low frequency base less correctly than derived words with high frequency base, suggesting that children refer to word bases, at least by the third grade. Evidence of the role of morphological structure in reading aloud comes also from Carlisle and Stone's (2005) study, where 2nd 3rd 5th 6th grade English readers are more accurate in reading derived words with transparent structure than simple words.

Therefore, 1st and 2nd grade children aim at learning to apply grapheme-to-phoneme conversion rules and at recognizing known words. Then, at 3rd grade they develop the ability in detecting orthographic patterns (stems, affixes) that can be found in several word contexts, in order to increase accuracy (in opaque-orthography languages) and/or fluency (in transparent-orthography languages) when long, complex words or new words are read. Morphemic units, larger than single graphemes but smaller than still not available whole-word representations, are very helpful for children's word reading and text comprehension. When achieving a full mastery in reading, orthographic-lexicon richness allows children to use whole-word representations for word decoding: so the role of morphemic units in word reading decreases, even though morphological structure keeps its relevance to understand the meaning of new words (morphological awareness) and to guide text comprehension (Deacon, Kieffer, and Laroche, 2014); Jarmulowics, Hay, Taran, & Ethington, 2008).

In Italian, young readers are used to find long complex words whose stem can be combined with many different both inflectional and derivational affixes. The presence of a stem, as useful chunk, may improve both fluency and accuracy in word reading. The higher is the number and the frequency of words that share the same stem (i.e. inflectional family size), the higher is the probability for that stem to become a useful chunk for decoding (Traficante & Burani, 2003). Verbal bases can be considered stronger chunks than nominal bases as leading to more accurate responses, thanks to the larger inflectional paradigm (Traficante, Marelli, Luzzatti, & Burani, 2014). Significant effects of the stem frequency in word reading has been found only for low-frequency words (Marcolini, Traficante, Zoccolotti, & Burani, 2011), which were read faster and more accurately than simple words matched by frequency. However, Italian children gain advantage in both latency and accuracy from the presence of a stem in reading aloud pseudowords (e.g., bagnezza*), but the presence of a suffix with an unreal stem (e.g., bognezza*) has only effect on accuracy (Traficante, Marcolini, Luci, Zoccolotti, & Burani, 2011). Both skilled readers and children with dyslexia benefit from morphological structure in reading aloud words and pseudowords consisting of stem + suffix morphemic constituents (Burani, Marcolini, De Luca, Zoccolotti, 2008).

It is worth investigating the semantic dimension of morpho-orthographic units not only in adult readers (Rastle and Davis, 2008), but also from a developmental point of view. Masked priming paradigm in a lexical decision task has been adopted in adults to assess whether the detection of morphemic units is driven by semantic information (Logtin et al., 2003; Rastle et al., 2000; 2004; 2008). More recently, this paradigm has been used also with children and a complex pattern of results emerged (Beyersmann, Castles, & Coltheart, 2012; Queémart & Casalis, 2014; Quémart, Casalis, & Colé, 2011; Shiff, Raveh, & Fighel, 2012). Indeed, children's age and language features seem to influence the size of priming effects.

Beyersmann et al. (2012) presented English-speaking 3rd and 5th graders with morphologically (e.g., golden-GOLD) and pseudomorphologically (e.g., mother-MOTH) related pairs and a control condition. With 50 ms prime exposure, a priming effect was found only for the truly suffixed condition. These data has been interpreted as evidence that the children's ability in using the morphological structure of complex words is based on the detection of the meaning shared by different words with the same morphological base. Moreover, the authors tried to explain the inhibitory pattern of pseudosuffixed (i.e., the usual opaque condition) priming effects obtained in developing readers: these effects may arise due to the lexical differences between primes and targets. While in the truly suffixed condition, primes (e.g., *farmer*) and targets (e.g., *farm*) share the same lexical stem and therefore have overlapping lexical entries, the pseudo prime–target pairs (e.g., *corner–corn*) do not share the same lexical stem and may therefore be more prone to producing a type of lexical interference leading to inhibition of any priming effects.

A different pattern of results came from the French language where Quémart et al. (2011) presented French 3rd, 5th and 7th graders with the masked prime paradigm using 3 different stimulus-onset asynchrony (SOAs) for primes (60 ms, 250 ms, 800 ms). The true morphological relationship (e.g., tablette-TABLE) was associated to reliable priming at any SOA, while the pseudoderived condition (e.g., baguette-BAGUE) produced a priming similar to the morphological one at 60 ms, but lower than that condition at 250 ms-prime exposure. With the longest SOA (800 ms) the pseudoderivation priming effect disappeared, and this result suggests that with long prime duration morphemic parsing is based only on the activation of semantic properties of morphemes.

In order to interpret this inconsistent pattern of results with children, it has been proposed that the richness of French morphology might lead young readers to be more competent in detecting morpho-orthographic units than their Australian English-speaking peers. A developmental trend has been hypothesized, according to which in early literacy levels form-meaning relationship would be the only dimension that drives the morphemic parsing, while in mastery reading levels the morpho-orthographic dimension would be prevalent. In other words, morpho-orthographic decomposition would occur later in reading acquisition (Beyersmann et al., 2012).

To assess the relationship between reading proficiency and morpho-orthographic decomposition ability, Beyersmann, Grainger, Casalis, and Ziegler (2015) presented a large sample of French primary school children from 2nd to 5th grade with a masked priming lexical decision task, and took into account not only the performance to the task, but also the literacy skills of the children. It was expected that the higher is the proficiency, the stronger is the morpho-orthographic priming, as the difference between English speaking children and adults seems to suggest. There were a suffixed nonword prime condition (e.g., *tristerie - TRISTE), a non-suffixed nonword condition (e.g., *tristald-TRISTE), and an unrelated prime control condition (e.g., direction-TRISTE). Results showed a reliable priming effect for suffixed words, larger than the priming effects of other suffixed and non-suffixed nonword conditions, confirming that the segmentation of the string of letters in stem + suffix units is driven by semantic interpretability of the combination. As for nonwords, the two conditions (suffixed and non-suffixed) produced priming of a similar size, suggesting that French children (irrespective to the grade) are able to detect and use the stem unit. The ability of gaining advantage from the stem embedded in nonword primes is positively correlated with the literacy skill: the higher is the skill, the larger is the priming size. In other words, skilled readers are more likely to detect a known stem in a string of letters than low-proficiency readers are.

To summarize, data from masked priming paradigm show that in primary school, both French and English children, are able to gain advantage from a truly morphologically related prime even at very short SOA (about 60 ms). This result suggests that in children the meaning of the morphemic units is subliminally activated. Therefore, semantics is likely to be the early dimension on which the ability of using morphological structure develops, and this claim is consistent with data from studies that analyze the relation between morphological awareness and text comprehension.

The sensitivity to morpho-orthographic dimension seems to be related to reading skills. Beyersmann et al.'s (2015) study shows that high-proficiency young readers tend to detect stems embedded in nonwords. This result is consistent with data from adults (Rastle and Davis, 2008). It supports the hypothesis of a developmental trajectory of the ability in detecting morphemic units in letter strings. This ability might stem on the semantic dimension of morphemes and leads to morpho-orthographic representations that skilled readers can use in gaining speed and accuracy when reading known as well as new words. Finally, the comparison between French and English children suggests that morphology richness and regularity of grapheme-to-phoneme correspondence in languages can play a role in using morphemic units and, consequently, in giving rise to different morphological effects in children's word reading.

We have first presented the most popular idea that morphemes are represented in the mental lexicon and these representational units are activated when processing morphologically complex words. Anyhow, results from former morphological (masked) priming studies in adults' word recognition showed diverging results, and more recent studies seem to draw a more complex scenario of results in which form-meaning associations that are not morpheme-mediated have a role to play in word recognition as well (Marelli et al., 2013; Marelli et al., 2015, Tsang and Chen, 2014). Still, the crucial role played in reading by the distributional properties of both complex words and their morphemic constituents (orthography-semantics consistency and morphological entropy) highlights the limits of the 'morpheme-as-unit' assumption.

Moreover, studies assessing morphological parsing in children show an inconsistent pattern of results. Developmental data converge on characterizing morphology as an age-related emergent aspect of written word processing: morphological complexity seems to help word processing in early readers, and morphological awareness becomes progressively more important in language development (Deacon et al., 2014; Jarmulowicz et al., 2008). Morphemes can be seen as distributional cues efficiently exploited by children in order to improve reading and overcome reading difficulties (Carlisle & Stone, 2005; Mann & Singson, 2003; Traficante et al., 2011).

Taking altogether all these evidences in children, as well as in adults, it is worth asking whether morphological effects really need dedicated morphological representations to be explained. Indeed, over and above morphemic constituents that children seem to rely on as reading units, there may be statistically strong form-meaning patterns. A unitary account for the complex scenario of results that came out in children, as well as in adults, may be offered by those learning models that focus on form-to-meaning mapping. This notion can already be found in the full-listing proposals (e.g., Butterworth, 1983), since they typically see morphology as a by-product of form and meaning similarity between independent representations. There is also a theoretical assumption arising from connectionist models (e.g. Seidenberg & McClelland, 1989), where a *triangle* approach to visual word recognition has been proposed, with a direct route from orthography to semantics and an indirect route via phonology. In these models, there are no explicit representations for morphemes and/or for words; rather, connectionist architectures are populated by more simple elements (graphemes, phonemes, semantic features) organized in nodes. Morphology, as well as lexicality, naturally unfolds by means of consistent patterns of activation within the links connecting the different nodes (Rueckl and Raveh, 1999; Plaut and Gonnerman, 2000). In other words, in these models the morphological status of *–er* is not captured through an explicit representation unit for the suffix, it rather emerges as strong connection links between the graphemic units (*e* and *r* at word endings) and the corresponding semantics (abstract nodes indicating instrumental or agentive traits).
Connectionist models define morphology as a specific expression of a more general cognitive ability to capture form-meaning patterns, and they work well in reproducing priming patterns (e.g., Plaut and Gonnerman, 2000), the acquisition of morphological chunks in learning (e.g., Moscoso del Prado Martin, Schreuder, and Baayen, 2004) and morphological errors in neuropsychological patients (e.g., Plaut and Shallice, 1993; Joanisse and Seidenberg, 1999).
The recent Naïve Discriminative Reader (Baayen, Milin, Filipovic Đurđević, Hendrix, & Marelli, 2011), a computational model based on examples of natural language use and trained on the British National Corpus (http://www.natcorp.ox.ac.uk/), has been proposed to account for morphological effects in word processing. NDR architecture is similar to what has been proposed in the connectionist network: an input layer (populated by orthographic unigrams and bigrams) is directly connected to a semantic layer (populated by symbolic word meanings) and connections between layers are learnt by means of the Rescorla-Wagner equations (Rescorla and Wagner, 1972). NDR provides a unique account for a wide range of morphological effects, such as family size (Schreuder, & Baayen, 1997), inflectional entropy (Milin et al., 2009), priming effects (Rastle et al., 2004), suggesting that morphology may simply reflect a cognitive sensitivity to systematic relations between forms and meanings. Offering a new perspective of the discrimination notion, the NDR model proposes that *learning* is equivalent to *learning to distinguish*. Children learn to distinguish between different form-meaning patterns that frequently co-occur in written texts. Morphemes are discriminative cues, namely, chunks of graphemic symbols that help to distinguish between different meanings. In conclusion, the NDR provides a morphological model that does not rely on explicit morpheme representations, rather focusing on form-meaning patterns that emerge in word distributions, is also

centered on psychologically plausible learning mechanisms, and constitutes a framework for understanding morphological effects in children's and adults' reading.

It is worth considering the parallel dual-route model proposed by Grainger, & Ziegler (2011) that makes predictions about the acquisition of morphological knowledge in visual word recognition. In this model, where two parallel orthographic routes have been postulated, the role of morphology in reading acquisition takes place and interesting cues to make up rehabilitative intervention are offered. In the faster route, the system uptakes the information about the presence of letter combinations, without precise positional information (*coarse-grained orthography*) to reach target identification as soon as possible. In the slower but more precise route, letters that co-occur very often in the language (e.g., affixes) can be grouped (chunking) to form higher-level orthographic representations (*fine-grained orthography*), coding precise information about the ordering of letters in the string. This kind of orthographic route leads to an improvement of the reading process, thanks to the reduction of units to be activated. When morphologically complex words are processed, they are parsed in root and affixes. Both the routes send activation to a whole-word level, in which only the representation corresponding to the visual input enables the associated meaning to be activated. In this model, morphological awareness is represented in the whole-word representations and emerges from the overlapping of several words in form and meaning. When processing complex words through the fine-grained orthography route, morpho-orthographic segmentation of the string leads to the activation of the stem and the affixes. These representations send activation to the whole-word level and, thanks to the special connectivity among words sharing form and meaning, the activation of the complex target is enabled. This model can be useful for understanding how children learn to read. The main task of beginning readers is to associate letter identities with sounds that resemble whole-word phonological representations of known words. Each successful decoding can provide beginning readers the opportunity to create connections between the word form and the meaning. Through the repeated exposure to printed words and the serial procedure of the phonological recoding, a parallel letter processing develops. Children begin to codify letter strings through location-specific letter detectors, which gradually leads to the coarse-grained and fine-grained routes. An improvement of reading acquisition can be obtained through developing the fine-grained processing route, i.e. the route providing access to semantics via phonological and morphological representations. In this way, children are helped in detecting frequently co-occurring letter combinations, favoring chunking. In learning to read, a child can learn that a contiguous sequence of letters corresponds to pre-existing phonological and/or morphological representations, acquired in spoken language.

The model supposes that, in the early phases of reading acquisition, visual inputs are processed letter by letter. Then, the repeated exposure to written words leads young readers to build up stable connections between form and meaning of words, and to extract information about letters position in the string.

Evidence from literature data and models suggest a new view of morphology that appears as a more general learning mechanism that exploits orthographic-semantic consistencies in the language system, and not surprisingly as morphology is "a linguistic branch investigating connections between form changes and meaning changes of words" (Thronton, 2005). It is worth thinking about morphemes as expression of more general form-meaning associations, rather than isolated representational units in the mental lexicon. In reading acquisition, children build up statistically-strong form-meaning connections after being enough exposed to written texts, namely, orthographic-semantic networks which are likely to be helpful in grasping reliable reading units for young readers. This form-meaning mapping might be responsible of the morphological parsing process: when consistent and inconsistent form-meaning patterns often occur, it is easier to chunk morphologically complex words.

In the following chapters, I am going to present examples of reading units that Italian (and English in Chapter 4) children have showed to rely on. In Chapter 2, Italian children showed lexical reading based on whole-word representations, despite the transparency of the Italian orthography. In Chapter 3, Italian children showed to rely on word morphological structure when they were reading morphologically complex words. In Chapters 4 and 5, English and Italian children showed to be affected by Orthography-Semantics Consistency (OSC), a new measure revealing more or less consistent orthographic-semantic associations within words. When children are coming across sublexical consistent and inconsistent orthographic-semantic patterns, they may be facilitated by the consistent ones (higher OSC values). Although further researches are needed, distributional effects, such as OSC effects, indicate that children are grasping form-meaning associations as processing units after repeated exposure to written texts.

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CHAPTER 2

Lexical activation in Italian children: evidence from a pseudoword reading task

INTRODUCTION

The alphabetic writing systems have been classified along an opacity–transparency continuum depending on their consistency level, namely, the complexity of their letter-to-sound correspondences (Frost, Katz, & Bentin, 1987). In languages with transparent orthographies the grapheme–phoneme correspondences are mostly one-to-one, whereas in languages with opaque orthographies one letter may represent different phonemes in different contexts and, conversely, different letters may represent the same phoneme. There is general consensus that the closest European orthographies to the opaque extreme are English, French, Danish, and Portuguese. In contrast, Italian as well as Finnish, Greek, Spanish, and German orthographies are the closest to the transparent extreme (e.g., Seymour, Aro, & Erskine, 2003).

The Orthographic Depth Hypothesis (Katz & Frost, 1992) stated that the process of word recognition, as indexed by performance on tasks such as lexical decision or word and pseudoword naming, differs in languages with opaque orthographies as English and in languages with transparent orthographies as Italian. According to this view, word reading in opaque orthographies necessarily involves lexical processing whereas word reading in transparent orthographies is more easily supported by sublexical processing. However, several studies have reported lexical effects on adults' word and pseudoword reading aloud in transparent orthographies such as Italian (Arduino & Burani, 2004; Barca, Burani, & Arduino, 2002; Colombo, Pasini, & Balota, 2006; Job, Peressotti, & Cusinato, 1998), Dutch (Brysbaert, Lange, & van Wijnendaele, 2000) or Turkish (Raman & Baluch, 2001; Raman, Baluch, & Sneddon, 1996).

Variations in orthographic depth may also affect the process of reading acquisition. According to some views, the strongly irregular print-to-sound mapping of opaque orthographies necessarily leads to an involvement of lexical knowledge when children are learning to read. In contrast, in transparent orthographies reading acquisition would mostly rely on grapheme-to-phoneme decoding routines thanks to the highly consistent print-to-sound mappings. Consequently, in transparent orthographies the development of reading would be based on sublexical processing by exploiting small grain-size units and lexical effects should be quite limited when children read aloud known and, especially, unknown stimuli (Goswami, Ziegler, Dalton, & Schneider, 2001; Ziegler & Goswami, 2005). However, in spite of orthographic consistency, lexical effects have been frequently reported on children's reading aloud in languages with transparent orthographies (e.g., for Spanish: Davies, Cuetos, & Glez-Seijas, 2007; for Greek: Protopapas & Gerakaki, 2009; for Dutch: Marinus & de Jong, 2010; Marinus, Nation, & de Jong, 2015).

The contribution of lexical procedures to reading acquisition has been largely demonstrated in Italian, indicating that Italian children benefit from lexical activation in learning to read. Both typically developing readers at different literacy levels (from 3rd to 6th grades) and children with dyslexia have been reported to show the lexicality effect (i.e., words read better than pseudowords: Paizi, De Luca, Zoccolotti, & Burani, 2013) and the word frequency effect (i.e., high-frequency words read better than low-frequency ones: e.g., Barca, Burani, Di Filippo, & Zoccolotti, 2006; Barca, Ellis, & Burani, 2007; Burani, Marcolini, & Stella, 2002; Paizi et al., 2013). Children with dyslexia showed also effects of neighborhood-size (N-size) in reading low-frequency words, as they read faster words with several orthographic neighbors, i.e., words with only one letter diverging from the target, than words with no neighbors (Marinelli, Traficante, Zoccolotti, & Burani, 2013). All these findings supported the view that lexical information is exploited in reading development in a language with transparent orthography (for a review, see Burani, Thornton, & Zoccolotti, in press).

Additional evidence for the involvement of lexical activation in learning to read comes from children reading aloud non-lexical material. Developing readers of an opaque orthography such as English read pseudohomophones faster and more accurately than other pseudowords (e.g., Laxon, Masterson, Gallagher, & Pay, 2002) and read better pseudowords for which real word analogues existed than pseudowords with no word analogues (e.g., Wimmer & Goswami, 1994). To our knowledge, only two studies (Marcolini, Burani, & Colombo, 2009; Peressotti, Mulatti, & Job, 2010) documented an influence of the lexicon on pseudoword reading in typically developing Italian children at different (2nd through 5th) grades of instruction. The existence of a lexical influence on pseudoword reading, if confirmed, may provide strong evidence for the interaction of lexical and sublexical procedures in a transparent orthography as Italian, in which newly encountered stimuli could in principle be read correctly on the basis of grapheme-to-phoneme conversion only.

Marcolini and coworkers (2009) reported that Italian typically developing 3rd, 4th and 5th graders read pseudowords derived from a high-frequency word more slowly and less accurately than pseudowords derived from low-frequency words. This inhibitory effect on pseudoword reading was interpreted as caused by the interference of the high-frequency base-word on pseudoword sublexical processing. Within the framework of the Dual-Route Cascaded Model (DRC: Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), reading aloud involves the simultaneous activation of both the lexical and the sublexical routines. Pseudowords are primarily processed through the sublexical routine that involves the use of grapheme-to-phoneme correspondence rules. Simultaneously, the orthographic and phonological representations of the words which are similar to the pseudoword are activated in the lexicon. Both the sublexical and the lexical routines thus feed activation to phonemes in the phonemic buffer which, in turn, returns feedback activation to lexical representations. If children are not able yet to monitor the contribution of lexical information, lexical activation in pseudoword reading may cause interference with sublexical information, thus resulting in reading errors and increased latencies (Marcolini et al., 2009).

The interaction of sublexical and lexical information in reading acquisition was also investigated by Peressotti and colleagues (2010). These authors designed non-lexical material changing either the first or the fourth letter of Italian 5-letter words. The literacy level of readers determined whether facilitation or interference effects were observed for pseudowords with the letter changing in first position (early diverging pseudowords) and pseudowords with the letter changing in fourth position (late diverging pseudowords). The oldest (5th grade) children showed the same effect shown by adults (Mulatti, Peressotti, & Job, 2007): They read late diverging pseudowords faster and more accurately than early diverging pseudowords, thus showing a benefit from activating the beginning of the corresponding word. The youngest children (2nd graders) showed the reversed pattern, namely, they read late diverging pseudowords more slowly and less accurately than early diverging pseudowords, thus showing to be interfered by lexical activation.

A final source of evidence for the contribution of lexical information to word and pseudoword reading are the effects caused by different compositions of the reading list. Paizi, Burani, De Luca and Zoccolotti (2011) found that a list that included only words speeded up word reading in Italian children, both with typical reading abilities and with dyslexia, relative to a list in which words were mixed with pseudowords. The facilitating effect of the lexical context was stronger for skilled children than for children with dyslexia. However, for all children, non-lexical stimuli (i.e., pseudowords) were not affected by context manipulation: Both typically developing readers and readers with dyslexia read as fast and as accurately pseudowords when presented together with words and with other pseudowords.

On the basis of the findings of Paizi et al. (2011), list context manipulation may not be expected to affect pseudoword reading in Italian. However, the study of Paizi et al. (2011) only considered pseudowords that had few similar words in the lexicon. In contrast, an influence of a lexical context might be expected in reading pseudowords which are similar to words, as indicated by some studies on adult readers. Job et al. (1998) reported that Italian adults read faster pseudowords that closely resembled real words than pseudowords that were less similar to a word, but only when presented in a list containing also words in addition to pseudowords.

In sum, several properties of stimuli and different list compositions have revealed lexical contributions to the reading of new (non-lexical) material. However, all the reviewed studies assessed the effect of one stimulus property at a time, and not in interaction with list composition. Furthermore, stimuli of different lengths were employed in the different studies.

The aim of the present study was to test how different properties of a non-lexical stimulus (i.e., base-word frequency, position of the diverging letter and stimulus length) may interact with each other and affect pseudoword reading. The inclusion of length among the experimental variables seemed essential in assessing the reading behavior of Italian children, who usually show large effects of stimulus length, especially in reading pseudowords (e.g., Marinelli, Romani, Burani, Mc Gowan, & Zoccolotti, 2016; Zoccolotti, De Luca, Di Filippo, Judica, & Martelli, 2009). In sum, a first novelty of the study is the simultaneous assessment of several stimulus properties, which might interact with each other. A second novelty of our study is that, in addition to the manipulation of stimulus properties, we also took into account the contribution of different list compositions to children's pseudoword reading.

Italian children with typical reading abilities at two different steps of reading instruction (i.e., 3rd and 5th grades) participated in the study. Children read aloud short and long pseudowords derived from words of varying frequencies by changing one letter in either first or fourth position. Two different experimental lists were constructed: A mixed list, which included both pseudowords and words, and a pure list composed of pseudowords only. Children were presented with each pseudoword twice, once in a mixed list and once in a pure list.

We expected different patterns of performance in 3rd and in 5th graders. Peressotti et al. (2010) showed that the literacy level of readers determines whether facilitation or interference effects for late diverging pseudowords are observed. Third graders might not be able yet to control the activation of lexical knowledge caused by the almost totally visible base-word in late diverging pseudowords, with consequent interference of lexical information on pseudoword reading. Accordingly, 3rd graders should read less accurately and more slowly pseudowords diverging from a real word at fourth letter position than pseudowords with the letter changing in first position, with the position of the diverging letter (hereafter: PDL) effect likely to be stronger in the case of pseudowords derived from a high-frequency word. In contrast, 5th graders might show a reversed pattern, i.e., facilitation effects on reading pseudowords with the letter changing in fourth position (Peressotti et al., 2010), and possibly derived from a high-frequency word, because the ability to balance the contributions of the lexical and sublexical systems increases with increasing literacy (Coltheart & Leahy, 1992).

We expected to find an influence of the base-word more in mixed list context than in pure list context. The latter prediction stems from the observation that a lexical context promotes lexical activation in pseudoword reading (Job et al., 1998; Traficante & Burani, 2014). In the mixed context contrasting effects of base-word frequency on reading latencies and accuracy, respectively, might also be conceived. Faster latencies may be expected when children read pseudowords derived from higher-frequency words because the presence of words in the mixed context contributes to speed up lexical activation and, consequently, response times. However, the fast activation of the lexical route might also increase the rate of reading errors because of interference of lexical information with the sublexical procedure, making children read faster but less accurately.

The stimulus length effect should remain unaffected by context manipulation (Paizi, Burani, & Zoccolotti, 2010; Paizi et al., 2011): Children are expected to read more slowly and less accurately long pseudowords than short pseudowords irrespective of being presented in pure blocks or mixed with words (Paizi et al., 2011).

METHOD

Participants

Twenty-eight children of a primary school in Bari, 14 recruited from 3rd grade classes (4 F; 10 M) and 14 recruited from 5th grade classes (4 F; 10 M), participated in the experiment. All participants had normal or corrected to normal visual acuity. Their nonverbal IQ level based on scores at the test of *Raven's Coloured Progressive Matrices* fell within normal range, according to Italian normative data (Pruneti et al., 1996). Children's performances on a standardized reading test, administered for Italian reading level examinations (*MT Reading test*, Cornoldi & Colpo, 1998) were well within normal limits (with mean *z*-scores near zero) for reading comprehension, reading speed and accuracy. Summary statistics and mean scores at the screening tests for participants of each grade are provided in Table 1.

	Third grade		Fifth grade	
	M raw	*M z*	*M raw*	*M z*
Age (years)	8.6	_	10.4	_
	(0.4)	_	(0.4)	_
Raven's Matrices Test	21.5	_	28.1	_
	(3.6)	_	(3.02)	_
Reading Comprehension	7	0.10	7	-0.60
	(1.41)	(0.3)	(2.13)	(1.19)
Reading Speed (MT Test) (time/syllable)	34.3	-0.3	24.6	-0.6
	(8.5)	(0.5)	-3	(0.3)
Reading Acc. (MT Test) (no. of errors)	6.6	-0.5	6.5	-0.6
	(2.6)	(0.7)	(2.8)	(0.5)

Table 1 - *Means and standard deviations (in parentheses) for Age, Raven's test, and MT reading test, by children's grade.*

Material and design

One hundred and twenty-eight pseudowords were obtained from 128 Italian words by changing one letter (always a consonant) either in 1st or in 4th position in the word. Pseudowords varied for length: They were either five-letter long (short pseudowords: e.g., FINZA* from *PINZA*, pliers; AMOPE* from *AMORE*, love) or seven-to-nine-letter long (long pseudowords: e.g., PORMICA* from *FORMICA*, ant; TARFARUGA* from *TARTARUGA*, tortoise). Pseudowords were derived from base-words that were present in a frequency count of 1 million word tokens read and written by primary school children (Marconi, Ott, Pesenti, Ratti, & Tavella, 1993). Base-words spanned a low-to-high frequency range (*Min*: 4; *Max*: 1967; *M* = 117.74; *SD* = 238.31). The four sets of short and long pseudowords with the letter changing either in 1st or 4th position were strictly matched for base-word frequency. All pseudowords were orthographically legal and easily pronounceable. Pseudowords in the four experimental sets were also matched for mean bigram frequency, number of geminate consonants and orthographic complexity (calculated as the number of the few Italian letters and letter clusters which require the following letter context to be assigned the correct pronunciation; see Barca et al., 2007). The correlation between orthographic neighborhood size (N-size) and length in letters was high, thus short and long pseudowords could not be matched for the number of orthographic neighbours[1] (http://dpss.psy.unipd.it/claudio/vicini2.php), which was higher for short (3) than long (1.30) pseudowords. Since the N-size variable may affect reading performance (Marinus & de Jong, 2010; Marinus et al., 2015) it was entered as a random effect in the statistical analyses (see below, *Data analysis* section). The mean values of the psycholinguistic variables for pseudowords are reported in Table 2.

[1] The base-word was included in the calculation of orthographic neighbourhood.

	Stimulus length			
	Short		Long	
	1PDL	4PDL	1PDL	4PDL
Base-word frequency	118.8 (188.5)	121.6 (174.9)	120.9 (349.5)	115.6 (214.6)
N-size	3.4 (2.3)	2.5 (1.6)	1.39 (0.7)	1.2 (0.5)
Bigram frequency	10.5 (0.4)	10.5 (0.4)	10.71 (0.3)	10.6 (0.3)
Contextual rules	0.3 (0.5)	0.3 (0.5)	0.5 (0.9)	0.6 (0.7)
Length in phonemes	5 (0.0)	5 (0.0)	7.8 (0.6)	7.8 (0.7)

Table 2 – Means and SDs values (in parentheses) of the psycholinguistic variables for pseudowords by length and position of the diverging letter (PDL)

The experimental list of pseudowords was presented in two contexts, mixed and pure. In order to avoid that stimuli were presented twice in the same session, the experimental list was randomly splitted into two different sublists, A and B, each including half of the stimuli (N = 64). Sublists were presented to participants in two experimental sessions, separated by at least ten days. In the first session a participant read sublist A in mixed context (with 64 filler words matched for length to experimental stimuli) and sublist B in pure context (with 64 filler pseudowords matched for length to the experimental stimuli), whereas in the second session the participant read sublist A in pure context and sublist B in mixed context. The order of administration of the two contexts was counterbalanced across participants. The order of presentation of stimuli within a sublist was fully randomized. The experimental sessions were preceded by a training block of six stimuli.

Procedure

The experimental task was reading aloud. Participants, tested individually, had to read each stimulus as quickly and accurately as possible. Each stimulus was presented in isolation on the centre of the PC screen and a voice-key connected to the PC recorded the onset of the vocal response and the reaction time (RT) in ms. The experimenter manually recorded pronunciation errors. Stimuli, printed in capital letters on a white background, were preceded by a fixation point (400 ms) and remained until the response was produced.

Data analysis

In both sets of data (in mixed and pure contexts), voice onset *reaction times* (RTs) were logarithmically transformed in order to obtain a Gaussian-like distribution and were introduced as a dependent variable. Mixed-effects models were employed with participants, items, and N-size (the variable which was not possible to match in the different conditions) as random effects (Baayen, Davidson, & Bates, 2008). Due to the high level of correlation between N-size and length in letters, N-size was included as standardized residuals of linear regression of N-size on pseudoword length, following a de-orthogonalization process.

Because of the complexity of the experimental design, we analyzed mixed and pure list contexts as two separate experimental conditions. Grade (3rd grade; 5th grade), position of the diverging letter (PDL for short: 1; 4), and stimulus length (short; long) were considered as categorical fixed effects. Base-word frequency was log-transformed and was considered as continuous fixed effect. Interactions among predictors were also tested. The analysis started with a full factorial model, which was progressively simplified by removing the variables that did not significantly contribute to the goodness of fit of the model (i.e., the result of the likelihood ratio test comparing the goodness-of-fit of the model before and after removing the effect of each non-significant parameter). Non-significant parameters were excluded at each step, starting from smaller effects and no parameter that was part of a higher-order interaction was removed from the model. *Post-hoc* analyses were carried out to improve understanding of the interaction effects. In case of higher than 3-way interactions, the database was splitted according to the categorical moderator variable, to better evaluate main effects and lower level interactions. Once the models were fitted, atypical outliers were removed (employing 2.5 *SD* of the residual errors as criterion). The models were then refitted to ensure that the results were not driven by a few excessively influential outliers. The statistical significance of the fixed effects was evaluated using a Markov Chain Monte Carlo (MCMC) sampling (Baayen et al., 2008).

A second analysis with response accuracy as the dependent variable was carried out, using the procedure adopted for RTs. Mixed-effects logistic models were employed (Jaeger, 2008).

RESULTS

1. Mixed context

Latencies

Fifth graders were faster than 3rd graders (3rd grade: M = 859.62, SD = 371.8; 5th grade: M = 647.64, SD = 162.3; t = -4.16, $pMCM$ < .001) and all children responded to longer stimuli with longer latencies (Short: M = 712.45, SD = 319.9; Long: M = 815.4, SD = 406.2; t = - 4.79, $pMCM$ < .001). It is worth noting that the base-word frequency effect reached significance level (t = -2.08, $pMCM$ = .038): The higher was the frequency of the base-word, the faster was the onset of pseudoword reading. The PDL effect did not reach significance level.

Accuracy

In the initial model, all main effects and *k*-way interactions were significant. Thus, the database was splitted by grade and the analyses were carried-out separately for 3rd and 5th graders. Both 3rd and 5th graders showed the effect of stimulus length (3rd graders: z = 6.904, p < .001; 5th graders: z = 5.766, p < .001): Children made more errors in reading long pseudowords than short pseudowords. Base-word frequency affected only 3rd graders' performance, but in interaction with position (z = 2.219, p = .026): In the case of pseudowords with PDL in first position the effect of frequency did not reach significance level (z = -1.035), while with

PDL in fourth position base-word frequency had a significant effect (z = 2.355, p = .018). This pattern of results indicates that when 3rd graders read pseudowords with PDL in fourth position, the higher the frequency of the base-word, the higher was the number of errors. In order to get further insight into the influence of base-word frequency in interaction with PDL, we divided stimuli in two equally sized sets (i.e., higher frequency base-words: M = 221, SD = 363; lower frequency base-words: M = 15, SD = 8.0). Then we calculated how many cases of production of the base word were present in the errors made by children for each stimulus type in each (higher and lower) base-word frequency set. An inspection of the quality of errors made by children indicated that, for 3rd graders, pseudowords derived from higher-frequency words and with diverging letter in fourth position were associated to the highest percentage of base-word productions. This observation supports interference from lexical representations.

Summary of results for mixed context

In mixed context, children showed the lexical effect of base-word frequency on pseudoword reading latencies: The higher the frequency of the base-word, the faster the response onset. However, 3rd graders also showed interference from lexical representations on accuracy: In reading a pseudoword diverging from a word at fourth letter, the higher the frequency of the base-word, the higher was the number of errors. Latencies and reading accuracy of all children also showed effects of stimulus length.

2. Pure context

Latencies

As in mixed context, also in pure context 5th graders were faster than 3rd graders (3rd grade: M = 890.74, SD = 448.9; 5th grade: M = 633.97, SD = 177.9; t = -5.54, $pMCM$ < .001) and all children responded to longer stimuli with longer latencies (Short: M = 712.45, SD = 312.9; Long: M = 815.4, SD = 406.2; t = - 8.08, $pMCM$ < .001). The two-way grade *by* length interaction was significant (t = 5.80, $pMCM$ < .001): Both 3rd graders and 5th graders were slower in reading long pseudowords than short pseudowords but the length effect was stronger for 3rd graders than for 5th graders.

Accuracy

The initial mixed-effects model on the whole sample showed that all main effects and k-way interactions were significant, including the 4-way grade *by* length *by* base-word frequency *by* PDL interaction. Thus, the database was splitted by grade and the analyses were carried-out separately for 3rd and 5th graders. Data from 3rd graders showed significant effects of both stimulus length (z = -2.032, p = .04) and PDL (z = 2.529, p = .01): Children responded with a higher rate of errors to long than short stimuli (short: 5.8%; long: 14.6%), and to stimuli with letter changing in 4th position than to stimuli with diverging letter in 1st position (1PDL: 8.9%, 4PDL: 11.5%). However, the 2-way interaction length *by* PDL was also significant (z = 2.012, p = .04), indicating that the PDL effect was reliable only in the case of long stimuli. A qualitative inspection of 3rd graders' reading errors in pure context did not show any relevant pattern of results. Significant effects of both length (z = -3.511, p < .001) and PDL (z = 2.237, p = .027) were observed for 5th graders too: They read less accurately long pseudowords (10.7%) than short pseudowords (3.9%), and less accurately pseudowords with letter changing in fourth position (8.8%) than pseudowords with letter changing in first position (5.8%). The qualitative inspection of 5th graders' reading errors did not reveal any specific pattern of results. In particular, the large majority of errors did not result in any lexicalization, and productions of the base-word were rare.

Summary of results for pure context

Analyses on accuracy confirmed for both 3rd and 5th graders a strong effect of length, but showed also an effect of PDL. For 3rd graders, the two variables affected responses in interaction with each other: Children read less accurately a pseudoword when it diverged from a real word at fourth letter position than a pseudoword with the letter changing in first position, but only when stimuli were long. Data from 5th graders showed main effects of the two variables, as they made more errors for long than for short stimuli, and for pseudowords with diverging letter in 4th position than for pseudowords with diverging letter in 1st position, irrespective of stimulus length.

DISCUSSION

According to the Orthographic Depth hypothesis (Katz & Frost, 1992), and the Grain-Size hypothesis (Goswami et al., 2001; Ziegler & Goswami, 2005) in a language with transparent orthography as Italian, reading can be easily supported by sublexical processing. However, lexical effects on Italian adults' and children's word and pseudoword reading have been reported in several studies (for a review, see Burani et al., in press). The present study further investigated the contribution of lexical activation to Italian children's pseudoword reading. In a single experiment we tested how children's reading proficiency, item properties (base-word frequency, position of the diverging letter, stimulus length) and list context (mixed vs. pure) could affect reading performance.

The results of our study showed different patterns of lexical effects in mixed and pure list conditions. Evidence for facilitatory lexical activation was found only in mixed context (i.e., when children read aloud pseudowords mixed to words), and on reading latencies only (no lexical facilitation was found on reading accuracy): In mixed context, all children, both 3rd and 5th graders, were faster in naming pseudowords derived from higher frequency words. However, younger (3rd grade) children made also more reading errors on the pseudowords which mostly resembled real words: In reading a pseudoword diverging from a word at fourth letter (e.g., FORBUNA* from FORTUNA, luck), the higher the frequency of the base-word, the higher was the number of children's incorrect pronunciations. The lexical source of interference was further suggested by the high percentage of errors consisting in the production of the base-word. This pattern of results is consistent with the view that the presence of words promotes lexical activation in pseudoword reading (Traficante & Burani, 2014), thus speeding up the onset of pronunciation for pseudowords which highly resemble real words (see Job et al., 1998), but also causing interference on the operation of sublexical procedures (Marcolini et al., 2009; Peressotti et al., 2010).

No facilitating effects of the lexicon were found in pure context. Only interfering effects were observed on reading accuracy: Both 3rd graders and 5th graders made more errors on pseudowords which diverged from a real word at a late letter position, especially (for 3rd graders) in the case of longer stimuli.

Considering the patterns of effects in mixed and pure contexts together, it can be claimed that when lexical activation is favored (i.e., in the mixed context), reading latencies on pseudowords benefit of the fast parallel activation of a similar word which is highly available in the lexicon (as indicated by the facilitating effect of base-word frequency). However, the same highly activated word may cause interference on the full production of the stimulus, and the younger readers, who do not fully monitor the balancing of lexical and sublexical procedures, are prone to make more errors in reading aloud the pseudowords which are more likely to activate a word.

The interfering effects on reading accuracy were consistently found on late-diverging pseudowords, i.e., on stimuli which differ from a real word late in processing. This result can be interpreted as a function of the serial processing which characterizes the application of sublexical procedures (Coltheart & Rastle, 1994; Rastle & Coltheart, 1999). Given that serial processing proceeds accumulating evidence from the orthographic input, then lexical activation may manifest its influence only when enough evidence for lexicality has cumulated (i.e., when a base-word is activated toward the end of the stimulus as in a late-diverging pseudoword).

Interestingly, the interfering effects on reading accuracy were different in mixed and in pure contexts. When the pseudowords were mixed to words, there was interference on accuracy from higher frequency base-words, as expected when lexical procedures are active. This interference was significant for younger children only (grade 3 readers), who are less able to monitor the contribution of lexical information to sublexical processing. In contrast, when pseudowords only were presented to children in the pure context (i.e., in a context that favors the application of sublexical procedures), both younger and older children did not fully monitor the impact of lexical interference in reading the pseudowords which activated a word neighbor late in the stimulus. In pure context, lexical activation was a source of noise on the application of sublexical procedures more than a source of lexical competition, as suggested by the quality of children's reading errors: These were rarely of a lexical type, but prevalently consisted in the production of a different pseudoword, in a fragment or in hesitations.

Not surprisingly, younger children were more affected by stimulus length than older ones (see, e.g., Marinelli et al., 2016; Zoccolotti et al., 2009). However, as expected, all children were consistently slower and less accurate in reading long pseudowords than short pseudowords irrespective of list context (Paizi et al., 2010; 2011).

The results of the present study present some differences with those of Marcolini et al. (2009). Consistently with our findings, Marcolini et al. (2009) did show effects of base-word frequency when typically developing 3rd-to-5th graders read pseudowords in a mixed list context that included words and pseudowords in similar proportions. However, in the study of Marcolini et al. (2009) high-frequency base-words consistently caused inhibition (not facilitation) on children's reading performance. Differently from present results, Marcolini et al. (2009) did not find any lexical facilitation on children's latencies. This discrepancy in the latency results may be due to the differences in the pseudowords used in the two studies. In the study of Marcolini et al. (2009), approximately 1/3 of the items were derived from words changing a stressed vowel, differently from the present study, where only consonants where changed. To the best of our knowledge, the differential effects of the phonological properties of the diverging letter have not been studied yet in the literature on neighborhood effects, but it could be expected that the substitution of a stressed vowel disrupts the phonological pattern of the base-word and leads to a higher degree of uncertainty than the substitution of a consonant (Duncan, Seymour, & Bolik, 2007). Moreover, in Marcolini et al.'s study, the position of the diverging letter was not considered as a variable affecting responses, whereas it was a design variable in our study and it showed reliable effects.

Our results are overall consistent with those of Peressotti et al. (2010). These authors assessed the effect of the position of the diverging letter on pseudoword reading in a context where pseudowords were mixed to words, and found varying effects on latencies and accuracy, depending on literacy level. Namely, they found that the oldest (4^{th} grade) children read more quickly and more accurately pseudowords where the diverging letter was late in the stimulus than when it was at the beginning. In contrast, the youngest (2^{nd} grade) children read late diverging pseudowors more slowly and less accurately than early diverging ones. The few differences between our findings and those of Peressotti et al. (2010) seem to be due to the different ages of children participating in the two studies, and to the different variables which were assessed. In the list condition comparable to that of Peressotti and colleagues (i.e., in mixed context) we confirmed a facilitatory contribution of lexical activation to the reading latencies of all children, both 3^{rd} and 5^{th} graders. Presumably, children in the 3^{rd} grade and even more so children in the 5^{th} grade have a sufficient literacy level to benefit of lexical activation as 4th graders (Peressotti et al., 2010) and adults (Mulatti et al., 2007). However, the facilitation we found on the pseudoword reading latencies of both 3rd and 5th graders was a function of base-word frequency, a variable that was not controlled by Peressotti and co-workers. We also confirmed an effect of lexical interference (caused by base-word frequency) on the reading accuracy of younger (3^{rd} grade) children. Such interference on accuracy proves that children in the 3rd grade do not show yet a full balancing of the relative contributions of the lexical and sublexical procedures.

Summing up our findings, the present study provides evidence for lexical activation in children reading newly encountered stimuli. However, facilitatory effects on pseudowords' reading latencies were only found in a condition which favored lexical access. Overall, lexical activation interfered with accuracy in reading unknown stimuli, irrespective of list context. The facilitatory effect of base-word frequency on the reading latencies of children is consistent with the facilitatory base-word frequency effect reported for Italian adults reading pseudohomophones (Peressotti & Colombo, 2012), and the inhibitory effect of the position of divergent letter on accuracy is in line with Peressotti et al.'s (2010) study.

One study of pseudoword spelling in Italian children reported results that are relevant for those found in the present study. Angelelli, Notarnicola, Marcolini and Burani (2014) adopted an experimental design similar to ours to assess the interaction of lexical and sublexical procedures in the spelling of pseudowords by typically developing Italian 3rd and 5th graders. The results on spelling accuracy showed facilitatory effects of base-word frequency, irrespective of grade, leading the authors to argue in favor of parallel processing of lexical and sublexical information in spelling at the early developmental levels during literacy acquisition (see also Angelelli, Marinelli, Putzolu, Notarnicola, Iaia, & Burani, 2017, for lexical effects on children's pseudoword spelling).

In conclusion, some cooperation of lexical and sublexical procedures was found in Italian children reading new stimuli, in spite of the almost total consistency of the orthography, similar to what happens in English-speaking children of the same ages (Coltheart & Leahy, 1996; Laxon et al., 2002; Wimmer & Goswami, 1994). This finding suggests that the process of reading acquisition may be similar in different orthographies. When a letter string with a high similarity to a word has to be read or spelled, primary-school children activate lexical representations that support sublexical processing, which is not automatized yet. This lexical activation may differently affect reading latencies and accuracy, depending on several features of the stimuli and of the list context, but also of the reader's ability.

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CHAPTER 3

Morpheme-based processes in Italian children reading aloud: evidence from morphological coding schemes of reading errors

INTRODUCTION

The study of morphologically complex word processing has been centered on the notion that morphemes, the smallest linguistic pieces with a grammatical function, may be processing units. Literature on the morphological processing in adult, as well as young, readers has been guided by the hypothesis that morphemes and/or complex words are stored as representational units within the mental lexicon.

The attitude of children to use morphemes as reading units in processing complex words has been largely observed in languages with different orthographies varying by orthographic depth and morphological richness (see, e.g., Verhoeven & Perfetti, 2011). Data from different languages are suggesting children learn to detect and to use frequent and stable chunks of letters corresponding to morphemes and shared by several words. In this way, they may improve fluency and accuracy in decoding new, unfamiliar and complex words but the advantage taken from morphemic structure varies according to the features of their language. Morphology richness and regularity of grapheme-to-phoneme correspondence can play a role in using morphemic units and, as a consequence, in giving rise to different morphological effects. Transparent orthographies like Italian and French present a grapheme-to-phoneme correspondence quite consistent that allows children to reach a good level of accuracy also by using small grain-size units in decoding new words (see the grain-size theory by Ziegler & Goswami, 2005). The opportunity of detecting morphemic units (both stems and affixes), that are larger than single graphemes, can allow them avoiding the time-consuming grapheme-to-phoneme procedure, gaining overall in fluency. On the contrary, in languages with opaque orthography like English children are not allowed to trust on small grain-size units, so they have to memorize the association between orthographic and phonological representations of the whole words as soon as possible to reach a good level of accuracy and fluency. In order to process a long complex word, it might be a good strategy learning to detect affixes and stripping them away to isolate the base word (very often base words are stems in English). In this way the probability of a correct pronunciation, if the stem/base word is a known word, increases in comparison to the strategy of reading through smaller units. The role of morphological structure comes also out in reading aloud task, where English primary school children are more accurate in reading derived words with transparent structure than simple words. Carlisle and Stone's (2005). The role of morphemic structure in reading acquisition may be tested in morphological awareness, namely, the awareness of complex word morphemic structure and the ability to manipulate it (Carlisle, & Feldman, 1995). Morphological awareness increases its role from third grade children, when the number of new complex words in the school texts increases (Mann and Singson, 2003). A developmental trajectory may be imagined. Children at first grades aim at learning to apply grapheme-to-phoneme conversion rules and at recognizing known words. Then, at 3rd grade they develop the ability in detecting orthographic patterns (stems, affixes), that can be found in several word contexts, in order to increase accuracy (in opaque-orthography languages) and/or fluency (in transparent-orthography languages) when long, complex words or new words must be read. Achieving a full mastery in reading, the richness of orthographic lexicon allow them to use whole-word representations for word decoding, so the role of morphemic units in word reading decreases, even though morphological structure keeps its relevance to understand the meaning of new words (morphological awareness) and to guide text comprehension. Deacon, Kieffer, and Laroche (2014), Jarmulowics, Hay, Taran, & Ethington, (2008). Moreover, the ability in detecting morphemic units in letter strings might stem, at the earlier stages, on the semantic dimension of morphemes and leads, later, to morpho-orthographic representations that young readers can use in gain speed and accuracy in reading known and new words (Traficante et al., 2012). Morphemic parsing process in children may be influenced by the relative frequency of the whole word and of the base and by the productivity of the affixes, both in a shallow orthography such as Italian (Marcolini, Traficante, Zoccolotti, & Burani, 2011) and Spanish (Lázaro, 2012) and in a deep orthography such as English (Deacon, Whalen, & Kirby, 2011). In Italian morphemic parsing may be also influenced by the width of the inflectional paradigm (Traficante et al., 2014).

Even though Italian children are able to rely on small grain size units to learn to read thanks to the transparent orthography (Ziegler, & Goswami, 2005) , they need to rely on larger units than single graphemes, thus, on morphemes and/or whole word representations to improve their reading performances and text comprehension. As children do not know any words in the lexicon, whole word representations are not always available and morphemes are the right intermediate units which building their lexicon on (Burani, Marcolini, & Stella, 2002).

Finally, the ability of using morphemic structure advantages both reading latencies and accuracy were found when Italian children with dyslexia read aloud pseudoword stimuli composed of morphemes (root + derivational suffix) as compared to pseudowords without morphological structure. (see Burani, Marcolini, De Luca, & Zoccolotti, 2008; Traficante, 2012; Traficante, Marcolini, Luci, Zoccolotti, & Burani, 2011). Morphemic units facilitate children with dyslexia in reading pseudowords with both high and low word base frequency due to the lack of whole word representations they have (Marcolini et al., 2011). Given their phonological difficulties, poor readers are more likely to use morphological processing to build up compensatory strategies in reading process.

Developmental morphological processing studies on children have mostly realized through word recognition tasks, such as (masked) primed or unprimed lexical decision and reading aloud tasks, with children performances always evaluated in terms of latency and accuracy. In reading aloud tasks, the accuracy parameter has been taken into account as number of correct reading performances only, and reading errors of wrong performances performed by children has been usually ignored. However, reading errors may say something more about reading acquisition process (see Trenta, Benassi, Di Filippo, Pontillo, & Zoccolotti, 2013).

Morphological reading errors in neuropsychological patients performing morphologically complex word reading have been largely assessed (Badecker, 1997; Badecker, & Caramazza, 1987; De Bleser, & Bayer, 1990; Castles, Coltheart, Savage, Bates, & Reid, 1996; Funnell, 1987; Joanisse, & Seidenberg, 1999; Job,

& Sartori, 1984; Luzzatti, Mondini, & Semenza, 2001; Patterson, 1980; Plaut, & Shallice, 1993; Rastle, Tyler, & Marslen-Wilson, 2006). In morphological errors, morphemes (stems or affixes) can be deleted (*speaker* read as *speak*), inserted (*speak* read as *speaker*), or substituted (*speaker* read as *speaking*). This phenomenon has been taken as evidence of word processing being morpheme-based in patients: morphemes are the building blocks of word processing, and are the most affected by the lexical impairment characterizing deep dyslexia. Morphological manifestations in neuropsychological patients cannot be reduced to a by-product of either semantic of orthographic similarity. For example, in the production of DE, the patient described in Rastle et al., (2006), morphological errors were more often observed in truly derived words (*killer*) as opposed to pseudosuffixed (*irony*) or non-complex words with embedded lexical strings (*cornea*). Moreover, Badecker (1997) described the case of a patient, FM, committing morphological errors also when presented with irregular verbs (*began* read as *begin*, as well as *passed* read as *pass*), suggesting that morphological representations would represent functional relations between lexical elements irrespective of their morpho-orthographic parsability.

To our knowledge, there are no studies in literature assessing morphological reading errors produced by children performing reading aloud task or other reading tasks. However, drawing reading error classifications seems to be very informative to characterizing developmental reading profiles (see Trenta, Benassi, Di Filippo, Pontillo, & Zoccolotti, 2013). For these reasons, we supposed the study of morphological reading errors might contribute to investigate morphological processing in children, being also a novel experimental method to present morphemes as representational units, helpful chunks larger than grain size of single letters, in reading acquisition.

Therefore, we were asking whether reading errors performed by children in morphologically complex words reading aloud tasks might be sortable from a morphological point of view, thus, being morphological errors. Indeed, the presence of reading errors clearly sortable as "morphological" might underline morphological parsing process in morphologically complex words recognition.

Our aim was twofold. First, we were aimed at developing a ***M**orphological **C**oding **S**cheme* (MCS) to categorize those errors performed by children in reading morphologically complex words that, over and above the involvement of visual and phonological features, have to do with the morphemic constituents and structure of the word. We consider MCS a reading error classification aimed at highlighting the morphological nature of erroneous productions. If it is true that children are able to morphologically decompose complex words and to detect their internal morphemic structure, when they are erroneously reading aloud morphologically complex words, they should produce morphologically-structured erroneous productions, namely, productions respecting the morphemic structure of the complex word they read. To our intuition, reading wrongly a morphologically complex word does not lead to random reading errors, rather often leading to a string of letters, real or unreal, that can be parsable in base + suffix morphemic structure. Developed our MCS, our second aim was to validate it applying it to a corpus of reading errors performed by children in reading morphologically complex words. As we had collected a corpus of reading errors from a derived word reading aloud task and another corpus from a (pseudo)-alterate word reading aloud task, we decided to develop a MCS fitting reading errors from derived words and another MCS fitting reading errors from alterate words. We are going to present MCS for complex derived words in Experiment 1 and MCS for (pseudo)-alterate words in Experiment 2.

EXPERIMENT 1 - *Morphological Coding Scheme for complex derived words*

Two morphological coding sub-schemes were designed, a first one for these reading errors where the base was the changed morphemic constituent, and a second one for these reading errors where the suffix was the changed morphemic constituent. Each of them was splitted in word production and psedoword production as resulting reading error.

In the MCS for the base change (Table 1), word productions may be realized through the substitution of the target base with another base (Target: **Falli**mento, Reading Error: **Fila**mento) or through the substitution of the target base with a non-morphemic orthographic string of letters (Target: **Mur**etto, Reading Error: **Fur**etto); whereas, pseudoword productions may be realized through the substitution of the target base with another base (Target: **Pend**enza, Reading Error: ***Prend**enza) or through the substitution of the target base with a non-morphemic orthographic string of letters (Target: **Scal**one, Reading Error: ***Scat**one). In the MCS for the suffix change (Table 2), word productions may be realized through the substitution of the target suffix with another consistent suffix (Target: Sper**anza**, Reading Error: Sper**ata**), the substitution of the target suffix with a non-morphemic orthographic string of letters (Target: Ris**ata**, Reading Error: Ris**alta**), the base production (Target: Aranci**ata**; Reading Error: Arancia), or through the root production (Target: Priva**zione**; Reading Error: Priv*). Pseudoword productions may be realized through the substitution of the target suffix with another non-consistent suffix (Target: Tenta**zione**, Reading Error: *Tenta**nza**) or through the substitution of the suffix target with a non-morphemic orthographic string of letters (Target: Umor**ista**; Reading Error: *Umor**isità**).

Code	Label	Description	Example	Target
B1	WBB	**Word production**: substitution of the base with another base	**Fila**mento	**Falli**mento
B2	WBO	**Word production**: substitution of the base with a non-morphemic orthographic string of letters	**Fur**etto	**Mur**etto
B3	PBB	**Pseudoword production**: substitution of the base with another base	**Prend**enza*	**Pend**enza
B4	PBO	**Pseudoword production**: substitution of the base with a non-morphemic orthographic string of letters	**Scat**one*	**Scal**one

Table 1- MCS for base change

Code	Label	Description	Example	Target
S1	WSS	**Word production**: substitution of the suffix with another consistent suffix	**Sperata**	**Speranza**
S2	WSO	**Word production**: substitution of the suffix with a non-morphemic orthographic string of letters	**Risalta**	**Risata**
S3	BP	**Base production**: deletion of the suffix	**Arancia**	**Aranciata**
S4	RP	**Root production**: deletion of both the suffix and the thematic vowel	**Priv***	**Privazione**
S5	PSS	**Pseudoword production**: substitution of the suffix with another non-consistent suffix	**Tentanza***	**Tentazione**
S6	PSO	**Pseudoword production**: substitution of the suffix with a non-morphemic orthographic string of letters	**Umorisità***	**Umorista**

Table 2- MCS for suffix change

We chose the corpus of reading errors collected in Traficante, Marelli, Luzzatti, Burani (2014). This study assessed whether noun and verb bases affect differently children's reading of derived words, and confirmed that in Italian children morphological decomposition may affect reading aloud of long complex words, and that the grammatical class of the base can modulate this effect. A sample of fifty-four Italian children attending the 4th and 5th grades was divided in thirty-six good readers and eighteen poor readers, and matched for gender, age and non-verbal intelligence (Raven's Colored Progressive Matrices). Poor readers scored at least 1,5 standard deviations below norms for speed or accuracy in text reading (Cornoldi & Colpo, 1995). Children had to read aloud seventy-one derived words divided in forty-two noun-derived nouns (e.g., *artista*) and twenty-nine verb-derived nouns (e.g., *punizione*); in addition, ninety-nine non-derived words comparable to the derived words for length, word frequency, and orthographic endings (e.g., *condizione*). Noun-base words and verb-base words were matched for base frequency, and they were not matched for word frequency, length frequency, and suffix length.

Latency results found suffix length as the only variable influencing latencies independently: the longer the suffix, the slower the response. Moreover, a three-way interaction between group, base category and word frequency showed that in good readers, as well as in poor readers, word frequency had a facilitatory effect on latencies, but only when reading derived words with a verb base. Obviously, poor readers had longer latencies than good readers. Certainly, we were more interested in accuracy where an expected pattern of results emerged. Good readers in general show a higher level of accuracy than poor readers, but all children are less accurate when reading words derived from a verb base in comparison to words derived from a noun base. The effect of the high number of competing forms belonging to the wide inflectional family of verbs emerged in the accuracy data. As the study aim was to assess whether the width of the inflectional paradigm might contribute to the use of the morpheme as a processing unit in children derived words reading aloud, the assumption claimed by authors was that base words with a wide inflectional paradigm (*i.e.*, verbs) are more likely to be processed as individual morphemes than base words with a limited inflectional paradigm (i.e., nouns), and so verb bases were expected to trigger (time-consuming) morphological parsing of the words in which they are included. It can be assumed that the distributional properties of the Italian language, in which word forms with a verb-base are much more numerous than those with a noun base, might favour the activation of morphemic constituents in the case of words derived from a verb base. However, the advantage of finding a morphemic unit (verb base) embedded in many different words (deverbal nouns) is counterbalanced by the probability of incorrectly activating a base + suffix combination other than the target. As shown by results, the resulting process is more time-consuming and less accurate at least for children.

All reading productions performed by children in reading derived words and pseudoderived words were audio-recorded, and all reading errors were transcribed. We collected this set of reading errors and we decided to apply our MCS to the transcripts in two independent coders, reaching a good level of inter-raters agreement (Cohen's K = .78).

Our main hypothesis was to find out mostly morphological errors in reading derived words both verb base and noun base. Reading errors are considered morphological when reproducing the morphemic structure base + suffix of complex targets, namely, they consist of morphemes, whereas they are considered non-morphological in case of random errors or sortable as orthographic and visual. So that, we tried to indistinctly apply MCS on reading errors performed from both derived words (verb base and noun base) and pseudoderived words. As we expected, when children read erroneously derived words mostly produced morphological errors (morphological errors: 71%; non-morphological errors: 29%), whereas when they read erroneously pseudoderived words mostly produced non-morphological errors (non-morphological errors: 83%; morphological errors: 17%). Children, from the earlier stages of reading acquisition, are able to detect the morphemic structure of morphologically complex words, and to use morphemes as reading units larger than grain size to improve their performances in terms of latencies and accuracy (Traficante et al., 2012). Their access to morphemic structure of complex words may be also proved by the presence of morphological errors when they are reading complex words. If children are really sensitive to morphemic constituents, they should not produce random errors, rather combinations base + suffix others than the complex target. It can be that, when they are reading complex words, have available several base + suffix combinations and they pick one up morphologically legal but different from the complex target. On the other hand, low percentage of morphological errors (17%) in reading pseudoderived words suggest morphological parsing process may not be mandatory and pre-lexical, as proposed by morpho-orthographic approach (Rastle et al., 2004), at least for Italian young readers.

As our aim was to underline the importance of classifying reading error types in children morphological processing investigation, we focused on those morphological errors produced from truly derived words, verb and noun base, only. Thus, we took into account reading errors like ***fila**ment* from the target ***falli**mento*, ***negozi**ante* from the target ***nega**zione*; and we did not take into account reading errors like **sclanio* from the target ***scalone*** as any morphemic constituent is present in this kind of error. We first noticed that both good readers and poor readers realized more pseudowords (good readers: 63%; poor readers: 61%) than words (good readers: 37%; poor readers: 39%) when producing morphological errors, thus, they tended to use morphemic constituents in inexistent base + suffix combinations in Italian language.

Then, we carried out chi-square test to comparing the distributions of morphological errors in verb-base derived words and noun-base derived words. These following results emerged as significant.

Pseudowords resulting from the substitution of the target suffix with another suffix inconsistent with the base (*e.g.*, ***umoroso****, humorous*, from ***umorista***, humorist) is more frequent for noun-base derived nouns (21%) than for verb-base derived nouns (8%) (*e.g.*, ***tentanza****, *t*emptance*, from ***tenta-zione***, temptation) (χ^2 = 4.37, p = .03). Moreover, the production of the bare root, *i.e.*, the base without the thematic vowel (*e.g.*, **priv** from ***privazione***, privation) appears only for verb-base derived nouns (8%) (χ^2 = 5.55, p = .02).

Hierarchical log-linear models were carried out to assess the relationships between Group (good *vs* poor readers), Base category (noun base *vs* verb base), Lexicality of morphological errors (word *vs* pseudowords), and misread Constituent. The best generated model produced two significant effects (χ^2= 9.7, df = 10, p= .467). A three-way interaction Lexicality x misread Constituent x Base category (χ^2 = 6.761; p = .034) showed a higher percentage (29%) of word productions for verb bases (e.g., prevalenza, prevalence from priva-zione, privation) than for noun bases (4%) (e.g., calzino, sock from colazione, break-fast), when both morphemic constituents change. No significant effects were found in pseudoword production as morphological reading errors. Distributional properties of Italian language seem to play a role in this case: when children are erroneously reading deverbal nouns, it easier to them legally combining another base and another suffix together and, thus, to produce a word, thanks to the wider inflectional paradigm of verbs. This distributional feature could make morpheme-based reading more likely for words embedding a verb base than for those embedding a noun base.

Moreover, a two-way interaction Group x Base category came out. Skilled readers do not show any significant difference, whereas, poor readers make fewer morphological errors with verb-base (37%) than noun-base (63%) targets. Indeed, verb-base nouns (9.48) were longer than noun-base nouns (8.02) and stimulus length usually affects performances of poor readers. Thus, they might be more likely to shorten verb-derived nouns (e.g., *penza from pendenza, inclination) than noun-derived nouns (e.g., *forlo from fornello, cooker), but shortening them they removed the central part of verb-base targets. These shortened productions lost the morphological structure of complex targets and resulted in non-morphological errors.

EXPERIMENT 1 - ***M**orphological **C**oding **S**cheme for complex (pseudo)-alterate words*

Two morphological coding sub-schemes were designed, a first one for these reading errors where the base was the changed morphemic constituent, and a second one for these reading errors where the suffix was the changed morphemic constituent. Each of them was splitted in word production and psedoword production as resulting reading error.

In the MCS for the base change (Table 3), word productions may be realized through the substitution of the target base with another base (Target: **Lett**ino, Reading Error: **Latt**ino), the substitution of the target base with a non-morphemic orthographic string of letters (Target: **Mur**etto, Reading Error: **Fur**etto), the substitution of orthographic string of letters at the begging of the word with a base (Target: **Bar**one, Reading Error: **Barb**one), or substitution of the orthographic string of letters at the begging of the word with another orthographic string (Target: **Cam**ino, Reading Error: **Camm**ino); whereas, pseudoword productions may be realized through the substitution of the target base with another base (Target: **Piatt**ello, Reading Error: ***Pist**ello), the substitution of the target base with a non-morphemic orthographic string of letters (Target: **Scal**one, Reading Error: ***Scat**one), the substitution of the orthographic string of letters at the begging of the word with a base (Target: **Fars**etto, Reading Error: ***Fras**etto), or the substitution of orthographic string of letters at the begging of the word with another orthographic string (Target: **Mugh**etto, Reading Error: ***Musch**etto). In the MCS for the suffix change (Table 4), word productions may be realized through the substitution of the target suffix with another real suffix (Target: Bicchier**ino**, Reading Error: Bicchier**one**), the substitution of the target suffix with a non-morphemic orthographic string of letters (Target: Arm**ato**, Reading Error: Arm**adio**), the base production (Target: Cintur**one**; Reading Error: Cintura), or through the root production (Target: Sospir**one**; Reading Error: Sospir*). Pseudoword productions may be realized through the substitution of the target suffix with another real suffix (Target: Tabell**one**, Reading Error: *Tabell**etto**) or through the substitution of the suffix target with a non-morphemic orthographic string of letters (Target: Bors**ello**; Reading Error: *Bors**etro**).

Code	Label	Description	Example	Target
B1	WBB	**Word production**: substitution of the base with another base	**Lattino**	**Lettino**
B2	WBO	**Word production**: substitution of the base with a non-morphemic orthographic string of letters	**Furetto**	**Muretto**
B3	PBB	**Pseudoword production**: substitution of the base with another base	**Pistello***	**Piattello**
B4	PBO	**Pseudoword production**: substitution of the base with a non-morphemic orthographic string of letters	**Scatone***	**Scalone**
B5	WOB	**Word production**: substitution of orthographic string of letters at the begging of the word with a base	**Barbone**	**Barone**
B6	WOO	**Word production**: substitution of orthographic string of letters at the begging of the word with another orthographic string	**Cammino**	**Camino**
B7	POB	**Pseudoword production**: Substitution of orthographic string of letters at the begging of the word with a base	***Frasetto**	**Farsetto**
B8	POO	**Pseudoword production**: Substitution of orthographic string of letters at the begging of the word with another orthographic string	***Muschetto**	**Mughetto**

Table 3- MCS for base change

Code	Label	Description	Example	Target
S1	WSS	**Word production**: substitution of the suffix with another real suffix	**Bicchierone**	**Bicchierino**
S2	WSO	**Word production**: substitution of the suffix with a non-morphemic orthographic string of letters		
S3	BP	**Base production**: deletion of the suffix	**Cintura**	**Cinturone**
S4	RP	**Root production**: deletion of both the suffix and the thematic vowel	**Sospir***	**Sospirone**
S5	PSS	**Pseudoword production**: substitution of the suffix with another real suffix	**Tabelletto***	**Tabellone**
S6	PSO	**Pseudoword production**: substitution of the suffix with a non-morphemic orthographic string of letters	**Borsetro***	**Borsello**

Table 4- MCS for suffix change

To apply our MCS, we moved from a reading aloud task of (pseudo)-alterate complex words performed by a group of Italian children. In this task, 63 children attending 4th and 5th grades were dived in 42 good readers (M:17; F:25) and 21 poor readers (M:9; F:12). The two groups were matched for age and non-verbal intelligence (Raven's Colored Progressive Matrices). Poor readers scored at least 1,5 standard deviations below norms for speed or accuracy in text reading (Cornoldi & Colpo, 1995) and/or in more than two subtests of the Word and non-word reading test (Zoccolotti, et al., 2005). All children had to read aloud 206 (pseudo)-alterate words representing four levels of morphemic transparency: 62 with suffixed transparent alteration (e.g, *lettino*), 43 with suffixed opaque alteration (e.g. *lampadina*), pseudosuffixed with real base (e.g. *girino*), pseudosuffixed without real base (e.g *delfino*). The four groups were matched for word frequency and base-word frequency, neighbourhood size of words and base-words but not for stimulus length. All reading productions were audio-recorded and all reading errors were transcribed. Collected all reading errors in a dataset and, looking at them with morphological "eyes", two independent coders applied the MCS to the transcripts, reaching a good level of inter-raters agreement (Cohen's K = .72). As for reading errors from derived words, most erroneous productions were morphological errors (94%), namely, they respected the morphemic structure base + suffix of (pseudo)-complex targets. 37% of these morphological reading errors were words, while 63% were pseudowords. Children tended to reproduce morphemic constituents but in inexistent base + suffix combinations for Italian language.

The analysis of the erroneous productions allowed us to assess the role of morphemic transparency in detecting and processing morphemic constituents. Chi square test (X^2 =29.87, p < .001), comparing the word production as morphological errors in suffixed words with transparent alteration (e.g, *lettino*) and suffixed words with opaque alteration (e.g. *lampadina*), showed that base substitution with another real base has a higher percentage in transparent base + suffix combination (100%) than in opaque combination (50%). Another chi square test (X^2 =8.56, p = .014), comparing the word production as morphological errors in suffixed words with transparent alteration and suffixed words with opaque alteration, showed that suffix substitution with another real and consistent suffix has a higher percentage in transparent base + suffix combination (62%) than in opaque combination(30%). Thanks to the morphological richness of Italian language, children find easy to substituting bases and suffixes with other real and legal morphemic constituents. Moreover, we carried out hierarchical log-linear models to assess the relationships between Group (good *vs* poor readers), Morphemic Transparency (suffixed transparent alteration; suffixed opaque alteration; pseudosuffixed with real base; pseudosuffixed without real base), Lexicality of morphological errors (word *vs* pseudowords), and misread Constituent (base *vs.* suffix). The best-generated model produced two significant effects (χ^2= 9.7, df = 10, p= .467). A two-way interaction between Lexicality and misread Constituents (X^2 =48.56, p < .001) revealed that the morphological reading errors resulting in word productions are mainly associated to the substitution of both constituents base and suffix. Again, thanks to the morphological richness of Italian language, children have available may real base + suffix combinations other than (pseudo)-alterate targets. Another two-way interaction between Lexicality and Morphemic Transparency showed (X^2 =50.36, p < .001) that the lower the morphemic transparency, the higher the probability of producing a pseudoword as morphological reading error instead of the word target. Children are likely to morphologically decompose both alterate words than pseudo-alterate words, but reading pseudo-alterate (e.g. *delfino*) they have available less base + suffix combinations leading to other words.

DISCUSSION

Most errors produced by Italian children when read aloud derived and (pseudo)-alterate words have a morphemic structure similar to the target. In these morphological errors, morphemic boundaries are preserved indicating the presence of morphemic parsing in the reading aloud of young readers in Italian. Despite the transparent orthography, Italian children make use of reading units such as morphemes at a grain-size that is wider than single letters. Our pattern of results may support the view that the developing lexicon is organized around morpheme units (Feldman and colleagues, 2002; Rabin and Deacon, 2008) in English, and developing readers are able to activate morphological representations directly when reading morphologically complex words. Morphological classifications of reading errors may play a role in assessing morphological parsing strategies during reading morphologically complex words: children seem to decompose complex targets and produce other real or unreal morphemes combinations. Certainly, further morphological classifications of reading errors are desirable in children at earlier grades of primary school, to provide further evidence of morphological processing in early phase of reading acquisition and to provide more data in favour of the developmental trajectory of morphological parsing process. That being said, Italian children at 4th and 5th seem to still use morphemic chunks to read morphologically complex words, at least looking at reading error types they are producing.

Rehabilitative interventions based on morphological training aimed at increasing morphological awareness have shown good results in children with dyslexia (Elbro, & Arnbak, 1996; Marinus, de Jong, & Van Der Leij, 2012; Tsesmeli e Seymour 2009). Teaching to relying on morphemes as small group of letters may improve children performances in text comprehension and writing. It might be useful looking at different types of morphological error performed by single child in reading aloud tasks, to organizing a more specific morphological training thought for each child.

Data from morphological coding schemes of reading errors are consistent with the parallel dual-route model proposed by Grainger, & Ziegler (2011). In this model, where two parallel orthographic routes have been postulated, the role of morphology in reading acquisition takes place and interesting cues to make up rehabilitative intervention are offered. In the faster route, the system uptakes the information about the presence of letter combinations, without precise positional information (*coarse-grained orthography*) to reach target identification as soon as possible. In the slower but more precise route, when there are letters that co-occur very often in the language (e.g., affixes), they can be grouped (chunking) to form higher-level orthographic representations (*fine-grained orthography*), coding precise information about the ordering of letters in the string. This kind of orthographic route leads to an improvement in the process, thanks to the reduction of units to be activated. Both the routes send activation to a whole-word level, in which only the representation corresponding to the visual input enables the associated meaning to be activated. In this model, morphological awareness is represented in the whole-word representations and emerges from the overlapping of several words in form and meaning. In processing complex words through the fine-grained orthography route, morpho-orthographic segmentation of the string leads to the activation of the stem and the affixes. These representations send activation to the whole-word level and, thanks to the special connectivity among words sharing form and meaning, the activation of the complex target is enabled. This model can be useful for understanding how children learn to read. The main task of beginning readers is to associate letter identities with sounds that resemble whole-word phonological representations of known words. Each successful decoding can provide beginning readers the opportunity to create connections between the word form and the meaning. Through the repeated exposure to printed words and the serial procedure of the phonological recoding, a parallel letter processing develops. Children begin to codify letter strings through location-specific letter detectors, which gradually leads to the coarse-grained and fine-grained routes. An improvement of reading acquisition can be obtained through developing the fine-grained processing route, i.e. the route providing access to semantics via phonological and morphological representations. In this way, children are helped in detecting frequently co-occurring letter combinations, favoring chunking. The useful chunking ability gained by children may be proved by the presence of morphological reading errors: morphemic constituents they reproduce in reading errors are chunks they detected in complex word stimuli. In learning to read, a child can learn that a contiguous sequence of letters corresponds to pre-existing phonological and/or morphological representations, acquired in spoken language. If the description of reading acquisition made by Grainger and Ziegler (2011) has a good fitness to the real process, teachers might try to improve the learning of the fine-grained orthography mechanism and in poor readers and in children with dyslexia (Traficante, 2012).

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CHAPTER 4

From morphemes to orthographic-semantic patterns: evidence from Orthography-Semantics Consistency in word recognition of English children

INTRODUCTION

The meaning of a morphological derived word can be more or less associated to the meanings of its constituent morphemes: a word like *farmer* can be easily interpreted given the meaning of its root *farm* (this is an example of a semantically "transparent" derived word), whereas in a word like *corner* root meaning is not fully maintained (this is an example of a semantically "opaque" word). Morphological processing studies have focused on the role played by this semantic transparency in the recognition of derived words, and in order to assess how semantic transparency of morphologically complex words affects the initial phases of visual word recognition, masked priming has been used as the principal experimental paradigm. From a developmental point of view, if the recognition of a stem target (e.g., *farm*) is facilitated by the prior presentation of a related derived form (e.g., *farmer*) compared to a control prime, this would mean that children are able to detect the stem (*farm*) while they process the derived form (*farmer*), and this is in line with the 'morpheme-as-reading unit' assumption (Traficante, 2012). Typically, transparent and opaque derived primes are compared for their effectiveness in facilitating the identification of their real and pseudo-stem targets. Priming effects in adults and children have been regularly observed for both transparent and opaque prime-target pairs (that is, for both *farmer-farm* and *corner-corn*), although differences in the effect magnitude are still debated (Rastle et al, 2004; Rastle, & Davis, 2008; Feldman et al, 2009).

However, Marelli and coauthors in their study (2015) underlined for the first time a curious side effect often emerging from morphological masked priming studies: target stems in derived words categorized as transparent (*e.g.* farmer-FARM) elicit faster response times than target stems from the opaque condition (*e.g.* corner-CORN), independently of prime type (related or unrelated) and even in experimental contexts unrelated to priming. Table 1 (Marelli et al., 2015) shows average latencies for transparent and opaque pairs in several relevant studies of morphological priming, namely, those that (a) have stems as visually-presented target words; (b) employ lexical decision as the task; (c) are run on native speakers of the language of interest; and (d) include both a transparent and an opaque condition in a between-target design. "Transparent" targets are systematically faster to recognize than "opaque" targets in the English language and the effect is quite strong in most of the studies taken into account. The hypothesis of Marelli and colleagues (2015) is clear: "transparent" words and "opaque" words are characterized by how consistently each stem form is associated to its meaning, namely, how informative any particular orthographic string is about the meaning of the word it identifies. "Transparent" words with strong association between form and meaning are easier to recognize than "opaque" words with weak association between form and meaning.

	Language Investigated	Opaque Stems	Transparent Stems	Effect Size
Rastle et al. (2000), Exp. 1	English	612 ms	582 ms	31 ms
Devlin et al. (2004)	English	673 ms	639 ms	34 ms
Rastle et al. (2004)	English	616 ms	586 ms	30 ms
Lavric et al. (2007)	English	688 ms	666 ms	22 ms
Morris et al. (2007)	English	669 ms	648 ms	21 ms
Marslen-Wilson et al. (2008)	English	548 ms	531 ms	17 ms
McCormick et al. (2008), Exp. 4	English	627 ms	607 ms	20 ms
Rueckl & Aicher (2008), Exp. 1	English	648 ms	613 ms	35 ms
Rueckl & Aicher (2008), Exp. 2	English	667 ms	626 ms	41 ms
Feldman et al. (2009)	English	650 ms	617 ms	33 ms
Diependaele et al. (2011), Exp. 1	English	592 ms	589 ms	3 ms
Andrews & Lo (2013)	English	576 ms	579 ms	-3 ms
Diependaele et al. (2005), Exp. 1*	Dutch	629 ms	619 ms	10 ms
Diependaele et al. (2009), Exp. 1	Dutch	599 ms	584 ms	15 ms
Diependaele et al. (2009), Exp. 3*	Dutch	602 ms	583 ms	19 ms
Longtin et al. (2003), Exp. 1	French	629 ms	631 ms	-2 ms
Diependaele et al. (2005), Exp. 2*	French	623 ms	608 ms	15 ms
Marelli et al. (2013), Exp. 2	Italian	631 ms	594 ms	37 ms
Kazanina et al. (2008)	Russian	662 ms	643 ms	19 ms
Kazanina (2011), Exp. 2	Russian	679 ms	666 ms	13 ms

Table 1: Average response latencies in the transparent and opaque conditions of published visual masked priming experiments. *only RTs on visually presented prime-target pairs were considered.

Table 1- Marelli et al., (2015), page 3

From this point of view, it might be concluded that morphological priming experiments do not provide information only about how (pseudo-)complex words are morphologically parceled out, but they may also reveal the existence of two groups of simple words (*i.e*., the stem targets) that are distinct for some linguistic property. Moreover, the authors validated a possible "stem transparency" effect, testing English words used as stem targets for opaque and transparent primes in published priming studies. More precisely, they tested the difference on lexical decision latencies extracted from the British Lexicon Project (BLP, Keuleers et al., 2012) between a group of stem words that were originally part of a set of transparent pairs and a group of stem words that were originally part of a set of opaque pairs. Again, stems extracted from transparent sets are recognized faster than stems extracted from opaque sets, even in an experimental context completely unrelated to priming techniques such as a pure lexical decision task. The authors explained this latency difference between the two groups of words as related to how reliable each word is as an orthographic cue for its meaning. At one end of the *continuum* there are stems which always appear in words whose meaning is related to their own, namely, when the orthographic information is consistently associated with a particular meaning (e.g., the stem *widow* in words like *widower*, *widowed*, *widowhood*); on the other hand there are stems appearing in words where their meaning is not maintained (e.g., the stem *whisk* in words like *whisky*, *whiskey*, *whisker*, *whiskered*), that are not very reliable orthographic cues for their semantics. Marelli et al., (2015) supposed that the so-called "semantic transparency" effect may be associated with a new measure that reflects the extent to which a word is a reliable orthographic cue for its semantics, and they proposed the Orthographic-Semantic Consistency (hence OSC) measure.

The OSC measure was computed by the authors in the following way. First, orthographic relatives were collected for each stem target, selecting all words starting with these items from a list including the top 30k most frequent content words (*i.e*., nouns, verbs, adjectives, adverbs) in a 2.8-billion corpus. Then, in order to compute a measure of semantic similarity between a word and each of its orthographic relatives, a distributional semantics model based on the assumption that the meaning of a word can be approximated by the way that word co-occurs with other words in the lexicon was constructed[2]. The more two words tend to occur with the same set of other words in similar contexts, so basically the more they co-occur, the more the vectors that represented them will be close, the more their meanings will be considered to be similar. This equates to measuring the cosine of the angle formed by the two vectors: the more similar the vectors, the smaller the angle between them and the higher their cosine. Given a target word and the set of its *k* orthographic relatives, OSC was computed as the frequency-weighted average semantic similarity. In formal terms:

$$OSC(t) = \frac{\sum_{x=1}^{k} f_{r_x} * \cos(\vec{t}, \vec{r_x})}{\sum_{x=1}^{k} f_{r_x}}$$

Where t is the target word, r_x each of its k orthographic relatives, and f_{rx} the corresponding frequencies extracted from the above described corpus. Since cosine values range from 0 to 1, the resulting OSC measure is a 0-to-1 score where values close to 0 identify words that are bad orthographic cues for their associated meanings, and values close to 1 indicate an almost perfect association between form and meaning.

Computing OSC value for each target, a linear regression was carried out having reaction times extracted from the BLP as a function of OSC values. It is worth noting that the average OSC was significantly different in the transparent set and opaque set, with the former showing larger OSC values than the latter. OSC had facilitatory effects on reaction times: the higher the OSC values the faster the reaction times. To summarize, OSC showed a significant effect in the expected direction: stems taken from transparent sets have significantly higher OSC than stems taken from opaque sets, and OSC has a facilitatory effect on reaction times in a pure lexical decision task.

This pattern of results suggests that the main effect of semantic transparency on simple stem targets in priming experiments may be explained by considering how much, across the whole lexicon, the orthographic information carried by the stem is consistent with its associated semantics. In conclusion, the grouping based on the semantic properties of the derived forms also identifies two sets of stems that are distinguishable for their level of OSC.

Subsequently, the authors extended the OSC effect to general word processing, assessing another larger dataset of words extracted from the BLP, for which OSC values were computed. Again, OSC showed facilitatory effect on reaction times in a lexical decision task.

[2] The distributional semantics model was built by using a large part-of-speech tagged and lemmatized corpus, formed by a concatenation of the ukWaC (http://wacky.sslmit.unibo.it/), English Wikipedia (http://en.wikipedia.org/), and BNC (http://www.natcorp.ox.ac.uk/) corpora (about 2.8 billion words in total).

It might be supposed that the facilitation for both transparent and opaque items observed in some priming studies may be explained by the OSC distributions in the target sets, since they both may include words characterized by high values of OSC. Item samples will be more or less likely to elicit a priming effect on the basis of their average OSC.

Moreover, the OSC effect fits with the learning models that consider morpho-lexical effects as emerging at the interface between orthography and semantics (Plaut & Gonnerman, 2000; Baayen, Milin, Durdevic, Hendrix, & Marelli, 2011). In these learning models based on connectionist networks, a word will be more difficult to process when part of opaque derived forms (see Andrews and Lo, 2013) because of competition during the learning process. Indeed, the same orthographic information (e.g., *whisk*) is associated with several meanings in this case (e.g., *whisky, whiskey, whisker, whiskered*), with the result that it becomes a relatively unreliable cue for the associated semantic representation. OSC is a natural consequence of the learning process implemented in these connectionist models, and it can be considered a proxy of the distributed nodes/weights linking orthography to semantics. For example, the Naïve Discriminative Reader (NDR) model (Baayen et al., 2011), accounting for morphological effects in word processing, provides a morphological model that does not rely on explicit morpheme representations, rather focusing on form-meaning statistical patterns that emerge in word distributions such as form-meaning patterns described by the OSC measure. NDR supposes that, over and above morphology, children may be sensitive to systematic relations between forms and meanings since when they are learning, they are learning to distinguish, and chunks of graphemic symbols may help them to distinguish between different meanings.

Andrews and Lo (2013) accounted for their masked priming results proposing that the association between an opaque derived word and its (pseudo-)stem (*e.g.*, *corn*) may be difficult to learn, and hence weaker, because of their similarity in form and their discrepancy in meaning. The OSC results added that, under simpler conditions of lexical decision when skilled readers are just presented with isolated stems, the knowledge that those stems have opaque and/or transparent derived forms is stored in the mental lexicon, and influences the way they are processed even when (pseudo-)morphological relatives are not presented as part of the experimental paradigm. In this sense, “opaque" stems may be worse symbols than “transparent" stems, which may lead to slower response times. Therefore, masked morphological priming effects may reflect a greater ease of learning transparent derived words due to their pairing with high OSC stems in comparison to opaque derived words containing lower OSC stems. The OSC effect found by Marelli and colleagues in adults clearly indicates that word processing is influenced by a distributional property such as the OSC measure: the distribution of form and meaning in the lexicon or, in other words, the strength of the association between orthography and semantics, contributes to determining how easily a word is recognized.

Our aim was to construct and validate the OSC measure from a developmental point of view, in order to investigate whether OSC plays a role in children’s word processing, similar to the role observed in adult studies (Marelli et al., 2015). Indeed, an OSC effect in children’s word processing may show that children are sensitive to some orthographic-semantic patterns occurring in words when they are learning to read.

The consolidated assumption of morphemes as representational units at the lexical level in morphologically complex word processing has been recently questioned by a complex scenario of results that have emerged from some morphological processing studies performed on adults (see Amenta, Marelli, and Crepaldi (2015); Marelli et al., (2013); Tsang and Chen, 2014). Moreover, this morpheme as representational unit assumption seems to fit uncomfortably with many of the results from developmental studies as well (see, for example, the complex set of results from morphological masked priming studies such as Beyersmann, Castles, & Coltheart, 2012; Quémart & Casalis, 2014; Quémart, Casalis, & Colé, 2011; Shiff, Raveh, & Fighel, 2012). Taking into account all this evidence on adults and children, it is worth noting that morphological effects observed in morphologically complex word recognition might not be explained through dedicated mental representations, rather through more general-purpose mechanisms that capture statistically-strong orthographic-semantic patterns, namely, orthographic-semantic patterns that frequently occur in written language and become symbols or reliable cues which rely on. Indeed, recent studies have shown that orthographic-semantic associations, which are not morpheme-mediated, have a role to play in word processing as well (see Marelli et al., 2015; Bergen, 2014), and the crucial role played in reading by the distributional properties of both the complex word and its morphemic constituents highlights the limits of the ‘morpheme-as-unit’ assumption. The OSC measure, as a distributional property of the language based on orthographic-semantic patterns, represents a new example of how distributionally-based orthographic-meaning associations, over and above morphological considerations, are central to word reading and, especially, to word reading acquisition. Therefore, words with high OSC values may act as representational cues, or symbols, more successfully than words with low OSC values and children might be affected by the OSC measure showing reliance on orthographic-semantic patterns.

In order to pursue our aims, we designed a morphological masked priming with lexical decision task (Experiment 1) and, then, a simple lexical decision task (Experiment 2), using the same sample of stem targets. In the morphological masked priming task stem targets were divided into the usual three conditions (i.e., transparent, opaque, and form condition); in the simple lexical decision task the same stem targets were varied according to OSC value. Our expectation was twofold: in the morphological masked priming task, stem targets in the transparent condition will reveal higher OSC values than stem targets in the opaque condition (see Marelli et al., 2015); in the lexical decision task, the OSC variable will affect latencies, namely, the higher the OSC values, the faster the response times. The morphological masked priming task (Experiment 1) will be described first and then the pure lexical decision task (Experiment 2).

Experiment 1. *Morphological masked priming task*

METHOD

Participants

Thirty-four children (18 F; 16 M) of a primary school in Dundee, Scotland (UK) recruited from two 7th grade classes (chronological age *M*=11.2; *SD*=0.4) took part in the experiment. All participants had normal or corrected to normal visual acuity, and their nonverbal IQ level based on scores on the *Raven's Coloured Progressive Matrices* (Raven, 1962) fell within normal range. Children performed three screening standardized tests: British Ability Scales (*BAS*) Word Reading Test (Elliot, Murray & Pearson, 1983); Test of Orthographic Choice (*TOC*) (Kohnen, Anandakumar, McArthur, & Castles, 2012); Wechsler Intelligence Scale for Children- Revised (*WISC-R*) Expressive Vocabulary Test (Wechsler, 1981). Children obtained mean standardized scores within the average range in each of the three screening tests (see Table 1).

	CA (years)	RA (years)	RAVEN (percentile)	WISC Vocabulary (standard score)	TOC (percentile)
	11.2	11.3	62	9.2	61
	(0.30)	(0.30)	(18)	(2)	(24)

Table 1- Mean chronological age (CA), mean BAS Reading Age (RA), mean performance on Raven's and WISC-R Vocabulary tests, and Test of Orthographic Choice (standard deviations in parentheses).

Materials

Eighty-four prime-target pairs were selected from the Children's Printed Word Database (CPWD, Masterson, Dixon and Stuart, 2003), and assigned evenly across three conditions. In the transparent condition, primes and stem targets constituted a genuine morphological and semantic condition, (e.g., farmer–FARM). In the opaque condition, primes and targets were semantically unrelated but shared an apparent morphological relationship (*e.g*., corner–CORN). In the form condition, primes and targets had a purely orthographic relationship (*e.g*., spinach-SPIN). Eighty-four control unrelated primes were also chosen. These were existent, morphologically complex English words, which did not have any relationship (semantic, morphological, or visual) with the corresponding targets. Targets were matched across condition for word frequency (CPWD, Masterson, Dixon and Stuart, 2003) and word length (see Table 2). Related primes and paired control unrelated primes were matched for the same variables (see Table 2).

The assignment of word targets to the two priming conditions was counterbalanced over participants, so that all participants received both related and unrelated primes but saw each target only once. This was achieved by presenting different groups of participants with two experimental lists containing different experimental items – each group saw only one list. In each list, there were the same 42 orthographically related prime-nonword pairs and 42 unrelated prime-nonword pairs, and the same 26 filler word prime-target pairs and 26 nonword filler pairs. All nonwords were orthographically legal and pronounceable. Each list was split into two parts with a break in between in order not to tire the children.

	Condition			
	Transparent	Opaque	Form	Anova
Word Frequency (P)	31.61	35.92	37.32	F(2.81) = 0.08, n.s.
Word Length (P)	6.29	6.11	6.29	F(2.81) = 0.38, n.s.
Word Frequency (T)	56.71	69.86	72.07	F(2.81) = 0.28, n.s.
Word Length (T)	4.21	4.07	3.93	F(2.81) = 1.15, n.s.

Table 2 - Matching of word frequency and length variables for targets and primes

Procedure

The experimental task was morphological masked priming followed by a lexical decision task. E-Prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2002) was used to control the presentation of the stimuli and for the registration of the reaction times (RTs) and errors. Participants were tested individually away from their classroom. The task was explained to them first verbally and then instructions were displayed on the PC screen and read aloud to them. Stimuli were presented in Courier New 40 point font and as white lettering on a black screen. Participants were given six practice trials before starting the experiment providing feedback each time. A fixation cross (+) was presented for 1000ms, followed by the mask (########) for 500ms, then the prime in lowercase for 57ms and the target in uppercase until a key was pressed or for 5000ms. Targets were presented in a random order determined by the software for each participant. The string of letters appeared on the screen centre and they had to decide if they were a real word or a made-up word and then press the correct response key on the response box (the right one, for yes responses; the left one, for no responses), as quickly and as accurately as possible. No feedback was provided for experimental targets.

Data analysis

The reaction times (RTs) analysis was performed only on correct responses. Responses with particularly long latencies (defined as two or more SD from RT mean by participants) or with RTs faster than 500 ms were considered as outliers and were excluded from the analysis. Two target words were removed, because error rates were above 50 %.

Reaction times were logarithmically transformed in order to obtain a Gaussian-like distribution. Linear Mixed-Effect (LME) models were carried out on reaction times (RTs) data for word targets using the lme4 package (Bates, Maechler, Bolker, & Walker, 2014) in the statistical software R (Version 3.0.3; RDevelopmentCoreTeam, 2008). This analysis approach is suited to the present research as it allows the effects of crossed and nested subject and item factors to be considered within a single analysis. It allows generality to be assessed over both participants and items while statistically controlling for a number of sources of extraneous variability. Indeed, previous applications of this approach have shown that, even when stimuli are carefully matched and counterbalanced, residual effects of stimulus attributes, list construction and trial sequence can explain substantial, systematic variance in RTs, and that partialling out this variance can both eliminate artefactual effects and increase power to detect real effects (Baayen, Davidson, & Bates, 2008). In our analysis, RTs were introduced as the dependent variable, participants and items as random effects, and relatedness (related; unrelated) and condition (transparent, opaque and form) were considered as categorical fixed effects.

The effects of interest here (fixed effects) were those associated with the experimental manipulations, that is, *relatedness* (control vs. related prime), *condition* (transparent vs. opaque vs. form), and their mutual interaction. Random intercepts for participants and items were also introduced. Effects were evaluated one by one on the basis of likelihood ratio tests and atypical outliers were identified and removed (employing 2.5 SDs of the residual errors as a criterion). P-values were determined using the package lmerTest (Kuznetsova, Brockhoff, & Christensen, 2014).

RESULTS

The interaction between *relatedness* and *condition* was significant (t=2.20, p=.02). No significant priming effect emerged either in the form condition or in the opaque condition. However, a significant effect was found in the transparent condition: RTs were shorter for target words preceded by a morpho-semantically related prime, in comparison with target words preceded by an unrelated prime. Table 3 reports the parameters of the significant effects included in the final model.

Fixed effects	Estimate	*SE*	*t* value	Pr(>|*t*|)
Intercept	7.01	0.03	189.08	.0001
Relatedness: related	0.01	0.02	0.69	.4870
Condition: opaque	0.01	0.04	0.43	.662
Condition: transparent	0.05	0.06	2.01	.05
Relatedness: related * condition: opaque	0.02	0.08	0.73	.46
Relatedness: related * condition: transparent	-0.06	0.08	2.25	.03

Table 3 - Fixed effects in the final model

DISCUSSION

This morphological masked priming study showed a very clear pattern of results in the field of developmental studies on morphological processing. Children showed priming effects in the semantically transparent condition only, namely, when prime and stem target shared a true morphological-semantic relationship. First, this confirms a reliable assumption in the literature, namely that children are able to activate a morphological decomposition process when they are reading morphologically complex word because they are able to recognize and use morphemes. Moreover, it can be supposed that morpho-orthographic decomposition mechanisms become automatized in a later stage in reading development (Beyersmann, Castels, & Coltheart, 2012). Even at this advanced stage in reading development, automatic form-based decomposition may not appear to occur and the morphological decomposition process may not be semantically "blind".

How did we compute OSC measure?

First, we focused on the orthographic relatives of each of the stem targets and, in order to collect them, we used the Children's Printed Word database (http://www.essex.ac.uk/psychology/cpwd/website) developed by Stuart, Masterson, Dixon & Quinlan (1996) and based on words which appear in books for children in primary school. This website allows a list of words to be generated "containing a specific digraph or larger group of letters". By considering stem targets as groups of letters contained in other words, we were able to generate our list of orthographic relatives for each stem target. Once all of the orthographic relatives for each stem target had been collected, we applied the original OSC formula designed by Marelli and colleagues in this way:

$$\mathbf{OSC}(t) = \frac{\sum_{x=1}^{k} (fr_x * LSA)}{\sum_{x=1}^{k} fr_x}$$

Where (t) is the target word, r_x each of its k orthographic relatives, and fr_x the corresponding frequencies extracted from the Children's Printed Word database. As shown in the formula, in order to compute OSC, we used Latent Semantic Analysis (LSA) values in place of the distributional semantic measures adopted by Marelli and coauthors. For this reason, we refer to our measure an LSA-based OSC.

LSA is a theory and method for extracting and representing the contextual-usage meaning of words by statistical computations applied to a large corpus of text (Landauer, & Dumais, 1997). The underlying idea is that the totality of information about all the word contexts in which a given word does and does not appear provides a set of mutual constraints that largely determines the similarity of meaning of words and sets of words to each other. This type of method determines and represents the similarity of meaning of words and passages by statistical analysis of large text corpora. After processing a large sample of machine-readable language, LSA represents the words used in it, and any set of these words-such as those contained in a sentence, paragraph, or essay, either taken from the original corpus (or new) as points in a very large (e.g. 50-1,000) dimensional semantic space. LSA is based on a mathematical matrix decomposition technique similar to factor analysis that is applicable to databases approaching the volume of relevant language experienced by people. Word representations derived by LSA are estimated to be able to simulate a variety of human cognitive phenomena, from acquisition of recognition vocabulary to sentence-word semantic priming.

From the http://lsa.colorado.edu/ website, the "One-to-Many Comparison" tool was used to compute the LSA value between stem targets and each orthographic relative. This tool allows comparison of the semantic similarity of multiple items within a particular LSA space. Once the suitable topic space has been selected, one central item is chosen for comparison with each of the other items. The system computes a similarity score between -1 and 1 for each pairing between the main item and the other submitted items.

Therefore, our LSA-based OSC measure has been computed as the sum of the product of the frequency and LSA value of each orthographic relative, divided by the sum of the frequencies of all orthographic relatives. The resulting LSA-based OSC measure is a 0-to-1 score where values close to 0 identify words that are bad orthographic cues for their associated meanings, and values close to 1 indicate an almost perfect association between form and meaning. For example, a stem like *whisk* will reach LSA-based OSC values close to 0 as it appears in words (*whisky*, *whiskey*, *whisker*, *whiskered*) where the meaning is not maintained, and it is not a very reliable orthographic cue for semantics; whereas a stem like *widow* will reach LSA-based OSC values close to 1 as it appears in words (*widower*, *widowed*, *widowhood*) where the orthographic information is consistently associated with a particular meaning.

Experiment 2. *Lexical decision task*

METHOD

Participants

The same participants as in Experiment 1.

Procedure

The experimental task was a lexical decision task. E-Prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2002) was used to control the presentation of the stimuli and for the registration of the reaction times (RTs) and errors. As the stem targets used as stimuli were the same as those in the morphological masked priming of Experiment 1, Experiment 1 and Experiment 2 were separated by ten days. Participants, tested individually, had to decide whether a string of letters formed an English word or not. They were instructed that, when a letter string appeared in the center of the PC screen, they had to press the correct response key on the keyboard (right for yes responses; left for no responses), as quickly and as accurately as possible. Reaction times and errors were recorded. No feedback was provided. Each stimulus, printed in capital letters, was preceded by a fixation point (1000 ms), and disappeared when the response button was pressed, or after 3,000 ms had elapsed. A practice session of four targets preceded the experiment and feedback was provided.

Materials

The 84 words used in Experiment 1 as the stem targets in the prime-target pairs were involved in this lexical decision task. Stem targets were matched for word frequency (CPWD, Masterson, Dixon and Stuart, 2003) and word length (see Table 2), but they spanned a low-to-high LSA-based OSC range (*Min*: 0.01; *Max*: 0.82; $M = 0.30$; $SD = 0.16$). In order to exclude words with LSA-based OSC = 1 that could have distorted the distribution of the variable of interest, each stem target had at least one orthographic relative over and above itself (Marelli et al., 2015).

Data analysis

The reaction times (RTs) analysis was carried out only on correct responses to words. Responses with particularly long latencies (defined as two or more SDs from the RT mean by participants) or with RTs faster than 500 ms were considered as outliers and were excluded from the analysis. Two target words were removed because error rates were above 50 %. Reaction times (RTs) were logarithmically transformed in order to obtain a Gaussian-like distribution and were introduced as the dependent variable. We decided to treat LSA-based OSC as a continuous variable and not dichotomized because when dealing with naturally continuous variables such as reaction times, a continuous indicator is to be preferred to its dichotomized counterpart in terms of both statistical power and estimation accuracy (Marelli et al., 2015).

RESULTS

First, we took into consideration stem targets included in the transparent and opaque conditions of the former morphological masked priming task, and we assessed the density distributions of LSA-based OSC in these two sets. It turned out that the average LSA-based OSC was significantly different in the transparent-set stems versus the opaque-set stems (Marelli et al., 2015) ($t(54) = 4.18$; $p = .0001$), with the former showing larger OSC than the latter ($M = 0.32$, $SD = 0.18$ vs. $M = 0.13$, $SD = 0.01$ respectively). Then, in order to assess whether the LSA-based OSC measure affected lexical decision latencies of children, we carried out a linear regression analysis with RTs as a function of LSA-based OSC values. This analysis showed a significant facilitatory effect of LSA-based OSC on latencies ($b = -0.306$; $t = -2.742$; $p = .008$): the higher the OSC values the faster the response times performed by children.

Marelli and colleagues (2015) proposed consideration of the combined effects on word recognition of the OSC measure and morphological family size (henceforth FS). Family size, namely, the type frequency of the morphologically complex words in which each stem appears (De Jong, Schreuder, & Baayen, 2000), was computed in our study using the Children's Printed Word database. This count revealed that we did not match for the FS of stem targets across the three experimental conditions (transparent, opaque, form) in the preceding masked priming experiment: FS values were higher in the transparent set compared to the opaque set ($p = 0.003$) and to the form set ($p = 0.04$). For this reason, we decided to include FS as a covariate along with the LSA-based OSC measure in a linear regression analysis. LSA-based OSC continued to show a significant facilitatory effect on latencies ($b = -0.329$; $t = -2.673$; $p = 0.009$), while FS did not show any significant effect. Therefore, the LSA-based OSC effect may be considered independent from possible mismatching in terms of family size.

DISCUSSION

In this second experiment, we built an LSA-based OSC, a measure of Orthography-Semantics Consistency exploiting Latent Semantic Analysis. We observed that LSA-based OSC showed significant effects on children's visual word recognition in the expected direction. Looking at the targets in the preceding morphological masked priming task (Experiment 1), stems taken from the transparent set had significantly higher LSA-based OSC values than stems taken from opaque set. Moreover, LSA-based OSC had a facilitatory effect on reaction times in the later lexical decision task (Experiment 2): the higher the LSA-based OSC values, the faster the latencies. Therefore, the main effect of semantic transparency on simple stem targets in the priming experiment may be explained by considering the degree to which, in the mental lexicon, the orthographic information contained in the stem is consistent with its associated semantics. Rather than the condition of semantic transparency, it may be that high values of (LSA-based) OSC facilitate children's stem recognition in morphological priming experiments, as measures based on orthographic-semantic consistency appear to affect children's word reading.

GENERAL DISCUSSION

Marelli et al., (2015) demonstrated that the OSC measure, quantifying the consistency of the orthographic and semantic information conveyed by words, influences adults' visual word access, even when target words are isolated stems. Following on from this , we extended this work to ask whether a word like *corn* would also be processed more slowly by children than a stem word like *farm* even in experimental contexts when the corresponding (pseudo)-derived form (*corner* and *farmer*, respectively) was not presented to the children. Wondering about the semantic relations existing between a word and its orthographic relatives, we built our LSA-based OSC measure focused on English-speaking children and we assessed how it facilitates children's visual word processing. In developmental priming studies, facilitation in terms of latency found in the transparent condition may be not due to semantic transparency (only), rather facilitation may (also) be due to a high consistency between the orthography and semantics of the stem words. OSC in adults, and LSA-based OSC in children, indicates that word processing is influenced by the relative distribution of form and meaning in the lexicon or, in other words, indicates that the strength of the association between orthography and semantics contributes to determining how easily a word is recognized. For this reason, it can be supposed that children are able to capture form-meaning associative patterns embedded in words, and that these types of patterns may represent reliable cues to them. Looking at the learning process as an establishing of connections, associations, children may be able to exploit the associations (more or less consistent) of orthography and semantics that occur in words, thus, they may be able to exploit a distributional property such as OSC. Developing orthographic-semantic networks, children are able to connect simple elements (graphemes, phonemes, semantic features) into nodes. This kind of procedure may help them to build vocabulary up, especially in a language with opaque orthography such English where it is more challenging exploiting the whole word representations.

The OSC effect fits well with connectionist architectures (e.g., Plaut & Gonnerman, 2000; Baayen, Milin, Durdevifc, Hendrix, & Marelli, 2011) because it can be considered a proxy of the distributed nodes linking orthography to semantics. In these learning models that see lexical and morphological effects as emerging at the interface between orthography and meaning, a word will be more difficult to process when part of opaque derived forms because of competition during learning: the same orthographic information (e.g., *bat*) is associated with several meanings in this case (e.g., *bat*, *battery*, *battle*, *batman*), with the result that it becomes a relatively unreliable cue for the associated semantic representation (Marelli et al., 2015). The Naïve Discriminative Reader (Baayen et al., 2011) equates "learning" with "learning to distinguish", and provides a morphological model that does not rely on explicit morpheme representations, but instead focuses on form-meaning statistical patterns that emerge in word distributions. As children are learning to distinguish, they may be sensitive to form-meaning statistical patterns as discriminative cues (see LSA-based OSC effect). In conclusion, the LSA-based OSC property should be taken into account in future developmental word recognition studies of the English language. Further studies on children in the early years of primary school, and on children with reading disabilities, are clearly desirable and necessary in order to provide a more complete picture of this effect.

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CHAPTER 5

From morphemes to orthographic-semantic patterns: evidence from Orthography-Semantics Consistency in word recognition of Italian children

INTRODUCTION

The meaning of a morphological derived word can be more or less associated to the meanings of its constituent morphemes: a word like *farmer* can be easily interpreted given the meaning of their root *farm* (this is an example of semantically "transparent" derived word), whereas in a word like *corner* root meaning is not fully maintained (this is an example of semantically "opaque" word). Morphological processing studies have focused on the role played by this semantic transparency in the recognition of derived words, and in order to assess how semantic transparency of morphologically complex words affects the initial phases of visual word recognition, masked priming has been used as principal experimental paradigm. From a developmental point of view, if the recognition of a stem target (e.g., *farm*) is made faster by the previous presentation of a related derived form (e.g., *farmer*) compared to a control prime, this would mean that children are able to detect the stem (*farm*) while they process the derived form (*farmer*), and this is in line with the 'morpheme-as-reading unit' assumption (Traficante, 2012). Typically, transparent and opaque derived primes are compared for their effectiveness in facilitating the identification of their real and pseudo stem targets. Priming effects in adults and children have been regularly observed for both transparent and opaque prime-target pairs (that is, for both *farmer-farm* and *corner-corn*), although differences in the effect magnitude are still debated (Rastle et al, 2004; Feldman et al, 2009).

Marelli and colleagues (2015) have underlined for the first time a curious side effect often emerging from morphological masked priming studies: target stems in derived words categorized as transparent (*e.g.* farmer-FARM) elicit faster response times than target stems from the opaque condition (*e.g.* corner-CORN), independently of prime type (related or unrelated) and even in experimental contexts unrelated to priming. Table 1 (Marelli et al., 2015) shows average latencies for transparent and opaque pairs in several and relevant studies of morphological priming, namely, those that (a) have stems as visually-presented target words; (b) employ lexical decision as task; (c) are run on native speakers of the language of interest; and (d) include both a transparent and an opaque condition in a between-target design. "Transparent" targets are systematically faster to recognize than "opaque" targets in English language and the effect is quite strong in most of the studies taken into account. The hypothesis of Marelli and colleagues (2015) is clear: "transparent" words and "opaque" words are characterized by how consistently each stem form is associated to its meaning, namely, how informative any particular orthographic string is about the meaning of the word it identifies.

	Language Investigated	Opaque Stems	Transparent Stems	Effect Size
Rastle et al. (2000), Exp. 1	English	612 ms	582 ms	31 ms
Devlin et al. (2004)	English	673 ms	639 ms	34 ms
Rastle et al. (2004)	English	616 ms	586 ms	30 ms
Lavric et al. (2007)	English	688 ms	666 ms	22 ms
Morris et al. (2007)	English	669 ms	648 ms	21 ms
Marslen-Wilson et al. (2008)	English	548 ms	531 ms	17 ms
McCormick et al. (2008), Exp. 4	English	627 ms	607 ms	20 ms
Rueckl & Aicher (2008), Exp. 1	English	648 ms	613 ms	35 ms
Rueckl & Aicher (2008), Exp. 2	English	667 ms	626 ms	41 ms
Feldman et al. (2009)	English	650 ms	617 ms	33 ms
Diependaele et al. (2011), Exp. 1	English	592 ms	589 ms	3 ms
Andrews & Lo (2013)	English	576 ms	579 ms	-3 ms
Diependaele et al. (2005), Exp. 1*	Dutch	629 ms	619 ms	10 ms
Diependaele et al. (2009), Exp. 1	Dutch	599 ms	584 ms	15 ms
Diependaele et al. (2009), Exp. 3*	Dutch	602 ms	583 ms	19 ms
Longtin et al. (2003), Exp. 1	French	629 ms	631 ms	-2 ms
Diependaele et al. (2005), Exp. 2*	French	623 ms	608 ms	15 ms
Marelli et al. (2013), Exp. 2	Italian	631 ms	594 ms	37 ms
Kazanina et al. (2008)	Russian	662 ms	643 ms	19 ms
Kazanina (2011), Exp. 2	Russian	679 ms	666 ms	13 ms

Table 1: Average response latencies in the transparent and opaque conditions of published visual masked priming experiments. *only RTs on visually presented prime-target pairs were considered.

Table 1- Marelli et al., (2015), page 3

From this point of view, it might be concluded that morphological priming experiments do not provide information on how (pseudo-)complex words are morphologically parceled out only, but also may reveal the existence of two groups of simple words (*i.e.*, the stem targets) that are distinct for some linguistic property. Moreover, authors validated a possible "stem transparency" effect, testing English words used as stem targets for opaque and transparent primes in published priming studies. Precisely, they tested the difference on lexical decision latencies extracted from the British Lexicon Project (BLP, Keuleers et al., 2012) between a group of stem words that were originally part of a set of transparent pairs and a group of stem words that were originally part of a set of opaque pairs. Again, stems extracted from transparent sets are recognized faster than stems extracted from opaque sets, even in an experimental context completely unrelated to priming techniques such as a pure lexical decision task. Authors explained this latencies difference between the two groups of words as related to how reliable each word is as an orthographic cue for its meaning. On the one hand of the *continuum* there are stems always appearing in words whose meaning is related to their own, namely, when the orthographic information is consistently associated with a particular meaning (e.g., the stem *widow* in words like *widower*, *widowed*, *widowhood*); on the other hand there are stems appearing in words where their meanings is not maintained (e.g., the stem *whisk* in words like *whisky*, *whiskey*, *whisker*, *whiskered*), that are not be very reliable orthographic cues for their semantics. Marelli et al., (2015) supposed that the so called "semantic transparency" effect may be associated to a new a measure that reflects how much a word is a reliable orthographic cue for its semantics, and they proposed the Orthographic-Semantic Consistency (hence OSC) measure.

OSC measure had been computed by authors in this way. First, orthographic relatives have been collected per each stem targets, selecting all words starting with these items from a list including the top 30k most frequent content words (*i.e.*, nouns, verbs, adjectives, adverbs) in a 2.8-billion corpus. Then, in order to compute a measure of semantic similarity between a word and each of its orthographic relatives, a distributional semantics model based on the assumption that the meaning of a word can be approximated by the way that word co-occurs with other words in the lexicon was made up[3]. The more two words tend to occur with the same set of other words in similar contexts, so basically the more they co-occur, the more the vectors that represented them will be close, the more their meanings will be considered to be similar. This means measuring the cosine of the angle formed by the two vectors: the more similar the vectors, the smaller the angle between them, the higher their cosine. Given a target word and the set of its *k* orthographic relatives, OSC was computed as the frequency-weighted average semantic similarity. In formal terms:

$$OSC(t) = \frac{\sum_{x=1}^{k} f_{r_x} * \cos(\vec{t}, \vec{r_x})}{\sum_{x=1}^{k} f_{r_x}}$$

Where t is the target word, r_x each of its k orthographic relatives, and f_{rx} the corresponding frequencies extracted from the above described corpus. Since cosine values range from 0 to 1, the resulting OSC measure is a 0-to-1 score where values close to 0 identify words that are bad orthographic cues for their associated meanings, and values close to 1 indicate an almost perfect association between form and meaning.

Computing OSC value for each target, a linear regression was carried out having reaction times extracted from the BLP as a function of OSC values. It is worth noting that the average OSC was significantly different in the transparent set and opaque set, with the former showing larger OSC values than the latter. OSC had facilitatory effects on reaction times: the higher the OSC values the faster the reaction times. To summarize, OSC showed a significant effect in the expected direction: stems taken from transparent sets have significantly higher OSC than stems taken from opaque sets, and OSC has a facilitatory effect on reaction times in pure lexical decision task.

This pattern of results suggest that the main effect of semantic transparency on simple stem targets in priming experiments may be explained by considering how much, in the whole lexicon, the orthographic information carried by the stem is consistent with its associated semantics. In conclusion, the grouping based on the semantic properties of the derived forms also identifies two sets of stems that are distinguishable for their level of OSC.

Then, authors extended the OSC effect to general word processing, assessing another larger dataset of words extracted from the BLP which OSC values were computed on. Again, OSC showed facilitatory effect

[3] The distributional semantics model was built by using a large part-of-speech tagged and lemmatized corpus, formed by a concatenation of the ukWaC (http://wacky.sslmit.unibo.it/), English Wikipedia (http://en.wikipedia.org/), and BNC (http://www.natcorp.ox.ac.uk/) corpora (about 2.8 billion words in total).

on reaction times in lexical decision task. It might be supposed that the facilitation for both transparent and opaque items observed in some priming studies may be explained by the OSC distributions in the target sets, since they both may include words characterized by high values of OSC. Item samples will be more or less likely to elicit a priming effect on the basis of their average OSC.

Moreover, the OSC effect fits with the learning models that consider morpho-lexical effects as emerging at the interface between orthography and semantics (Plaut & Gonnerman, 2000; Baayen, Milin, Durdevic, Hendrix, & Marelli, 2011). In these learning models based on connectionist networks, a word will be more difficult to process when part of opaque derived forms (see Andrews and Lo, 2013) because of competition during learning process. Indeed, the same orthographic information (e.g., *whisk*) is associated to several meanings in this case (e.g., *whisky, whiskey, whisker, whiskered*), with the result that it becomes a relatively unreliable cue for the associated semantic representation. OSC is a natural consequence of the learning process implemented in these connectionist models, and it can be considered a proxy of the distributed nodes/weights linking orthography to semantics. For example, the Naïve Discriminative Reader (NDR) model (Baayen et al., 2011), even if account for morphological effects in word processing, provides a morphological model that does not rely on explicit morpheme representations, rather focusing on form-meaning statistical patterns that emerge in word distributions such as form-meaning patterns described by OSC measure. NDR supposes that, over and above morphology, children may be sensitive to systematic relations between forms and meanings as when they are learning, they are learning to distinguish and chunks of graphemic symbols may help them to distinguish between different meanings.

Andrews and Lo (2013) accounted for their masked priming results proposing that the association between an opaque derived word and its (pseudo-)stem (*e.g.*, *corner-corn*) may be difficult to learn, and hence weaker, because of their similarity in form and their discrepancy in meaning. OSC results may add that, also under simpler conditions of lexical decision when skilled readers are just presented with isolated stems, the knowledge that those stems have opaque and/or transparent derived forms is stored in the mental lexicon, and influences the way they are processed even when (pseudo-)morphological relatives are not involved by the experimental paradigm. In this sense, “opaque" stems may be worse symbols than “transparent" stems, which may drive to slower response times. Therefore, masked morphological priming effects may reflect a greater ease of learning transparent derived words due to their pairing with high OSC stems than opaque derived words containing lower OSC stems. The OSC effect found by Marelli and colleagues in English adults clearly indicates that word processing is influenced by a distributional property such as OSC measure: the distribution of form and meaning in the lexicon or, in other words, the strength of the association between orthography and semantics contributes to determining how easily a word is recognized.

Given OSC influence in word processing of English adults, OSC influence in word processing of English children was assessed in Chapter 4, showing the reliability of this orthographic-semantic measure in English language. In this chapter, we were aimed at developing OSC for Italian language and at validating it on Italian children, to assess whether OSC plays a role in Italian children word processing similar to the role observed in English children. As English peers, Italian children may be sensitive to some orthographic-semantic patterns occurring in words when they are learning to read.

The consolidated assumption of morphemes as representational units at lexical level in morphologically complex word processing has been recently questioned by a complex scenario of results emerged from adults studies (see Amenta, Marelli, and Crepaldi (2015); Marelli et al., (2013); Tsang and Chen, 2014) as well as developmental studies (Beyersmann, Castles, & Coltheart, 2012; Quémart & Casalis, 2014; Quémart, Casalis, & Colé, 2011; Shiff, Raveh, & Fighel, 2012). Morphological effects observed in morphologically complex word recognition might not be explained through dedicated mental representations, rather through more general-purpose mechanisms that capture statistically-strong orthographic-semantic patterns, namely, orthographic-semantic patterns that frequently occur in written language such as symbols which rely on. As recent studies on adults have shown (Marelli et al., 2015; Bergen, 2014), orthographic-semantic associations, not morpheme-mediated, have a crucial role to play in word processing and this role highlights the limits of the 'morpheme-as-unit' assumption. OSC measure, as distributional property of the language based on orthographic-semantic patterns, represents a new example as to how distributionally-based orthographic-meaning associations, over and above morphological considerations, are central to word reading and, especially, to word reading acquisition. In languages with different levels of orthographic transparency, words with high OSC values may be representational cues, or symbols, better than words with low OSC values. For this reason, it can be supposed that Italian children, as seen for English peers, may be show reliability to orthographic-semantic patterns, being their reading performances affected by OSC measure.

Italian children carried out the same experimental design thought for English children. Therefore, we designed a morphological masked priming task (Experiment 1) and, then, a simple lexical decision task (Experiment 2), using the same sample of stem targets. In the morphological masked priming task stem targets were divided into the usual three conditions (i.e., transparent, opaque, and for condition); in the simple lexical decision task the same stem targets were varied for OSC value. Our expectation was twofold: in morphological masked priming task, stem targets in transparent condition reveal higher OSC values than stem targets in opaque condition (see Marelli et al., 2015); in lexical decision task, the OSC variable affects significantly latencies, namely, the higher the OSC values, the faster the response times. We are going to describe first the morphological masked priming (Experiment 1) and then the pure lexical decision task (Experiment 2).

Experiment 1. *Morphological masked priming task*

METHOD

Participants

Twenty-seven (12 F; 15 M) children of a primary school in Ferrara (Italy) recruited from two 5th grade classes (chronological age *M*=10.2; *SD*=0.6) took part in the experiment. All participants had normal or corrected to normal visual acuity. Their nonverbal IQ level based on scores at the test of *Raven's Coloured Progressive Matrices* fell within normal range, according to Italian normative data (Pruneti et al., 1996). Children performed three screening standardized tests: *Prove di lettura di parole e non-parole Santa Lucia* (Zoccolotti, De Luca, Di Filippo, Judica, & Spinelli, 2005) administered as Italian reading level examination; a vocabulary assessment, *Peabody Picture Vocabulary Test–Revised*, *PPVT-R* (Stella, Pizzaioli, & Tressoldi, 2000) and a morphological awareness assessment, *Test for Reception of Grammar-Version 2*, *TROG 2* (Bishop, 2009). Children obtained mean standardized scores within the average range in each of the three screening tests. Mean scores at Raven's Test, PPVT-R, and TROG-2 are provided in Table 2; whereas mean scores at each list of Prove di lettura di parole e non-parole Santa Lucia Test are provided in Table 3.

	M	*SD*
Chronological age	10.2	0.32
Raven's Progressive Matrices	28.5	3.07
PPVT - R	127.6	35.11
TROG - 2	112.25	5.28

Table 2 - Means and standard deviations for chronological age in years, scores at Raven's Progressive Matrices, PPVT-R, and TROG-2.

	M	*SD*
Reading speed in short PW	28.9	7.7
Reading speed in long PW	51.1	10.4
Reading speed in HF short W	20.3	3.89
Reading speed in HF long W	27.3	7.1
Reading speed in BF short W	26.4	4.4
Reading speed in BF long W	41.6	9.7
Reading accuracy in short PW	2.0	1.80
Reading accuracy in long PW	3.73	2.13
Reading accuracy in HF short W	0.71	0.65
Reading accuracy in HF long W	1.88	1.90
Reading accuracy in BF short W	1.9	1.67
Reading accuracy in BF long W	2.84	1.22

Table 3 - Means and standard deviations on reading speed (seconds) and accuracy (number of errors) in each list of Prove di lettura di parole e non-parole Santa Lucia Test

Materials

Sixty-six prime-target pairs were selected from *Elementary lexicon: Statistical data on written and read Italian language in primary school children* (Marconi, Ott, Pesenti, Ratti, & Tavella, 1993) and *CoLFIS - Corpus and frequency lexicon of written Italian* (Bertinetto, Burani, Laudanna, Marconi, Ratti, Rolando, & Thornton, 2005). Prime-target pairs were equally assigned to three conditions. In the transparent condition, primes and stem targets entertained a genuine morphological and semantic condition, (e.g., artista–ARTE). In the opaque condition, primes and targets were semantically unrelated but entertained an apparent morphological relationship (*e.g*., retaggio–RETE, an analogous example in English would be corner–CORN). In the form condition, primes and targets had a purely orthographic relationship (*e.g*., spiaggia–SPIA, an analogous example in English would be spinach–SPIN). Sixty-six control unrelated primes were also chosen. These were existent, morphologically complex Italian words, which did not entertain any relationship (semantic, morphological, or visual) with the corresponding targets. Targets were matched across condition for word frequency (NoSketch Engine, free corpus management system: http://nl.ijs.si/noske/index.html) and word length (see Table 4). Related primes and paired unrelated primes were matched across condition for the same variables (see Table 4).

The assignment of word targets to the two priming conditions was counterbalanced over participants, so that all participants received both related and unrelated primes but saw each target only once. This was achieved by submitting to different groups of participants two experimental lists containing different experimental items. In each list there were the same 33 orthographically related prime-nonword pairs and

33 unrelated prime-nonword pairs, and the same 16 filler word prime-target pairs and 16 nonword prime-target pairs. All nonwords were orthographically legal and pronounceable. Each list was split in A part and B part with a break between the two part in order to not get children tired.

	Condition			
	Transparent	Opaque	Form	*Anova*
Log-frequency (P)	2.0 (0.8)	2.3 (0.7)	2.3 (0.7)	F(3.25) = 0.08, n.s.
Word Length (P)	8.3 (1.7)	8.15 (1.25)	7.8 (1.3)	F(1.216) = .300, n.s.
Log-frequency (T)	2.9 (0.9)	2.7 (0.9)	3.0 (0.9)	F(0.0805) = 0.77, n.s.
Word Length (T)	5.6 (1.25)	5.05 (0.95)	4.9 (0.6)	F(2.93) = 0.07, n.s.

Table 4 - Matching of word frequency and length variables for targets and primes

Procedure

The experimental task was a morphological masked priming followed by a lexical decision. E-Prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2002) was used to control the presentation of the stimuli and for the registration of the reaction times (RTs) and errors. Participants were tested individually away from their classroom. The task was explained to them first verbally and then instructions were displayed on the PC screen and read aloud to them. Stimuli were presented in Courier New 40 point font and as white lettering on a black screen. Participants were given six practice trials before starting the experiment providing feedback each time. A fixation cross (+) was presented for 1000ms, followed by the mask (########) for 500ms, then the prime in lowercase for 57ms and the target in uppercase until a key was pressed or for 5000ms. Targets were presented in a random order determined by the software for each participant. The string of letters appeared on the screen centre and they had to decide if they were a real word or a made-up word and then press the correct response key on the response box (the right one, for yes responses; the left one, for no responses), as quickly and as accurately as possible. No feedback was provided for experimental targets.

Data analysis

The reaction times (RTs) analysis was performed only on correct responses. Responses with particularly long latencies (defined as two or more SD from RT mean by participants) or with RTs faster than 500 ms were considered as outliers and were excluded from the analysis. Reaction times were logarithmically transformed in order to obtain a Gaussian-like distribution. Linear Mixed-Effect (LME) models were carried out on reaction times (RTs) data for word targets using the lme4 package (Bates, Maechler, Bolker,

& Walker, 2014) in the statistical software R (Version 3.0.3; RDevelopmentCoreTeam, 2008). This analysis approach suits to the present research as it allows the effects of crossed and nested subject and item factors to be considered within a single analysis. It allows assessing generality over both participants and items while statistically controlling for a number of sources of extraneous variability. Indeed, previous applications of this approach have shown that, even when stimuli are carefully matched and counterbalanced, residual effects of stimulus attributes, list construction and trial sequence can explain substantial, systematic variance in RTs, and that partialling out this variance can both eliminate artefactual effects and increase power to detect real effects (Baayen, Davidson, & Bates, 2008). In our analysis, RTs were introduced as dependent variable, participants and items as random effects, and relatedness (related; unrelated) and condition (transparent, opaque and form) were considered as categorical fixed effects. The effects of interest (fixed effects) were those associated to the experimental manipulations, that is, *relatedness* (control vs. related prime), *condition* (transparent vs. opaque vs. form), and their mutual interaction. Random intercepts for participants and items were also introduced. Effects were evaluated one by one on the basis of likelihood ratio tests and atypical outliers were identified and removed (employing 2.5 SDs of the residual errors as a criterion). P-values were determined using the package lmerTest (Kuznetsova, Brockhoff, & Christensen, 2014).

RESULTS

The interaction between *relatedness* and *condition* was significant (t=3.30, p=.02) in this way: related primes speeded up lexical decisions compared with unrelated primes in both the transparent condition and the opaque condition, but not in the form condition. In addition, t test indicated that the amount of priming did not differ in transparent and opaque conditions ($t < 1$). Table 5 reports the parameters of the significant effects included in the final model.

Fixed effects	Estimate	*SE*	*t* value	Pr(>|*t*|)
Intercept	7.19	0.04	161.93	.0001
Relatedness: related	0.08	0.04	1.81	.08
Condition: opaque	0.09	0.04	2.2	.03
Condition: transparent	0.1	0.04	2.3	.02
Relatedness: related * condition: opaque	0.1	0.05	-286	.0001
Relatedness: related * condition: transparent	0.16	0.05	-33	.0001

Table 5 - Fixed effects in the final model

DISCUSSION

In this experiment, Italian fifth grade children showed priming effects in both semantically transparent condition and in semantically opaque condition, namely, when prime and target shared a true morphological relationship and a pseudomorphological relationship (Casalis et al., 2009; Quemart et al, 2011). This pattern of results confirms a reliable assumption in literature, so that children are able to activate a morphological decomposition process when they are reading morphologically complex word, as they are able to exploit morphemically structured representations (Feldman et al., 2002; Rabin & Deacon, 2008). In addition, it seems that the almost total consistency of orthographic Italian system favour the detection of morpho-orthographic patterns in the language. Indeed, the priming effect in opaque condition may support the orthographic-based hypothesis of morphological processing, holding that developing readers rely on the orthographic properties of morphemes to process morphologically complex words through their decomposed form (Rastle et al., 2008).

Anyhow, we are far from claiming that semantics and form-meaning patterns do not play a role in triggering morphemic parsing, or, more in general in children word reading, especially considering the complex scenario of results emerging from developmental priming studies (Marelli, Traficante, Burani, *in press*). It might be that, at an advanced stage of reading acquisition (5th grade), Italian children may be more keen on activating morpho-orthographic parsing, not necessary driven by semantics. Moreover, at the earliest steps of word recognition (with a prime of 57 ms), developing readers are sensitive to the co-occurrence of base and suffix in words, but the activation of the semantic properties of morphemes is still not necessary to process complex words through their constituents. Semantic properties play a crucial role in morphological processing only later in the time course of word recognition (Quemart et al., 2011).

How did we compute OSC measure?

To compute OSC values per each word targets, the help of Dr. Marco Marelli was precious and fundamental. First, we collected all the orthographic relatives (OR) of each of the 66 experimental word target used in masked priming task. Word targets have been considered as group of letters contained in other words in any position (at the beginning, in the middle, at the ending), and *CoLFIS* (Bertinetto et al., 2005) has been used as tool to generate our list of orthographic relatives per each word targets. Word target was considered as orthographic relative as well, and orthographic relatives had to contain the whole word target, not only the base/root (e.g. ***fune****rale* is OR of *fune* whereas *fungo* is not OR of *fune*; *s****barra****mento* is OR of *barra*, whereas *barriera* is not OR of *barra*). It is worth clarifying that any kind of morphological consideration has been made to collect relatives out, as it was a pure orthographic selection. To compute semantic similarity between word targets and each of its orthographic relatives, a distributional semantics model (Turney & Pantel, 2010) was build up as it have been doing in Marelli et al. (2015) to compute OSC for English language. The itWac, a 2 billion tagged and lemmatized word corpus constructed by downloading texts from the web (http://www.natcorp.ox.ac.uk/), has been used as semantic space. In distributional semantic models, word meaning in semantic spaces can be approximated by the way that word co-occurs with other words in the lexicon, and it is represented as vector deriving from these co-occurrences. The more two words tend to occur with the same set of other words in similar contexts, the more the vectors that represented them will be close, the more their meanings will be considered to be similar. This means measuring the cosine of the angle formed by the two vectors: the more similar the vectors, the smaller the angle between them, the higher is their cosine. Once computed cosines for the co-occurrence of each word target with each of its orthographic relatives, and deleted cosines = 0, the OSC value of word target was equivalent to the sum of each OR (log-frequency*cosine) value dived for the sum of ORs log-frequencies (see the formula below).

$$\mathbf{OSC(t)=} \quad \frac{\sum^{rx}(\mathbf{freq*cos}\ )}{\sum^{rx}(\mathbf{freq})}$$

Experiment 2. *Lexical decision task*

METHOD

Participants

The same participants of Experiment 1.

Procedure

The experimental task was a lexical decision task. E-Prime 2.0 software (Schneider, Eschman, & Zuccolotto, 2002) was used to control the presentation of the stimuli and for the registration of the reaction times (RTs) and errors. As w targets involved as stimuli were the same of the morphological masked priming of the Experiment 1, Experiment 1 and Experiment 2 were separated by ten days. Participants, tested individually, had to decide whether a string of letters formed an English word or not. They were instructed that, when a letter string appeared in the center of the PC screen, they had to push the correct response key on the keyboard (the right one, for yes responses; the left one, for no responses), as quickly and as accurately as possible. Reaction times and errors were recorded. No feedback was provided. Each stimulus, printed in capital letters, was preceded by a fixation point (1000 ms), and disappeared when the response button was pressed, or after 3,000 ms had elapsed. A practice session of four targets preceded the experiment and feedbacks were provided.

Materials

Sixty-six word targets used in Experiment 1 were involved in this lexical decision task. Primes have been not considered. Word targets were matched for word frequency (NoSketch Engine, http://nl.ijs.si/noske/index.html) and word length (see Table 3), whereas spanned a low-to-high OSC range (*Min*: 0.06; *Max*: 0.90; $M = 0.30$; $SD = 0.13$). A word like *gelo* reached OSC value close to 0 as it appears in words (*angelo*, *vangelo*, *gelosia*) where the meaning is not maintained, and it is not very reliable orthographic cues for semantics. A word like *legna* reached OSC value close to 1 as it appears in words (*taglialegna*, *legname*, *falegnameria*) where the orthographic information is consistently associated with a particular meaning.

Data analysis

The reaction times (RTs) analysis was carried out only on words on correct responses. Responses with particularly long latencies (defined as two or more SD from RT mean by participants) or with RTs faster than 500 ms were considered as outliers and were excluded from the analysis. Reaction times (RTs) were logarithmically transformed in order to obtain a Gaussian-like distribution and were introduced as a dependent variable. We decided to treat OSC as continuous variable and not dichotomized because when dealing with naturally continuous variables such as reaction times, a continuous indicator has to be preferred to its dichotomized counterpart in terms of both statistical power and estimation accuracy (Marelli et al., 2015).

RESULTS

First, we took into consideration word targets included in transparent and opaque conditions of the former morphological masked priming task, and we assessed the density distributions of OSC in these two sets. It turned out that the average OSC was larger in transparent set ($M = 0.26$) than in opaque set ($M = 0.21$) but not significantly ($t < 1$; $p = 0.4$). Then, in order to assess whether the OSC measure affected lexical decision latencies of children, we carried out a linear regression analysis having RTs as function of OSC values. This analysis showed significant facilitatory effect of OSC on latencies ($b = 0.384$; $t = -3.49$; $p = .0001$): the higher the OSC values the faster the response times performed by children.

DISCUSSION

In this second experiment, OSC measure was built to assessing whether and how it affects Italian children word recognition. Differently from what has been found in English children study (Chapter 4), word targets of morphological masked priming (Experiment 1) taken from transparent set did not reach significantly higher OSC values than word targets taken from opaque set. However, OSC measure carried on revealing a facilitatory effect on reaction times in lexical decision task (Experiment 2): the higher the OSC values, the faster the latencies of Italian children.

The consistency of orthographic-semantic patterns embedded in words seems to play a role in Italian children word reading and it should be taken into account in reading acquisition studies.

GENERAL DISCUSSION

Marelli and colleagues (2015) had attested that OSC measure, quantifying the consistency of the carried orthographic and semantic information, influences English adults' visual word access, even when target words are isolated stems. Following this assumption, we assessed in Chapter 4 whether and why a word like *corn* should be processed slower by English children than a stem word like *farm* even in experimental contexts when the corresponding (pseudo)-derived form (*corner* and *farmer*, respectively) is not presented to children. Wondering about the semantic relations existing between a word and its orthographic relatives, we assessed how (LSA-based) OSC measure facilitated English children's visual word processing. The same assumption has been made for Italian children in this chapter and we were wondering whether a word like *rete* should be processed slower by Italian children than a word like *arte* even in experimental contexts when the corresponding (pseudo)-derived form (*retaggio* and *artista*, respectively) is not presented to children. Although OSC values of word targets in transparent set (Experiment 1) were not significantly higher than OSC values of word targets in opaque set (Experiment 1) as for English children, Italian children latencies were facilitated by OSC measure (Experiment 2) as well. Indeed, a word like *legna* reaching a high OSC value was read faster than a word like *gelo* reaching a low OSC value. It is worth underlining that OSC measure was differently computed in English and Italian language studies. To develop OSC for English children we exploited Latent Semantic Analysis (LSA) and we took word frequency values from a children's database; to develop OSC for Italian children we did not exploit a measure as LSA and we took word frequency values from an adults' corpus, as the main Italian children's word database (Marconi et al., 1993) contains a limited number of items. It can be supposed that the different pattern of results between the English study and the Italian study is due to different ways in OSC computation, and a similar or more precise OSC computation may lead to similar pattern of results.

Anyhow, LSA-based OSC in English as well as OSC in Italian affect children performances, indicating that word processing is influenced by the relative distribution of form and meaning in the lexicon or, in other words, that the strength of the association between orthography and semantics contributes to determining how easily a word is recognized. For this reason, it can be supposed that Italian children are able to capture form-meaning associative patterns embedded in words, and these types of patterns may represent reliable cues to them. Looking at the learning process as an establishing of connections, associations, children may be able to exploit the associations (more or less consistent) of orthography and semantics that occur in words, thus, they may be able to exploit a distributional property such as OSC. Despite the transparency of the orthography, Italian children confirmed to be able to grasp more holistic, global processing units than single graphemes and others than morphemes. Developing orthographic-semantic networks, they are able to connect simple elements (graphemes, phonemes, semantic features) into nodes. This kind of procedure may help them to build vocabulary up when whole word representations are not still available.

The OSC effect fits well with connectionist architectures (e.g., Plaut & Gonnerman, 2000; Baayen, Milin, Durdevifc, Hendrix, & Marelli, 2011) because it can be considered a proxy of the distributed nodes linking orthography to semantics. In these learning models that see lexical and morphological effects as emerging at the interface between orthography and meaning, a word will be more difficult to process when part of opaque derived forms because of competition during learning: the same orthographic information (e.g., *bat*) is associated to several meanings in this case (e.g., *bat*, *battery*, *battle*, *batman*), with the result that it becomes a relatively unreliable cue for the associated semantic representation (Marelli et al., 2015). The Naïve Discriminative Reader (Baayen et al., 2011) attests "learn" as equivalent to "learn to distinguish", and provides a morphological model that does not rely on explicit morpheme representations, rather focusing on form-meaning statistical patterns that emerge in word distributions. As children are learning to distinguish, they may be sensitive to form-meaning statistical patterns as discriminative cues (see OSC effects in Italian and English children).

In conclusion, OSC distributional property should be taken into account in future word recognition studies in Italian language. Further studies on children in the earlier years of primary school are clearly needed to draw a developmental trajectory of OSC influence. Moreover, an investigation of OSC on children with reading disabilities and adult readers is desirable to complete the experimental scenario.

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General Discussion

This dissertation investigated the morphological, orthographic and semantic word features involved in the reading process of Italian primary-school children and, at the same time, the processing units which young readers are able to rely on. Aim of this dissertation was to show how Italian children are able to rely on both large and small units during the reading process, and how the assumption of processing units as simple linguistic elements (graphemes, phonemes, semantic features) connected in networks is the most representative in the word recognition processes.

In Chapter 1, an overview of the more or less recent theoretical issues presented in the literature has been proposed together with the complex scenario of results emerging from several studies on both adults and children. In the following chapters, psycholinguistic experiments assessed different types of reading units which Italian children rely on. In Chapter 2, a pseudoword reading task has been carried out by Italian children in order to provide evidence for a lexical reading based on whole-word representations, despite the transparency of the Italian orthography. In Chapter 3, we aimed at presenting morphological-oriented coding schemes of reading errors performed by Italian children in morphologically complex words reading. This analysis showed reliability on morphemic structure when children are reading morphologically complex words, and their ability to use morphemes as intermediate grain size reading units. Chapters 4 and 5 presented the Orthography-Semantics Consistency (OSC), a new measure first tested in English language that quantifies the consistency of the orthographic and semantic information carried in words and reveals more or less consistent orthographic-semantic associations within words. English children in Chapter 4 and Italian children in Chapter 5 have showed to be affected by OSC. When children are coming across sublexical consistent and inconsistent orthographic-semantic patterns, they are facilitated by consistent patterns that correspond to higher values of OSC. Although further researches are needed, effects of a distributional property of language such as OSC indicate that children are able to grasp orthographic-semantic associations as processing units after repeated exposure to written texts. Although not being morpheme-mediated, orthographic-semantic associations play a crucial role in word reading process and highlight the limits of the consolidated 'morpheme-as-unit' assumption. Morphology seems to be connoted as an age-related emergent aspect of written word processing, exploited by children in order to overcome their reading difficulties. Morphological representations may be helpful reading units which to rely on in the earlier stages of reading acquisition and/or in case of reading disabilities (poor young readers, children with reading disabilities, neuropsychological patients).

Our experimental evidence supported a new definition of morphology (Marelli, Traficante, Burani, *in press*): a more general learning mechanism, experience-acquired, that exploits orthographic-semantic consistencies in the language system. Morphology emerges as by-product of form and meaning similarity between independent representations, and expresses a more general cognitive ability to capture form-meaning patterns in language system. It is worth thinking about morphemes as expressions of more general form-meaning associations, rather than isolated representational units in the mental lexicon. In reading acquisition, children build up statistically-strong form-meaning connections after being enough exposed to written texts, namely, orthographic-semantic networks which are likely to be helpful in grasping reliable reading units for young readers. This form-meaning mapping might be responsible of the morphological parsing process: when consistent and inconsistent form-meaning patterns often occur, it is easier to chunk morphologically complex words.

Learning models focused on form-to-meaning mapping fit well with this new assumption. This notion can already be found in the full-listing proposals (e.g., Butterworth, 1983), since they typically see morphology as a by-product of form and meaning similarity between independent representations. There is also a theoretical assumption arising from connectionist models (e.g. Seidenberg & McClelland, 1989), where a *triangle* approach to visual word recognition has been proposed, with a direct route from orthography to semantics and an indirect route via phonology. In these models, there are no explicit representations for morphemes and/or for words; rather, connectionist architectures are populated by more simple elements (graphemes, phonemes, semantic features) organized in nodes. Morphology, as well as lexicality, naturally unfolds by means of consistent patterns of activation within the links connecting the different nodes (Rueckl and Raveh, 1999; Plaut and Gonnerman, 2000). The recent Naïve Discriminative Reader (Baayen, Milin, Filipovic Đurđević, Hendrix, & Marelli, 2011), proposed to account for morphological effects in word processing, is similar to what has been proposed in the connectionist networks and suggests that morphology simply reflects a cognitive sensitivity to systematic relations between forms and meanings. Offering a new perspective of the discrimination notion, the NDR model proposes that *learning* is equivalent to *learning to distinguish*. Children learn to distinguish between different form-meaning patterns that frequently co-occur in written texts. Morphemes are discriminative cues, namely, chunks of graphemic symbols that help to distinguish between different meanings. NDR provides a morphological model that does not rely on explicit morpheme representations, rather focusing on form-meaning patterns that emerge in word distributions, is also centered on psychologically plausible learning mechanisms, and constitutes a framework for understanding morphological effects in children reading.

In the model proposed by Grainger, & Ziegler (2011), two parallel orthographic routes have been postulated. In the faster route, the system uptakes the information about the presence of letter combinations, without precise positional information (*coarse-grained orthography*) to reach target identification as soon as possible. In the slower but more precise route, letters that co-occur very often in the language (e.g., affixes) can be grouped (chunking) to form higher-level orthographic representations (*fine-grained orthography*), coding precise information about the ordering of letters in the string. This kind of orthographic route leads to an improvement of the reading process, thanks to the reduction of units to be activated. Morphological awareness is represented in the whole-word representations and emerges from the overlapping of several words in form and meaning. This model can be useful for understanding how children learn to read. The main task of beginning readers is to associate letter identities with sounds that resemble whole-word phonological representations of known words. Each successful decoding can provide beginning readers the opportunity to create connections between the word form and the meaning. Through the repeated exposure to printed words, children begin to codify letter strings through location-specific letter detectors, which gradually leads to the coarse-grained and fine-grained routes. An improvement of reading acquisition can be obtained through developing the fine-grained processing route, i.e. the route providing access to semantics via phonological and morphological representations. In this way, children are helped in detecting frequently co-occurring letter combinations, favoring chunking. In learning to read, a child can learn that a contiguous sequence of letters corresponds to pre-existing phonological and/or morphological representations, acquired in spoken language. Again, the repeated exposure to written words leads young readers to build up stable connections between form and meaning of words, and to extract information about letters position in the string. Form-meaning connections, rather than morphemes, may be the associative base for reading acquisition process.