WORD MORPHOLOGY ENHANCES READING FLUENCY IN CHILDREN WITH DEVELOPMENTAL DYSLEXIA

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1. INTRODUCTION

In orthographies with regular letter-to-sound mapping, such as German or Italian, the reading of children with developmental dyslexia is extremely slow and fragmented; accuracy is also impaired, but to a considerably lesser extent than in opaque orthographies, such as English (Wimmer 1993; Zoccolotti et al. 1999). Italian children with developmental dyslexia are markedly sensitive to stimulus length effects - with long words yielding much longer reaction times than short words - and are much slower than typically developing readers at reading aloud words and nonwords (Spinelli, De Luca, Di Filippo, Martelli, and Zoccolotti 2005; Zoccolotti et al. 2005). A consistent pattern is found when children's eye movements are recorded during reading. Developmental dyslexics exhibit extremely fractionated text scanning, as they proceed through stimulus display making a large number of very small amplitude saccades; in addition, they show longer fixation durations than typically developing readers. This pattern holds not only in reading passages of text (De Luca, Di Pace, Judica, Spinelli, and Zoccolotti 1999), but also in reading lists of single words and nonwords (De Luca, Borrelli, Judica, Spinelli, and Zoccolotti 2002; see also Hutzler and Wimmer 2004).

The characteristic impairment of reading fluency in children with dyslexia may be interpreted as due to the limitations of their perceptual span (Martelli, Di Filippo, Spinelli, and Zoccolotti 2009), which causes difficulties in processing word stimuli as whole-units. Similarly to children at an early

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stage of learning to read (Ziegler and Goswami 2005), children with dyslexia rely on small grain-size units (single letters or letter clusters) for letter-to-sound mapping, even when larger reading units are available to them (Zoccolotti et al. 1999; 2005).

However, single letters or letter clusters are not the only alternative reading units to whole-word units. The word constituent morphemes, and specifically the morphemes comprising a derived word (roots and derivational affixes) may be useful reading units for developing readers, particularly when children encounter a new or unfamiliar printed word. In Italian, similarly to other languages (see Nagy and Anderson 1984), about 70% of less familiar words are either derivatives (by suffixation, prefixation or conversion) or compounds (Thornton, Iacobini, and Burani 1997).

In the present paper, recent studies which show that morphemic reading units are available to Italian children with developmental dyslexia and can help reduce their reading fluency problem will be reviewed. It will be shown that word morphemes (roots and suffixes, specifically) can be efficient reading units for children with dyslexia because they have an intermediate size between single letters, which entail extremely slow and analytical processing, and the word, which is usually too a large unit to be processed as a whole by children with dyslexia.

Similarities and differences between the reading behaviour of children with dyslexia and skilled readers (both children and adults), and the specific benefits of morpheme-based reading aloud for enhancing reading fluency in children with dyslexia, will be discussed. It will be argued that the probability of morphemic parsing in reading is constrained by both the frequency and perceptual properties of word morphemes and the reader's ability.

2. READING ALOUD SUFFIXED PSEUDOWORDS AND WORDS

Mature readers can use the morphemic constituents of a word (roots and affixes) to speed up lexical access and comprehension (Burani and Thornton 2003; Schreuder and Baayen 1995). Knowledge of morphemes establishes early in development and is used by children in word comprehension and production tasks (see Bimonte and Burani 2005, for a review). However, it is debated whether access to morphemic units (roots and affixes) is useful to improve fluency in reading aloud and whether morphemes are available to developing readers with different reading abilities.

Morpheme-based lexical reading has been demonstrated in typically developing children in the first primary grades, in both reading aloud and

lexical decision tasks (Burani, Marcolini, and Stella 2002; Marcolini, Donato, Stella, and Burani 2006). In a word naming task, Burani et al. (2002) found that both adults and children read aloud novel stimuli (pseudowords) made up of a familiar root (e.g., DONN-, 'woman') and a derivational suffix (e.g., –ISTA, '-ist') resulting in nonexistent combinations (e.g., DONNISTA, 'womanist': morphological pseudowords) faster and more accurately than pseudowords that contained neither roots nor suffixes (e.g., DENNOSTO: simple pseudowords). In a lexical decision task, in which participants decide whether a visually presented letter string corresponds to an existing word, both adult and young readers recognised as possible words morphologically complex pseudowords more often than simple pseudowords. These results indicated that morpholexical reading develops quite early in Italian.

In the study of Burani et al. (2002), the presence of morphemes in a pseudoword facilitated the reading performance of typically developing readers, similarly to adult readers. In subsequent studies - all adopting the paradigm of single word naming in which vocal reaction times (the onset of pronunciation) and pronunciation accuracy were registered - it was investigated whether less skilled readers, and specifically children with dyslexia in the sixth grade, could also benefit of the presence in the stimulus of reading units, such as morphemes, larger than single letters. On the basis of the studies documenting the difficulty of dyslexics in whole-stimulus processing, we expected that morphemic constituents (roots and suffixes) would help dyslexics to read aloud both pseudowords and words. If whole word processing is challenging for children with dyslexia more than for skilled readers, then the presence of morphemic constituents in a word might be more beneficial for developmental dyslexics than for skilled readers. For skilled readers, both adults and children, the benefits due to morpheme-based reading aloud might not be present when reading real words aloud, because of their ability to process larger (than the morpheme) reading units (i.e., words) as a whole.

In a study conducted by Burani, Marcolini, De Luca, and Zoccolotti (2008), the reading aloud of both morphologically complex pseudowords and words was assessed in Italian children with dyslexia, compared to reading of typically developing readers, who were matched either for reading age or for chronological age, and proficient adult readers. The first experiment reported by Burani et al. (2008) focused on the effect of familiar morphological constituents on reading aloud morphologically complex pseudowords (e.g., DONNISTA, 'womanist') compared to simple pseudowords (e.g., DENNOSTO) that did not contain morphemes. All four groups of readers read pseudowords composed of root and suffix faster and more accurately than simple pseudowords. The results confirmed previous findings for skilled readers

(Burani et al. 2002; see also Burani and Laudanna 2003, for a review), and indicated that children with dyslexia are sensitive to lexical elements (morphemic constituents) in pseudoword reading aloud, similarly to the other groups of readers.

In a second experiment, using the same participant groups, Burani et al. (2008) tested the effect of morphemic constituents in reading aloud words. Two sets of existing words (derived vs. simple) were employed. Derived words contained a familiar root and a frequent derivational suffix (e.g., CASSIERE, 'cashier'). In contrast, simple words were not parsable into root + derivational suffix (e.g., CAMMELLO, 'camel'). The results showed that morphological structure did not affect word reading of proficient, young and adult readers, but led to faster naming times for both dyslexic and younger reading skill-matched children.

Overall, these results illustrate that, when a stimulus does not have a lexical representation, as in the case of a pseudoword, all readers, including proficient readers, take advantage of the presence of morphological constituents in the stimulus. No advantage due to the presence of morphemes is found for skilled readers in reading aloud words, i.e., stimuli which have a whole-word lexical representation. When words can be accessed holistically by means of whole-word processing, morphemic parsing may be neither necessary nor advantageous, possibly entailing costs more than benefits (see, e.g., Laine, Vainio, and Hyönä 1999; Traficante and Burani 2003; see also the concluding section below). For unskilled readers, in contrast, the presence of morphemic constituents may prove beneficial for both pseudoword and word reading. It is noteworthy that, even though children with dyslexia and younger readers may have not yet fully mastered whole word processing, they can rely on smaller than whole word lexical units, i.e. morphemes, to enhance their reading fluency.

The reason why, in contrast to skilled readers, reading based on familiar morphemes (roots and affixes) is effective for children with dyslexia and beginning readers in processing different types of linguistic stimuli, including words, may be that, for unskilled readers, most words may not (yet) be present in their orthographic lexicon, or may be too long to be processed as a whole. The latter issues were addressed in two follow-up studies, that will be reviewed in the two ensuing sections. The two studies investigated, respectively, whether the frequency with which a word occurs in print may affect the recourse to morphemic units in reading aloud (section 3), and whether the length of a word may affect the probability of morpheme-based reading (section 4), to different extents in children with dyslexia and skilled readers.

3. WORD FREQUENCY, READER'S ABILITY AND THE PROBABILITY OF MORPHEME-BASED READING ALOUD

Models of adult word recognition assume that recourse to morphemic constituents becomes increasingly probable as whole-word frequency decreases, with morphemic processing maximally affecting low-frequency (LF) words composed of high-frequency morphemes (Alegre and Gordon 1999; Baayen, Wurm, and Aycock 2007; Burani and Laudanna 1992; Chialant and Caramazza 1995; Schreuder and Baayen 1995). In a race model of word processing (e.g., Schreuder and Baayen 1995), there are two routes for identifying a word: a direct look-up and a compositional route, in which words are accessed via their constituent morphemes. Which route predominates depends on the relative speed of the two processes, with the direct look-up route taking precedence for high-frequency (HF) words and the compositional one predominating for LF polymorphemic words.

For Italian, root frequency effects on low-frequency words have been reported in lexical decision (Burani and Caramazza 1987; Burani and Thornton 2003) and word naming (Colombo and Burani 2002), with high-frequency roots speeding up the processing of LF words. Eye movement studies provide converging evidence. Holmes and O'Reagan (1992) varied the frequency of French suffixed and mono-morphemic words matched for length and frequency to the derived words. Gaze durations differed little between HF suffixed words and their monomorphemic controls, whereas they were shorter for LF suffixed words as compared to LF mono-morphemic words, especially when the initial fixation was in a good position for viewing the root morpheme.

Models of reading acquisition also predict that the facilitation obtained by morpheme-based processing may be particularly relevant for unfamiliar words and for less-skilled readers. According to Reichle and Perfetti (2003), the acquisition of reading skill requires several encounters with printed words to build up orthographic representations that reflect familiarity and knowledge of the word. Due to insufficient reading practice, developing readers, and especially less skilled readers, may not have established the orthographic knowledge required for word-specific (whole-word) representations. Rarely encountered LF words will have a low probability of being represented and processed as whole words. However, unfamiliar words that include a HF root will still be easily recognizable based on their familiar root.

The issue of whether the orthographic familiarity of the printed word may affect the probability of morpho-lexical reading, and whether such probability interacts with the reader's processing ability, was addressed in the

study by Marcolini, Traficante, Zoccolotti, and Burani (in press). In the previous study of ours - in which morphemic decomposition in word reading was found in children with dyslexia, but not in skilled readers (Burani et al. 2008) - polymorphemic words were selected from a medium/low-frequency range in a child-written corpus (Marconi, Ott, Pesenti, Ratti, and Tavella 1993). Very high- and very low-frequency words were not included in the experimental sets. In the experiment reported by Marcolini et al. (in press), words with a high frequency (polymorphemic and simple) were contrasted with low-frequency (polymorphemic and simple) words to assess whether readers' reliance on morphemic reading would differ for high- versus low-frequency root + suffix combinations, and whether the probability of morpheme-based reading differed according to reading skill.

Word frequency (high and low in the child-written frequency count of Marconi et al. 1993) was varied orthogonally with morphological type (derived and simple). High-frequency derived words (e.g., DIVERTIMENTO, 'amusement') were contrasted with high-frequency simple words that were not parsable into root + derivational suffix (e.g., MONUMENTO, 'monument'). Low-frequency derived words (e.g., TRATTAMENTO, 'treatment') were contrasted with low-frequency simple words (e.g., DOCUMENTO, 'document'). Simple words were matched to derived words for lexical and sub-lexical characteristics possibly affecting the speed of lexical access. All the derived words were phonologically and semantically transparent with respect to their base word and included highly familiar roots and suffixes (see Carlisle and Stone 2003; Carlisle, Stone, and Katz 2001; Windsor 2000, for the higher probability that children reading is based on morphemes when derived words are transparent with respect to their base).

On the basis of previous results, we expected all groups of readers to show word frequency effects, with HF words being read faster than LF words (see Paizi, Zoccolotti, and Burani 2010). Less skilled readers were also expected to show faster naming latencies to polymorphemic than to simple words, irrespective of word frequency. Being the word longer than its constituent morphemes, children with dyslexia should always take benefit from the presence of lexical units smaller than the word, that is, morphemes, to enhance their reading performance. By contrast, young skilled readers were expected to show an advantage of morphemic parsing on naming latencies for low-frequency words only, which are less likely to be present in their developing lexicon. Skilled readers should read morphologically complex and simple HF words equally fast and accurately, because of their capacity to process familiar words as whole units.

The results confirmed the predictions: children with dyslexia read both low-frequency and high-frequency polymorphemic words faster than simple

words. By contrast, young skilled readers read polymorphemic words faster than simple words only when they were of low frequency; high-frequency root + suffix words were read as fast as high-frequency simple words. Adult readers never showed a significant morphological effect, with polymorphemic words being read as fast as matched simple words, irrespective of frequency. These results provided further support to the view that morphemes (roots and affixes) are particularly useful in fostering reading fluency in less skilled readers, whose reading behaviour is largely constrained by processing limitations and limited reading experience. For skilled readers, morpheme-based reading may be efficient only when a whole-word representation is not yet firmly established in the reader's orthographic lexicon.

4. WORD LENGTH, READER'S ABILITY AN THE PROBABILITY OF MORPHOLOGICAL PARSING

The study reviewed in the preceding paragraph showed that skilled sixth-grade readers, similarly to less skilled readers, may benefit of morphemic parsing when reading low-frequency words aloud. In the study that will be reviewed here, we addressed the issue of whether word length may affect the probability of morphemic parsing when young readers of different proficiency levels read a low-frequency polymorphemic word.

In reading words of 6 to 11 letters, readers with dyslexia usually make at least two fixations, or even more (see, e.g., Hutzler and Wimmer 2004; Martelli et al. 2009), whereas skilled readers of the same age flexibly adapt the amplitude of their saccades, with most (mainly short) words processed in one shot (see Häikiö, Bertram, Hyönä, and Niemi 2009; Rayner 1986). It might thus be expected that, in reading a root + suffix derived word in the range of 6-11 letters length, children with dyslexia will benefit of the presence of the root – that is, a processing unit shorter than the word - in both short and long words. In contrast, skilled readers' naming latencies may take advantage of the presence of a root only in long words.

Burani, Marcolini, Traficante, and Zoccolotti (2010) addressed the question of whether the facilitating effect found in children on low-frequency derived word reading is influenced by the length of the word. Sixth-grade children with dyslexia and skilled readers of the same age read aloud four sets of low-frequency words. Short (with a mean length of 7.4 letters) derived words (e.g., DUREZZA, 'hardness') were compared to simple words of the same length not parsable into root + derivational suffix (e.g., DIFETTO, 'defect'). Long (with a mean length of 9.4 letters) derived words (e.g.,

LONTANANZA, 'distance') were compared to simple words of the same length (LIQUIRIZIA, 'liquorice'). Derived and simple words were matched for the main psycholinguistic variables.

The results showed that in reading short stimuli only children with dyslexia took advantage of the morphemic structure of the word, reading derived words faster than simple words; skilled readers were equally fast at reading both derived words and matched simple words. As for long stimuli, both children with dyslexia and skilled readers were faster in reading derived words than simple words. In the case of skilled readers, the likelihood of relying on the root morpheme as a processing unit depended on stimulus length: the longer the word is, the more likely it is to be parsed into constituent morphemes. In contrast, readers with dyslexia were always facilitated by the presence of a root within a derived word, irrespective of word length, because of their difficulty in processing the input word as a whole.

Our findings on skilled young readers are consistent with eye-movement data showing that, for adult readers, short polymorphemic words are more subject to whole-word processing than long polymorphemic words, with increasing word length enhancing the probability of compositional processing. Eye-movement studies conducted both in English (e.g., Niswander, Pollatsek, and Rayner 2000; Niswander-Klement and Pollatsek 2006) and Finnish (e.g., Bertram and Hyönä 2003) found effects of frequency manipulations of either the first or second morphemic components on fixation patterns. The morphological effects were found when two-morpheme words were long, but they were null, or weaker, for short polymorphemic words. On the other hand, whole-word frequency effects were observed for short words in first fixation duration, with small and unreliable whole-word effects for long words, indicating that the whole-word form becomes immediately available in processing short polymorphemic words.

These findings need to be accommodated within a model of morphological processing in which the activation of the decomposition route is affected both by the perceptual properties of morphemes, such as root length, and by differing reading abilities. Bertram and Hyönä (2003), for instance, proposed a race model incorporating a headstart for the decomposition route in case whole-word information of polymorphemic words cannot be extracted in a single fixation. Based on the dynamic interaction between short-term memory and long-term memory processes, Ferro, Ognibene, Pezzulo and Pirrelli (2010) propose a computational model of the interlocked relationship between lexical self-organization and active sensing strategies for reading. The model exploits expectations on stored lexical representations to drive gaze planning. Shorter frequent words are

more likely to be scanned in one shot as they develop dedicated memory chains on the map during lexical training. Polymorphemic longer words, on the other hand, typically take more fixations, as their memory chains are shared by more word forms and bifurcate over morpheme boundaries. Both models may explain the pattern of results reviewed above.

5. ANY EFFECT OF MORPHEMES ON WORD PRONUNCIATION ACCURACY?

The finding that, in reading words aloud, children with dyslexia benefit more than skilled readers of morphological structure to improve their reading latencies, is in line with the results obtained for deep orthographies. For both English and Danish, only younger readers and children with dyslexia showed faster reading times for derived than for monomorphemic words, whereas reading speed did not differ between word types in the older skilled children (Carlisle and Stone 2005; Elbrö and Arnbak 1996). In the study by Carlisle and Stone (2005), English-speaking second and third graders read faster high-frequency derived than monomorphemic words, whereas speed of reading the two word types did not differ for fifth and sixth graders.

Interestingly, in Italian the presence of morphemes did not lead to better pronunciation accuracy in reading polymorphemic vs. simple words, except for children with dyslexia in the case of low-frequency long words. Only in the latter case, children with dyslexia made significantly less pronunciation errors in reading derived than simple words (Burani et al. 2010). This weak facilitation of morpheme-based reading on pronunciation accuracy is in sharp contrast with studies on deep orthographies, which consistently reported significantly higher accuracy in reading derived than monomorphemic words in groups of children with different reading skills (e.g., Carlisle and Stone 2005) and with dyslexia (Elbrö and Arnbak 1996). The slight morphological facilitation on word pronunciation accuracy in the Italian studies highlights that, in a transparent orthography, knowledge of word morphology is not necessary for correctly transcoding graphemes into phonemes.

In transparent scripts such as Italian, most letters are assigned the same pronunciation irrespective of the surrounding letter context. Consequently, in regular orthographies children achieve high levels of accuracy after a few months of teaching, whereas children learning to read an irregular orthography reach good reading accuracy much later (Seymour, Aro, and Erskine 2003). In transparent scripts, larger than single letter units are seldom necessary to obtain good reading accuracy.

In contrast, for beginning readers of an opaque orthography, the use of

large grain size units, such as multiletter graphemes and word endings, is essential to resolve the great number of inconsistencies in grapheme-to-phoneme conversion, i.e., to obtain good reading accuracy (Ziegler and Goswami 2005; 2006). For orthographies such as English, Danish and French, in which word spelling is to some degree morphologically governed, knowledge of morphemes may help the child in assigning the correct word pronunciation (Seymour 1997; Verhoeven and Perfetti 2003). For instance, in English there are words (e.g., 'shepherd') which contain a letter cluster (e.g., 'ph') that has apparently an irregular print-to-sound translation, being not pronounced as in other words, such as 'phosphorus', 'pharmacy', etc. However, if the reader knows other words containing the morpheme 'herd' which refers to herdsmen (e.g., 'cowherd'; 'goatherd'), he/she may be able to get the correct pronunciation of 'shepherd' by relying on the morphemes 'herd' and 'shep', although the latter is orthographically and phonologically transformed with respect to its base 'sheep'. In opaque orthographies, the presence in a word of known morphemes, such as roots and affixes, may affect young readers' accuracy in reading aloud, mainly when polymorphemic words are phonologically and semantically transparent with respect to the base word (Carlisle and Stone 2003; Elbrö and Arnbak 1996), or suffixes are frequent and productive (Mann and Singson 2003).

In a transparent orthography, such as Italian, knowledge of morphemes is not essential to assign correct spelling or pronunciation to a word, because the orthography contains no morphologically based spelling rules (see also Lehtonen and Bryant 2005, for a similar view in investigating Finnish children's use of morphology in spelling).

Notably, although Italian morphemes had only a slight effect on pronunciation accuracy in the case of existing words, they did affect pronunciation accuracy in the case of pseudoword reading. For all readers, both skilled and with dyslexia, adults and children, pseudowords containing a root and a suffix were consistently more correctly pronounced than matched pseudowords that did not include any morpheme. The facilitatory effect of morpheme-based reading on pseudoword reading accuracy may arise from the possibility of exploiting, for pronunciation, the combination of two morphemic units in which phonemes are pre-assembled, whereas pronunciation of non-decomposable pseudowords must necessarily be accomplished by segmenting, transcoding into phonemes and assembling, on the fly, numerous smaller units (letters, letter clusters and/or syllables) into larger ones. The latter analytical process is not only slower but also more subject to error than morphemic processing, as a function of the high probability of making errors when assembling a high number of processing units. Thus morphemic units may also increase reading accuracy, when the

alternative reading procedure consists of relying on small units (i.e., single letters or graphemes), which are the only ones available for strings of letters never encountered in print. However, when a unit larger than the morpheme (i.e., the whole-word) is available, morphemic parsing does not necessarily increase pronunciation accuracy.

6. ROOT AND SUFFIX: WHAT ARE THEIR ROLES IN READING ALOUD?

The presence of morphemes in a stimulus speeded up reading aloud, especially in the case of newly encountered words. However, we did not assess whether the facilitation on naming latencies was caused by the activation of the root only, for its role as access code to the lexicon (Taft and Forster 1975), and its initial position in the stimulus (Hyönä, Bertram, and Pollatsek 2004). Therefore, we aimed to determine the relative impact of roots and suffixes on reading aloud by children who differ in fluency.

In a previous study on adults, based on pseudoword stimuli (Burani, Arduino, and Marcolini 2006), roots had a strong facilitating effect on naming times, whereas suffixes had a weaker effect. If this difference is due to the position of the suffix in the stimulus, children with dyslexia, who typically present highly sequential scanning of the stimulus, may show even stronger differential effects related to the position of the morphemic units in the word than adults, thus revealing a prominent role of the root. Skilled sixth-grade readers may already resemble adults regarding the size of their perceptual span in reading (Häikiö et al. 2009; Rayner 1986). Consequently, they might be able to take more advantage from the rightmost morphemic unit (the suffix) than children with dyslexia.

Based on the developmental data on low frequency derived words (e.g., Carlisle and Stone 2005), a further distinction between fluency and accuracy performance might be expected, with roots mainly affecting reading latencies, possibly because of their role in providing meaning (Elbrö and Arnbak 1996), and suffixes mainly affecting accuracy, because of their effect on correct stress assignment to new stimuli (see, e.g., Jarmulowicz, Taran, and Hay 2007; 2008).

In order to study the differential roles of left vs. right morphemic constituents on children's reading performance, we presented sixth-grade children with dyslexia and skilled readers with pseudoword stimuli that exhibited a varying morphological structure (Traficante, Luci, Marcolini, Zoccolotti, and Burani 2010). Four sets of pseudowords were administered: pseudowords in the first set (root + suffix, e.g., BAGNEZZA) consisted of a

familiar root (BAGN-, 'bath') and a frequent derivational suffix (-EZZA, '-ness') in a combination not attested in the Italian language. Pseudowords in set 2 (root + non-suffix, e.g., BAGNEZZO) included the same root (BAGN-) used in the first set, followed by an orthographic sequence (-EZZO*) not corresponding to a real Italian suffix. Pseudowords in set 3 (non-root + suffix, e.g., BOGNEZZA) were formed of orthographic sequences (BOGN*) that did not correspond to any existing root, but were matched to the roots of the morphological sets for orthographic structure and bigram frequency and were combined with the same suffixes (-EZZA) used in the first set. Finally, pseudowords in set 4 (non-root + non-suffix, e.g., BOGNEZZO) were formed of the same non-morphemic orthographic sequences - non-suffix and non-roots, respectively - used in sets 2 and 3. Non-suffixes were matched for length, orthographic structure and average frequency in word-final position to the experimental suffixes.

The results showed that, for both skilled young readers and children with dyslexia, a root in the initial part of the stimulus led to faster and more accurate naming than a similar non-root orthographic sequence of letters in the same position. The suffix significantly affected pronunciation accuracy but not RTs, with no clear-cut differences between typically developing readers and children with dyslexia.

This pattern of results emphasizes the role of constituent position in the stimulus, by assigning a leading role to the first unit and reducing the effect of the second one. In the case of new or low-frequency root + suffix combinations, the root (the first, left-end constituent) may provide a headstart to the morphological parsing route (Bertram and Hyönä 2003). Activation coming from the suffix (the second, right-end constituent) occurs later in processing, thus the suffix is less relevant than the root in inducing parsing. The headstart to decomposition provided by the root, already demonstrated for adults in lexical decision on words (Burani and Thornton 2003), was here found in pseudoword naming, more evidently in young readers than in adults (Burani et al. 2006). These data, along with the suffix effect on accuracy, are consistent with eye movement studies in sentence reading, indicating that both morphemic constituents (namely root and suffix) play a role (Hyönä and Pollatsek 1998; Kuperman, Bertram, and Baayen 2008) but exert different effects: the former influences the duration of the first fixation while the latter affects later processing (Pollatsek, Hyönä, and Bertram 2000).

The suffix did not influence the onset of pronunciation but had a role similar to the root in enhancing pronunciation accuracy of pseudowords. The effect of the suffix on the correct phonological rendering of a new word might be related to its role in assigning stress to the new combination. In Italian, assembling the pronunciation of a root and a suffix at the production stage

implies assigning a stress to the root + suffix combination which is different than the root stress. For instance, in assembling the pronunciation of a root + suffix pseudoword like BAGNEZZA, the root stress (*bàgn-*) must shift to the following syllable (bagnèzza). The second morphemic constituent (i.e., the suffix) is crucial in such a process for its role as stress attractor (see Jarmulowicz et al. 2007; 2008), thus affecting co-articulation of the morphemic combination.

In understanding the relevance of morphemic units in reading it is worth noting that morphemes cannot be considered only as high-probability sequences of letters. In the study by Traficante et al. (2010), a number of regression analyses showed that root and suffix frequencies were significant predictors of naming performance, over and above the effects of the frequency of their constituting orthographic patterns. The information drawn from morphemic constituents seems not to be reducible to pure orthographic information. The peculiarity of the root in improving reading fluency and accuracy may result not only from its orthographic familiarity but also from the regularity of the orthography-to-semantics mapping provided by the unit. This possibility is consistent with connectionist models that use distributed representations rather than discrete morphemes and in which non discrete morphological structures emerge from orthographic, phonological and semantic regularities (e.g., Gonnerman, Seidenberg, and Andersen 2007; Pagliuca and Monaghan 2010).

Interestingly, the computational model of Italian reading aloud developed by Pagliuca and Monaghan (2010) was effective in simulating the morphological effects in reading pseudowords, only by discovering the relevant units in terms of mapping between orthography and phonology - that is, by computing the multiple regularities between written and spoken words - without recourse to a semantic system (see also Plaut and Gonnerman 2000, for computational modelling of morphological effects in the absence of semantic similarity in Hebrew). These computational models accounting for morphological effects with no semantic mediation in morphologically rich languages like Italian and Hebrew raise the issue of how the morphological effects we found in children's reading aloud may be related to semantic effects. This question is addressed in the next section.

7. A SEMANTIC MORPHOLOGY-BASED COMPENSATORY READING STRATEGY FOR CHILDREN WITH DYSLEXIA?

Morpheme processing has been considered to be a compensatory reading

strategy in word decoding and comprehension in dyslexia (e.g., Casalis, Colé, and Sopo 2004; Elbrö and Arnbak 1996). The morphology-based reading strategy in dyslexics is assumed to be semantic, because it may involve meaning extraction from the morphemic units (stems and affixes) constituting the word. For instance, Elbrö and Arnbak (1996) found that Danish adolescent dyslexics read words with a semantically transparent morphological structure better than words with an opaque structure, an advantage not found for the control group.

Morphemes do help to obtain the meaning of a morphologically complex word in comprehension tasks, because the meaning of a derived unfamiliar word can be drawn by analyzing and combining the meanings of the two morphemic constituents (root and affix). In contrast, the meaning of a simple word, when it is encountered for the first time out of context, cannot be inferred. Burani, Bimonte, Barca, and Vicari (2006) studied how word morphology may facilitate the comprehension of a new word in both typically developing 6 to 10 years old children and in individuals with Williams syndrome, a genetically based neurodevelopmental disorder associated with mild to severe mental retardation and verbal skills usually better preserved than nonverbal skills. By employing a word definition task, derived unfamiliar suffixed words (e.g., COLORISTA, 'colorist') were compared to simple, equally unfamiliar words (e.g., FARABUTTO, 'rascal'). The results showed that derived words were better defined than simple words by both typically developing children and mental age-matched individuals with Williams syndrome, and that both groups were positively affected by the frequency and productivity of the suffixes (i.e., the more productive and frequent a suffix, the easier it is to understand a derived word; see also Bertram, Laine, and Virkkala 2000, for similar results in Finnish children). Thus Burani et al. (2006) demonstrated access to word-formation morphology and employment of root and suffix knowledge to understand the meaning of non familiar words in developing readers of different cognitive and linguistic abilities.

Whether in reading aloud availability of the root also implies access to the word meaning has to be demonstrated. On the sole basis of the results of our naming studies, it cannot be adjudicated whether the reading advantage shown by dyslexic and younger readers on morphologically complex words is due to accessing meaningful units (morphemes). However, two observations can be made. First, studies on reading aloud in adults (e.g., Baayen, Feldman, and Schreuder 2006; Baayen et al. 2007; Balota, Cortese, Sergent-Marshall, Spieler, and Yap 2004; Burani, Arduino, and Barca 2007), as well as in children with dyslexia and skilled young readers (De Luca, Barca, Burani, and Zoccolotti 2008) indicate a general insensitivity of word naming to semantic

variables such as word imageability. Second, in previous studies, it was shown that for both adult and young Italian skilled readers the semantic interpretability of a new root-suffix combination (e.g., DONNISTA, 'womanist', interpretable as 'somebody who likes or supports women') affected lexical decision but had no effect on reading aloud (Burani, Dovetto, Spuntarelli, and Thornton 1999; Burani et al. 2002).

In the latter studies, pseudowords were rated for semantic interpretability on a seven-point scale. Mean interpretability ratings were then used as predictors in post-hoc correlations with mean reaction times and error rates at naming and lexical decision as dependent variables, for both children and adults. The degree of semantic interpretability of the new morphological combination negatively affected lexical decision, with highly interpretable morphological pseudowords being harder to be rejected as non existing words relative to less interpretable morphological pseudowords. However, semantic interpretability did not affect naming performance at all, neither for children in any grade nor for adults (similar results were reported in the case of Dutch new compounds by Coolen,Van Jaarsveld, and Schreuder 1991).

Burani et al. (1999) argued that the activation of lexical morphemic representations, resulting in faster and more accurate naming of newly encountered morphemic combinations, does not necessarily imply that the semantics of the new combination is activated. The meaning of a new morphological combination is processed and has a main role in judging for its acceptability, or in comprehending its meaning. However, it might not play a role in the process of reading aloud. These results add further evidence in favour of the hypothesis that morpheme-based lexical reading does not necessarily imply parallel access to a semantic component in which the meaning of the combination is activated, not even in children (for the view that lexical reading is not inevitably mediated by semantic activation, see also Peressotti and Job 1999).

The effects of the semantic characteristics of morphologically complex stimuli on the reading performance of Italian dyslexics has not been assessed yet. Nevertheless, our studies suggest that morphemic units are instrumental for dyslexic readers of transparent orthographies to increase reading fluency.

7. CONCLUSIONS

In the experimental studies reviewed above, we have shown that morpheme-based reading is used by Italian readers with developmental reading deficit, and is particularly beneficial to enhance their reading fluency. For children with dyslexia, the presence of root and suffix morphemes in a

polymorphemic stimulus leads to faster naming times than in the case of stimuli that have similar formal characteristics but are not analyzable in morphemes. Morphemic constituents affected positively the speed of children with dyslexia in reading all types of stimuli, namely (a) both pseudowords and words; (b) both low-frequency and high-frequency words; (c) both long and short low-frequency words. By contrast, for skilled readers of the same age as children with dyslexia, the possibility of parsing a stimulus into root and suffix affected naming latencies positively only in the case of new (pseudoword) stimuli and long low-frequency words.

This pattern of results suggests that morpheme-based reading is available and useful for children with dyslexia, who are otherwise prone to serial analytical reading processing (see Paizi et al. 2010). In accordance with some findings obtained on developing readers of opaque scripts, we found that access to morphemes can help less skilled readers to compensate the difficulty they show with whole-word units. We argued that the presence of morphemes in a stimulus is beneficial for readers with dyslexia because morphemes provide reading units that are larger than graphemes (which entail extremely slow and analytical processing) but are smaller than words (which readers with dyslexia find difficult to process as a whole). In readers with processing limitations, the fact that letters (and phonemes) are assembled within morphemes speeds up the reading process with respect to the more analytical process of segmenting, transcoding and re-assembling small units (letters and phonemes) into larger ones. Morpheme-based reading can thus reduce the limitations due to analytical reading in less skilled readers.

By contrast, in experienced readers, morphemic parsing is an effective strategy only when the root + suffix combination is new, or not familiar enough, and long: that is, when the alternative reading procedure consists in relying on smaller reading units such as single letters or letter clusters. On the other hand, skilled readers do not seem to resort to morphemic parsing in the case of known and easily processable polymorphemic words, that is, when a whole-word unit (larger than the morpheme) is present in the reader's lexicon and can be obtained in a single fixation.

In summary, morpheme-based reading aloud favours reading fluency in all cases where whole-word processing is less likely, either because of properties of the stimulus word or because of processing limitations on the reader's part. When a word is known and available as a whole, parsing costs (connected with word segmentation and recombination of the segmented units both at orthographic and phonological processing stages) can outweigh benefits. Consequently, whole-word processing turns out to be more convenient.

The effects of morphemic processing on reading latencies that we

observed in Italian are in line with some results found in deep orthographies. However, unlike what was observed with developing readers of opaque orthographies, we were able to show effects of morphemes on pronunciation accuracy in pseudoword reading only. The effects of morphemic processing on the pronunciation accuracy of real words were weak, and were found only in children with dyslexia while reading long low-frequency words. We interpreted these findings as due to the characteristics of the Italian transparent script, where, in sharp contrast with some opaque scripts, morphologically-governed pronunciation rules are absent (see section 5).

Overall, the reviewed studies indicate that in Italian, as in other alphabetical scripts, the larger the reading unit, the faster the reading performance. Similarly to what happens with deeper scripts, reading based on units of a large grain size, i.e., whole-word and morphemic units, is inevitable in transparent orthographies and develops very early on, to face reading fluency requirements.

These findings contribute to play down the emphasis on the role of recoding accuracy in the acquisition of reading expressed by some recent views (see, e.g., Ziegler and Goswami 2005; 2006). According to these views, developing readers of transparent scripts differ from readers of opaque scripts because, in order to obtain good pronunciation accuracy, they rely on small grain size reading units, specifically graphemes and phonemes, as opposed to readers of deeper scripts like English, for which multiple grain size mappings are necessary, due to the inconsistencies of the script. However, recoding accuracy forms only a fraction of the proficiency of a mature skilled reader. Being a fast and fluent reader requires mastering large reading units, in both deep and transparent orthographies (see also Paulesu 2006; Wimmer 2006).

Overall, our studies show that the reading of Italian children with dyslexia can be based on grain size units larger than single letters. Some questions are still open. The effect of word morphology that we found on naming latencies was driven mainly by the root morpheme, whereas pronunciation accuracy, in the case of new (pseudoword) stimuli, was positively affected by both the root and the suffix. The respective roles of root and suffix, and specifically the key function of the root in accessing meaning, as well as the importance of the suffix for stress assignment and for its semantic and syntactic information need to be further explored. Whether the reading advantage shown by readers with dyslexia on morphologically complex stimuli is due to facilitated access to the word's meaning is still to be convincingly demonstrated, at least for readers of a language with transparent orthography and rich word morphology. However, the whole set of our studies strongly suggests that reading based on morphemic units should be given a central role in the training intervention with dyslexic readers of transparent

orthographies to increase reading fluency.

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SUMMARY: Nel presente articolo, vengono passati in rassegna studi recenti che mostrano come i morfemi (radice e suffisso derivazionale) costituiscano unità di lettura accessibili ai ragazzi italiani con dislessia evolutiva. Viene mostrato come la lettura basata sui morfemi sia d'aiuto ai ragazzi con dislessia, per ridurre le loro difficoltà nella lettura fluente. Vengono illustrate somiglianze e differenze fra la lettura dei ragazzi con dislessia e quella di ragazzi e adulti normo-lettori. Viene discusso come la probabilità di lettura basata sui morfemi varii a seconda delle caratteristiche di lessicalità, frequenza e lunghezza delle parole, e dell'abilità del lettore.