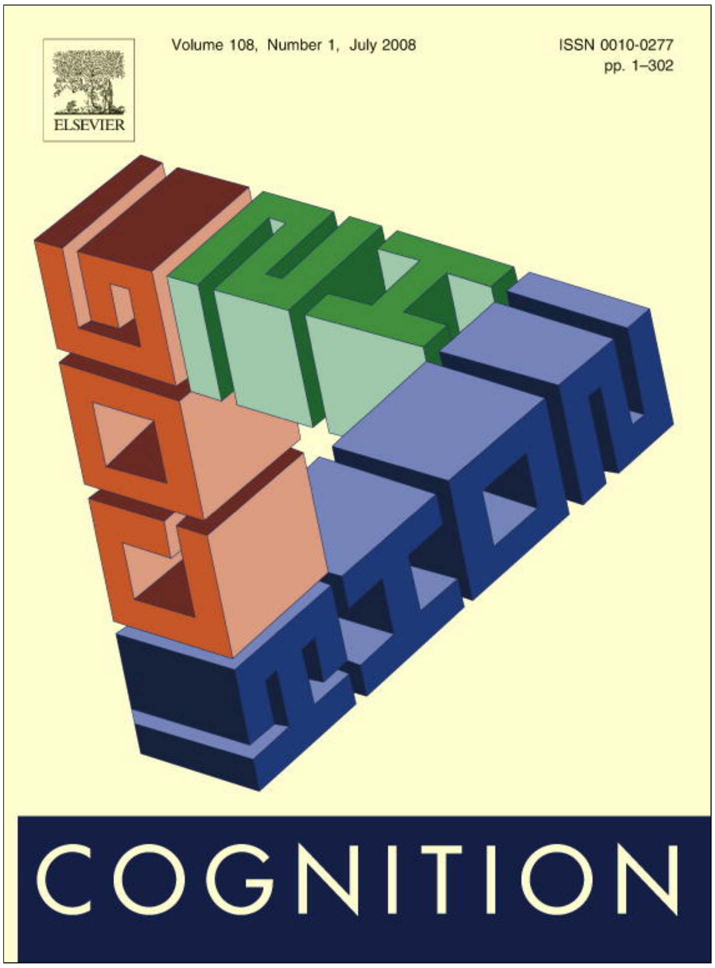
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Brief article

Morpheme-based reading aloud: Evidence from dyslexic and skilled Italian readers

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Abstract

The role of morphology in reading aloud was examined measuring naming latencies to pseudowords and words composed of morphemes (roots and derivational suffixes) and corresponding simple pseudowords and words. Three groups of Italian children of different ages and reading abilities, including dyslexic children, as well as one group of adult readers participated in the study. All four groups read faster and more accurately pseudowords composed of root and suffix than simple pseudowords (Experiment 1). Unlike skilled young and adult readers, both dyslexics and younger children benefited from morphological structure also in reading aloud words (Experiment 2). It is proposed that the morpheme is a unit of intermediate grain size that proves useful in processing all linguistic stimuli, including words, in individuals with limited reading ability (dyslexics and younger readers) who did not fully develop mastering of whole-word processing. For skilled readers, morphemic parsing is useful for reading those stimuli (i.e., pseudowords made up of morphemes), for which a whole-word lexical unit does not exist; where such whole-word lexical units do exist, skilled readers do not need to rely

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on morphological parsing because they can rely on a lexical (whole-word) reading unit that is larger than the morpheme.

Keywords: Morphology; Reading; Developmental dyslexia

1. Introduction

In languages as different as English, Finnish and Italian, elementary school children use the morphemic constituents of words in performing tasks on written stimuli such as fragment completion (Feldman, Rueckl, DiLiberto, Pastizzo, & Vellutino, 2002), word definition (Bertram, Laine, & Virkkala, 2000; Burani, Bimonte, Barca, & Vicari, 2006) and lexical decision (Burani, Marcolini, & Stella, 2002). Sensitivity to word morphology develops early in childhood (Carlisle & Nomabody, 1993; Casalis & Louis-Alexandre, 2000) and is present to some extent also in impaired readers (Casalis, Sopo, & Colé, 2004; Elbrö & Arnbak, 1996; Leong & Parkinson, 1995).

Morphological knowledge in word comprehension and production tasks does not necessarily imply that morphemes also play a role as processing units in a print-to-sound decoding task such as reading aloud. Little information on this topic is available on children. Studies in opaque orthographies, such as English, Danish and French, followed the assumption that in such orthographies (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 & Perfetti, 2003). With untimed stimulus presentation, the presence of known morphemes in a word, such as stems and affixes, may affect young readers' accuracy in reading aloud, mainly when morphologically complex words are phonologically and semantically transparent with respect to the base word (Carlisle & Stone, 2003; Elbrö & Arnbak, 1996; Laxon, Rickard, & Coltheart, 1992), or when suffixes are frequent and productive (Mann & Singson, 2003).

Up-to-date, only one study has assessed the role of morphology in children's reading aloud a transparent language. Burani et al. (2002) showed that young Italian readers in third to fifth grades could benefit from the presence of morphemes similarly to adult readers (see review in Burani & Laudanna, 2003). In a naming task, pseudowords made up of a root and a derivational suffix in a combination not existing in Italian (e.g., DONNISTA, 'womanist') were read faster and more accurately than simple pseudowords matched for orthographic familiarity (e.g., DENNOSTO).

To our knowledge, no study has investigated whether in transparent orthographies morphemes are effective units also in reading aloud words. For an experienced reader, parsing a word into morphemic sub-parts may be an efficient strategy when it is not familiar. For low-frequency words, the recourse to higher-frequency constituents (morphemes) may facilitate processing (Burani & Thornton, 2003).

Apart from frequency, the adoption of morphemes as reading units may also be constrained by the joint effect of word length and reader's ability. For both adult and young skilled readers, 7–10 letter words can be processed in one shot (Hutzler & Wimmer, 2004; Rayner & McConkie, 1976). However, developmental dyslexics experience difficulties in processing such stimuli as whole units. Italian dyslexics' eye fixations reveal fractionated text scanning, with a prevalence of small amplitude saccades (De Luca, Di Pace, Judica, Spinelli, & Zoccolotti, 1999). These eye-fixation patterns result in an extremely slow and analytical reading strategy and in marked stimulus length effects (Spinelli et al., 2005; Zoccolotti et al., 1999, 2005a) affecting similarly words and non-words (De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, 2002; see also Hutzler & Wimmer, 2004). This pattern of reading performance resembles that of children at an early stage of learning to read (Zoccolotti et al., 2005a).

The present study assessed reading aloud of morphologically complex words and pseudowords in Italian children of different reading abilities, including developmental dyslexics. Our hypothesis was that morphemic constituents (roots and suffixes) could help dyslexics to read aloud both pseudowords *and* words. Morphemes may be efficient reading units for dyslexics because they have an intermediate size between graphemes, which lead to extremely slow and analytical processing, and words, which for dyslexics are too large units to be processed as a whole. Similar benefits from morpheme-based reading aloud of familiar words may be present in younger readers, but may not occur for skilled readers due to their ability to process larger reading units as a whole. Word-based reading avoids parsing and assembling costs connected to morpheme-based reading (for costs of morphemic parsing in lexical decision, see Laine, Vainio, & Hyönä, 1999; Traficante & Burani, 2003).

The reading aloud of both pseudowords and words composed of morphemes (roots and derivational suffixes) was compared to that of simple pseudowords and words with no root + suffix structure. Three groups of Italian children of different ages, with and without reading difficulties, were tested along with a group of adult readers. The aim was to show that, in a transparent orthography, readers of different skills may take advantage of reading units (morphemes) of larger than the single grapheme grain size. All groups of readers, irrespective of reading skill, were expected to take advantage of morphemic units in reading aloud pseudowords: the presence of morphemes in a pseudoword would result in shorter reading latencies and higher reading accuracy than grapheme-based reading. Only less skilled readers, i.e., younger readers and dyslexics, who have not developed efficient whole-word reading ability, were expected to rely on morphemic constituents when reading aloud words. In contrast, skilled readers, both children and adults, should read as fast and accurately both morphologically complex and simple words, because of their capacity to process both types of words as whole units.

2. Experiment 1. Reading aloud pseudowords

In the first experiment, the reading aloud of pseudowords made up of morphemes was contrasted with the reading of simple pseudowords.

2.1. Method

2.1.1. Participants

Four groups of participants were included in the study: dyslexics, chronologically-matched skilled readers, reading-matched younger normally-developing children and adults.

Criterion for inclusion in the dyslexic group was marked reading delay on a standard reading achievement test (MT test, Cornoldi, Colpo, & Gruppo, 1981). The child reads aloud a passage with a 4-min time limit; speed (second per syllable) and accuracy (number of errors, adjusted for the amount of text read) are scored. Dyslexics scored below 1.5 *z*-scores in either speed or accuracy. A total of 17 dyslexics was examined. Of these, 7 were below the cut-off for both speed and accuracy and 10 for accuracy only.

Dyslexics were compared to 34 skilled readers of the same chronological age. Performance of these children on the MT test was well within normal limits (with mean *z*-scores near-zero) for both accuracy and speed. Dyslexics and same-age skilled readers were matched for sex and non-verbal intelligence (Raven's Colored Progressive Matrices). Summary statistics and mean scores on screening tests are given in Table 1.

Dyslexics were also compared to 17 younger typically developing children matched for sex and reading speed on the MT test (0.45 and 0.41 second per syllable for the dyslexic and typically developing children, respectively; $t < 1$, ns). Also these children performed within normal limits on the MT test (with mean *z*-scores near-zero) according to their respective age norms (Table 1).

Table 1
Summary statistics (mean age in years and months, with range in parentheses

	Chronological age	Male	Female	Raven test	Reading speed	Reading accuracy
Dyslexic 6th graders	11;3 (10;10–12;3)	$N = 11$	$N = 6$	30.12 ($SD = 3.4$)	−1.41 ($SD = 1.2$)	−2.27 ($SD = .67$)
2nd–3rd graders	8;3 (7;1–9;2)	$N = 10$	$N = 7$	25.6 ($SD = 2.9$)	.19 ($SD = .17$)	−0.04 ($SD = .38$)
Skilled 6th graders	11;1 (10;4–11;8)	$N = 22$	$N = 12$	30.15 ($SD = 3.1$)	.30 ($SD = .33$)	.01 ($SD = .49$)

N of male and female participants), mean scores at Raven test (with standard deviation in parentheses), mean *z*-scores on reading speed and accuracy (with standard deviation in parentheses) for dyslexics, reading-matched young children and skilled children. Values are based on the respective age norms.

All children had normal or corrected-to-normal vision. Performance on the Raven's Colored Progressive Matrices was well within normal limits for all three groups according to normative Italian data (Pruneti, 1985).

Finally, 30 adults (15 male and 15 female students at Universities of Rome), 20–32 years old, participated in the experiment.

The characteristics of the dyslexic participants' reading disturbance were also examined by additional tasks. Four lists of words (varying for frequency and length) and two of non-words (varying for length) were administered (Words and Non-words Reading test; Zoccolotti, De Luca, Di Filippo, Judica, & Spinelli, 2005b). Thirty stimuli per list were given; number of errors and reading speed were scored. The dyslexic children were severely affected: their mean standardised scores were less than two SDs in most conditions (see Table 2). The children were similarly impaired for both reading speed and accuracy. Word and non-word reading were similarly impaired. This latter finding is similar to previous observations on Italian children (Zoccolotti et al., 1999). A Blending test measured phonological awareness. Words (and non-words) were presented phoneme by phoneme at a rate of 1 per second. Then, the participants repeated aloud the whole-word (or non-word). Nineteen words and 19 non-words (5–6 letters) were presented (for details see Angelelli, Judica, Spinelli, Zoccolotti, & Luzzatti, 2004). The number of correctly blended items was counted. Overall, the dyslexics' mean performance was well within normal limits (see Table 2), consistently with previous observations indicating limited metaphonological deficits among Italian dyslexics (Brizzolara et al., 2006).

2.1.2. Materials

Two sets of 16 three-syllable pseudowords (morphological and simple) were constructed. Morphological pseudowords were composed of a root (e.g., DONN-, 'woman') plus a derivational suffix (e.g., -ISTA, '-ist') resulting in a combination not existent in Italian (e.g., DONNISTA, 'womanist'). Simple pseudowords (e.g., DENNOSTO) did not include any existing morpheme. The roots were of high-frequency (Marconi, Ott, Pesenti, Ratti, & Tavella,

Table 2
Performance of dyslexic children on the Words and Non-words Reading test and on the Blending test

Words and Non-words Reading test	Speed	Accuracy
HF short words	−2.14 (*SD* = 3.65)	−0.98 (*SD* = 2.58)
HF long words	−2.34 (*SD* = 2.73)	−2.37 (*SD* = 3.23)
LF short words	−2.46 (*SD* = 2.77)	−2.16 (*SD* = 2.26)
LF long words	−2.77 (*SD* = 2.64)	−1.52 (*SD* = 2.26)
Short non-words	−2.37 (*SD* = 2.72)	−2.03 (*SD* = 2.90)
Long non-words	−2.58 (*SD* = 2.84)	−1.37 (*SD* = 1.71)
Blending test	Whole target repetition	Blended phoneme pairs
Words	−0.23 (*SD* = .80)	−0.17 (*SD* = 0.79)
Non-words	−0.78 (*SD* = .88)	−0.68 (*SD* = 0.58)

Values indicate *z*-scores based on normative samples.

1993), and suffixes were among the most frequent and productive in Italian nominal and adjectival derivatives. The non-suffix final strings in simple pseudowords had the same average frequency in word-final position as the suffixes in morphological pseudowords. The two pseudoword sets (Appendix A) were matched for initial phoneme, syllabic structure, length, bigram frequency, orthographic neighborhood size and orthographic complexity (Barca, Ellis, & Burani, 2007; Burani, Barca, & Ellis, 2006).

To favour lexical reading, 16 filler words were included in the list. The total 48 stimuli were presented in two blocks in different random orders. The order of block presentation varied. A short practice including both pseudowords and words preceded the experimental session.

2.1.3. Procedure

The stimuli, presented in lower case in the centre of a PC screen, disappeared at the response or after 6000 or 1000 ms, for children and adults, respectively. Participants read the stimuli aloud as quickly and accurately as possible. Using a voice key connected to the computer, in the SuperLab Pro-2.0 software, reaction times (RT) were collected from the stimulus presentation to the onset of vocalization. The experimenter noted mispronunciations.

2.2. Results and discussion

Invalid trials due to registration errors or responses exceeding the deadline (7.5% of total data points for adults, 11.2% for skilled children, 11.4% for younger children and 16.9% for dyslexics) were excluded from the analyses. RTs for correct responses in the two pseudoword sets and pronunciation errors are shown in Fig. 1, separately for the four participating groups.

For children, by-participant ANOVAs with group (dyslexic, younger and skilled) as unrepeated factor and pseudoword type (morphological vs. simple) as repeated factor were carried out both on log transformed RTs data and number of pronunciation errors. In the by-item ANOVAs, pseudoword type was the unrepeated factor and readers' group was the repeated factor.

In the RTs analyses, there were main effects of group ($F1\ (2,65) = 24.07$, $p < .0001$, $MSE = 0.052$; $F2\ (2,60) = 291.92$, $p < .0001$, $MSE = 0.003$), with slower naming times for both dyslexic and younger children than for skilled children, and no speed differences between dyslexic and young children. There was a significant effect of pseudoword type ($F1\ (1,65) = 51.32$, $p < .0001$, $MSE = 0.002$; $F2\ (1,30) = 10.35$, $p < .005$, $MSE = 0.008$), with no group × pseudoword interaction ($F1\ (2,65) = 2.28$, $p > .1$, $MSE = 0.002$; $F2\ (2,60) = 0.68$, $p > .1$, $MSE = 0.003$). All groups of children took advantage of morphemic units to speed up pseudoword processing.

The analyses on errors showed significant effects of group ($F1\ (2,65) = 6.47$, $p < .005$, $MSE = 5.10$; $F2\ (2,60) = 10.63$, $p < .001$, $MSE = 87.7$), with dyslexics less accurate than both skilled and younger children, pseudoword type ($F1\ (1,65) = 71.31$, $p < .0001$, $MSE = 2.79$; $F2\ (1,30) = 54.49$, $p < .0001$, $MSE = 111.78$) and

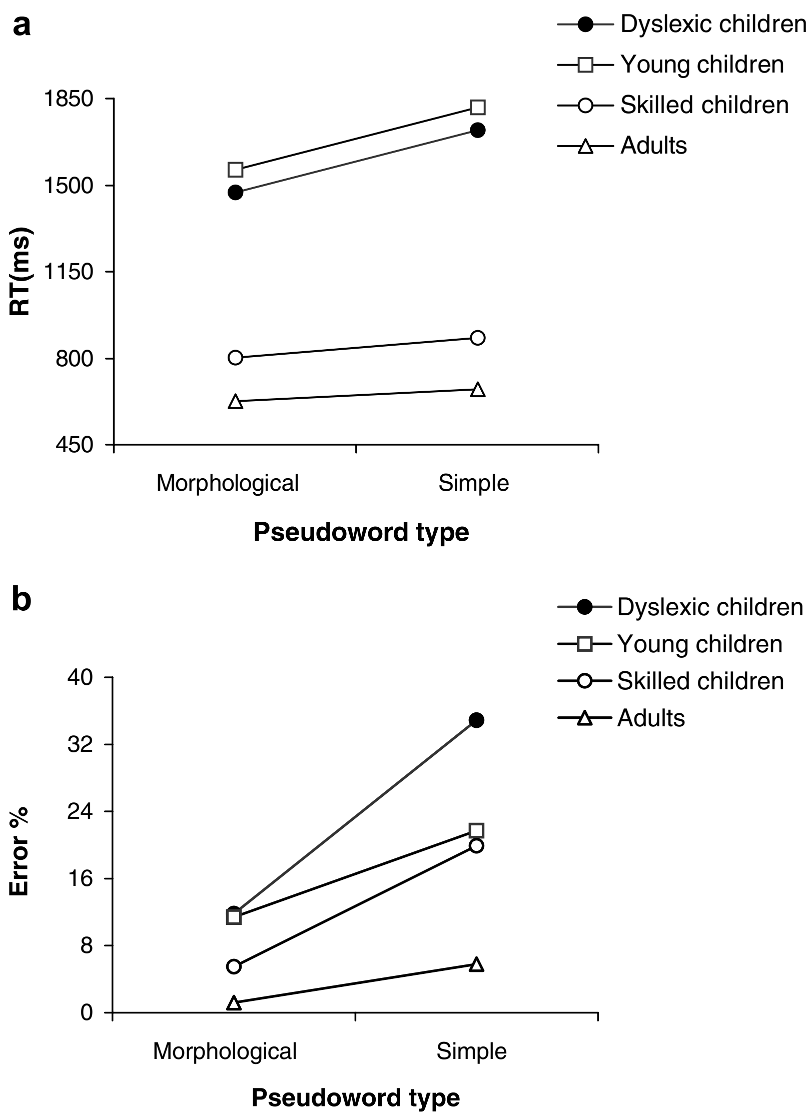

Fig. 1. Mean by-item naming times in ms (a) and percent pronunciation errors (b) as a function of pseudoword type (morphological and simple) and reader's ability (dyslexic children, young children, skilled children, adults) Experiment 1.

group × pseudoword interaction (F1 $(2,65) = 3.45$, $p < .05$, $MSE = 2.79$; F2 $(2,60) = 3.95$, $p < .05$, $MSE = 87.71$). All groups of children benefited from morphemic units to obtain better pseudoword pronunciation accuracy ($p < .005$ in all cases), with a bigger advantage for dyslexics. No between-group difference was present for morphological pseudowords; in contrast, dyslexics made more errors on simple pseudowords than both skilled ($p < .005$) and younger ($p < .005$) children who did not differ from each other.

Based on their nearly flawless performance, only RTs were analyzed in the case of adult readers. The ANOVA showed faster RTs for morphological than simple pseudowords ($F1\ (1,29) = 67.24$, $MSE = 644.77$, $p < .0001$; $F2\ (1,30) = 10.7$, $MSE = 1739.8$, $p < .003$).

Irrespective of reading skill, all groups of readers read faster and more accurately pseudowords made up of morphemes than simple pseudowords. The effect of morphemic constituency on reading accuracy was larger for dyslexic readers than for all the other groups. Thus for all readers, and specifically for dyslexics, morphemes resulted in more effective reading units than graphemes.

3. Experiment 2. Reading aloud words

In Experiment 1, pseudowords were considered, contrasting pseudowords made up of morphemes and control pseudowords. In Experiment 2, words were considered, contrasting derived words and simple words; the aim was to answer whether morphemes are effective processing units (and equally effective reading units for readers of different reading skills) also when a larger reading unit (i.e., the word) is present. Morphemic constituents (roots and suffixes) in a word may affect positively the reading performance of less skilled readers (i.e., younger and dyslexic children), for which the word represents a difficult unit to be processed as a whole. Skilled readers, both children and adults, who are better at processing words as whole units, should read as fast and accurately morphologically complex and simple words.

3.1. Method

3.1.1. Participants and procedure

Same as in Experiment 1.

3.1.2. Materials

Two sets of 38 derived and 38 simple words each were selected. Derived words were composed of a root and a derivational suffix (e.g., CASS-IERE, 'cashier'). Simple words were not parsable in root + derivational suffix (e.g., CAMMELLO, 'camel'). The words, 7–10 letters long, had medium-to-low frequency in the child written frequency count (Marconi et al., 1993), were phonologically and semantically transparent, and included frequent roots and suffixes. All words had the most frequent Italian stress, on the penultimate syllable. The two sets (Appendix B) were matched on initial phoneme, word frequency, familiarity, length, bigram frequency, orthographic neighborhood size and orthographic complexity.

Thirty simple and nine derived word-fillers were added to balance the number of repetitions of suffixes and simple word endings and increase the variety of suffixes. The materials were divided into five blocks of 23 words each, for a total of 115 words. The blocks, and the words within a block, were presented in a random order. A brief practice session preceded the experiment.

3.2. Results and discussion

Missing data accounted for 2.4% of data points for adults, 8.5% for skilled children, 10% for younger children and 16.6% for dyslexics. The RTs and pronunciation

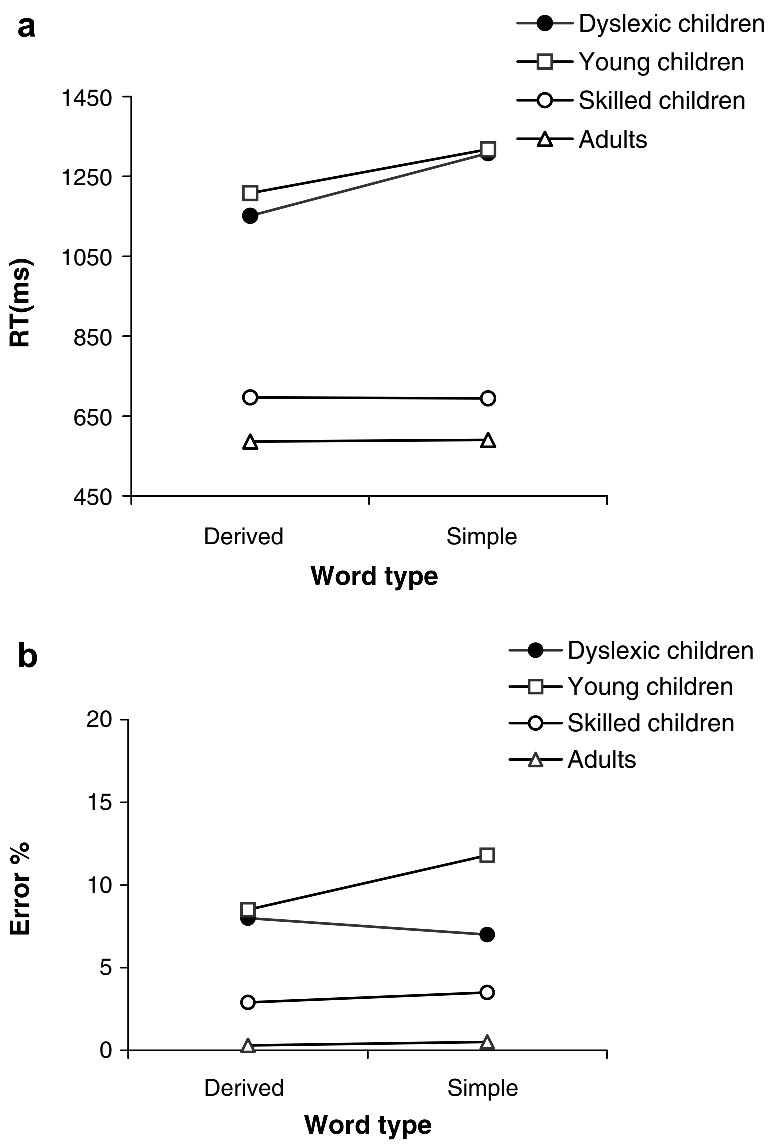

Fig. 2. Mean by-item naming times in ms (a) and percent pronunciation errors (b) as a function of word type (derived and simple) and reader's ability (dyslexic children, young children, skilled children, adults) Experiment 2.

errors for the two word sets are shown in Fig. 2 separately for the four participating groups.

For children, ANOVAs on log transformed RTs showed main effects of group (F1 $(2,65) = 26.73$, $p < .0001$, MSE = 0.031; F2 $(2,148) = 723.76$, $p < .0001$, MSE = 0.002), word type (derived vs. simple) (F1 $(1,65) = 17.72$, $p < .0001$, MSE = 0.001; F2 $(1,74) = 5.34$, $p < .05$, MSE = 0.002) and group × word type interaction (F1 $(2,65) = 6.54$, $p < .005$, MSE = 0.001; F2 $(2,148) = 6.5$, $p < .005$, MSE = 0.002). Skilled children were faster than both dyslexic and younger readers, who did not differ from each other. Both dyslexic and younger children were faster in reading aloud words including morphemic units ($p < .005$). No effect of word morphology was present in skilled children.

The analyses on pronunciation errors showed a significant effect of group only (F1 $(2,65) = 18.99$, $p < .0001$, MSE = 31.29; F2 $(2,148) = 22.65$, $p < .0001$, MSE = 41.04), with dyslexics more accurate than young readers ($p < .001$) and less accurate than skilled readers ($p < .05$). The group × word type interaction was not significant.

The ANOVA on RTs on adults showed no differences in reading aloud derived vs. simple words.

As expected, only less skilled readers (i.e., younger and dyslexic children) displayed faster latencies and higher accuracy in reading aloud words made up of morphemes than simple words. In contrast, skilled readers read as fast and accurately derived and simple words, for which whole-word lexical units are available.

4. General discussion

Confirming previous evidence (Burani, Arduino, & Marcolini, 2006; Burani & Laudanna, 2003; Burani et al., 2002), both adults and skilled children read faster and more accurately pseudowords composed of a root and a suffix. Less skilled (dyslexic and younger) readers also engaged in morphemic processing to supplement grapheme-phoneme decoding. These results add up to recent data showing that lexical units are available to Italian developmental dyslexics (Barca, Burani, Di Filippo, & Zoccolotti, 2006) as well as to children in the first grades (Orsolini, Fanari, Tosi, De Nigris, & Carrieri, 2006). Morphemes provide lexical reading units of a larger-grain size than graphemes thus reducing the limitations owed to the analytical reading processing of less skilled readers. Pseudoword reading in dyslexic and younger readers was similar to that of skilled children and adults: Whenever possible, all readers exploit the possibility of segmenting a new polysyllabic stimulus at a larger size than the letter/grapheme.

Unlike skilled readers, only dyslexic and younger readers benefited from morphological structure in reading words aloud. This new finding may appear surprising. According to developmental models, the morphographic level of representation is an advanced phase of development of literacy that is established on top of orthographic knowledge (Seymour, 1997); thus it should be available to skilled readers (see reviewed evidence in Section 1). However, the characteristics of both the task and the orthography should be taken into account. In word comprehension tasks, morphological decomposition can be useful to understand the meaning of a newly encountered root + suffix combination (provided that the root and the suffix are known by the reader). In contrast, in reading aloud, the reader must quickly assign the correct pronunciation to a word and morphemic parsing does not necessarily speed up processing. When a larger reading unit (the whole-word) is available, parsing a word into smaller reading units (the morphemes) may entail costs, as well as benefits. Parsing a familiar word into morphemic sub-parts can be more laborious and time-consuming than full-form activation, entailing processing costs at stages such as morpheme segmentation and composition (Schreuder & Baayen, 1995). Processing costs consequent to morphemic parsing may also occur at the production stage that is involved in reading aloud. In Italian, assembling the pronunciation of a (bound) root and a suffix to obtain whole-word pronunciation implies re-assigning to the root + suffix combination a different stress than the stress of the root alone, with consequent planning of a new co-articulation of the morphemic combination. In contrast, reading aloud English compounds or suffixed words does not entail re-assigning stress to the constituent word morphemes. Thus, English adult readers may produce lower error rates in naming compound and suffixed words in comparison to monomorphemic words, as well as faster naming latencies for compound than for monomorphemic words (Inhoff, Briihl, & Schwartz, 1996), or for compounds with a high-frequency second constituent (Juhasz, Starr, Inhoff, & Placke, 2003). Overall, for skilled readers an headstart to the morphological reading route may occur only in those cases in which the advantages connected to parsing prevail on the parsing costs (Bertram & Hyönä, 2003; Caramazza, Laudanna, & Romani, 1988).

In contrast to skilled readers, morpheme-based reading is efficient for less skilled readers in processing different types of linguistic stimuli, including words, because low-frequency words may not yet be in their orthographic lexicon, or may be too long to be processed as a whole. This is in agreement with results obtained on deeper orthographies. Carlisle and Stone (2005) showed that only younger English speaking elementary students (second and third graders) had faster reading times on derived than on monomorphemic words, whereas speed of reading the two word types did not differ for fifth and sixth graders. Using an untimed presentation, Elbrö and Arnbak (1996) found that Danish adolescent dyslexics read words with a semantically transparent morphological structure (e.g., sunburn) better than words with an opaque structure (e.g., window), an advantage not found for the control group.

Elbrö and Arnbak (1996) suggested that morpheme recognition is a compensatory reading strategy in word decoding and comprehension in dyslexia. In a lexical decision task, Colè, Leuwers, and Sprenger-Charolles (2005) reported stronger morphological priming effects in college dyslexics than in controls. All these authors concluded that the morphologically based reading strategy in dyslexics is semantic, because it involves meaning extraction from the smallest units (stems and affixes) constituting morphologically complex words.

On the basis of the present results, we cannot adjudicate whether the advantage shown by dyslexic and younger readers is due to accessing meaningful units (morphemes). Whereas a semantic strategy may account for performance in tasks such as primed lexical decision (Colè et al., 2005) or untimed reading aloud (Elbrö & Arnbak, 1996), speeded naming in a transparent orthography is not likely to be affected by semantic variables (Burani, Arduino, & Barca, 2007). Both in adult and child Italian readers the degree of semantic interpretability of new root–suffix combinations affects lexical decision but has no impact on reading aloud (Burani, Dovetto, Spuntarelli, & Thornton, 1999; Burani et al., 2002).

A recent theoretical proposal focuses on the reading units' grain size that is used during reading acquisition. According to the psycholinguistic grain size theory (Ziegler & Goswami, 2005), children learning to read a transparent orthography rely on small grain size units of processing such as single letters and phonemes, even when large-unit information is available. In contrast, readers of inconsistent orthographies are "forced" to develop multiple grain size mappings. This view does not consider morphemes in explaining the grain sizes used in decoding, although the authors acknowledge that salient units of different grain size may emerge as bigger units that are phonologically more accessible than single graphemes (Goswami & Ziegler, 2006).

The present results indicate that morphemes may develop as orthographic and phonological salient reading units not only when smaller grain sizes are inconsistent or unavailable, as in unpointed Hebrew spelling (Frost, 2006), but also when smaller reading units are easily available as in a transparent orthography. However, even in a transparent orthography, whole-word units can be more salient and efficient reading units than morphemes for readers not suffering from processing limitations. Further work on readers of different abilities of Italian and other languages is required to confirm the present findings as well as to extend our knowledge of the role of morphemes in reading aloud across different orthographies.

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Appendix A

Pseudowords used in Experiment 1

	LETT	BIGR FREQ	*N*-SIZE	CONT RULE	RT (% ERR) DYSL	RT (% ERR) YOUNG	RT (% ERR) SKILLED	RT (% ERR) ADULTS
Morphological								
bagnezza (bathness)	8	9.97	0	1	1885 (.18)	1686 (.06)	821 (.09)	594 (.03)
cartismo (paperism)	8	10.61	1	1	1360 (.06)	1092 (.12)	806 (0)	590 (0)
codismo (tailism)	7	10.48	0	1	1513 (.06)	1725 (.24)	765 (.06)	586 (0)
corpezza (bodyness)	8	10.30	0	1	1368 (.24)	1928 (.06)	857 (.03)	624 (0)
cuoroso (heartous)	7	10.84	1	1	1796 (.18)	1903 (.24)	837 (.24)	673 (0)
donnista (womanist)	8	11.04	0	0	1073 (.06)	1129 (.12)	808 (0)	599 (0)
erbista (herbist)	7	10.69	0	0	949 (.12)	1246 (0)	629 (0)	568 (0)
gitista (hikist)	7	10.95	0	1	1648 (.12)	1892 (.24)	1063 (.09)	714 (0)
guerroso (warous)	8	10.62	0	1	1440 (0)	1543 (.24)	773 (.03)	658 (0)
mammista (motherist)	8	10.79	1	0	1283 (.12)	1579 (.06)	762 (.03)	607 (0)
pallismo (ballism)	8	10.65	1	0	1311 (0)	1432 (.06)	701 (.06)	576 (.03)
sonnezza (sleepyness)	8	10.51	0	0	1688 (.18)	1420 (0)	799 (.09)	656 (0)
stelloso (starrous)	8	11.15	0	0	1584 (.18)	1671 (.06)	864 (.03)	640 (0)
stradoso (streetous)	8	10.98	0	0	1910 (.12)	1730 (.06)	853 (0)	661 (0)
vetrezza (glassness)	8	10.42	0	0	1509 (.24)	1568 (.18)	705 (.12)	592 (.13)
zampismo (pawism)	8	9.77	0	0	1220 (.06)	1456 (.12)	807 (.03)	654 (0)
Mean	7.75	10.61	0.25	0.44	1471 (.12)	1562 (.11)	803 (.06)	625 (.01)
SD	0.45	0.37	0.45	0.51	262 (.07)	258 (.08)	94 (.06)	42 (.03)
Simple								
bognezzo	8	9.70	0	1	1133 (.59)	1550 (.18)	905 (.21)	640 (.13)
cudosta	7	10.67	0	1	1553 (.47)	1903 (.18)	903 (.18)	680 (.03)
cuonede	7	10.87	0	1	1691 (.18)	2514 (.24)	1049 (.18)	707 (.07)
cuprezzo	8	9.98	0	1	1562 (.29)	1438 (.18)	873 (.06)	646 (0)

(*continued on next page*)

Appendix A (*continued*)

	LETT	BIGR FREQ	*N*-SIZE	CONT RULE	RT (% ERR) DYSL	RT (% ERR) YOUNG	RT (% ERR) SKILLED	RT (% ERR) ADULTS
curtosta	8	10.83	0	1	1717 (.41)	2010 (.29)	991 (.12)	672 (.13)
dennosto	8	11.19	0	0	2012 (.53)	1798 (.06)	806 (.32)	666 (.03)
ermosto	7	10.99	0	0	1587 (.24)	1532 (.06)	698 (0)	585 (0)
getosto	7	10.86	0	1	2160 (.18)	1710 (.35)	791 (.44)	658 (.3)
guarrede	8	10.62	0	1	1383 (.47)	1617 (.29)	864 (.18)	701 (.03)
memmosto	8	10.71	0	0	2222 (.41)	1552 (.18)	927 (.18)	660 (0)
pillosta	8	11.07	0	0	1670 (.35)	1600 (.18)	838 (.15)	622 (0)
sannezzo	8	10.34	0	0	1617 (.41)	2059 (.41)	756 (.21)	703 (.07)
stollede	8	11.18	0	0	2071 (.29)	1675 (.35)	1001 (.26)	719 (0)
strodasa	8	10.75	0	0	1658 (.18)	2073 (.29)	1070 (.32)	765 (0)
vatrezzo	8	10.37	0	0	1639 (.41)	2145 (.18)	823 (.21)	673 (.07)
zemposta	8	10.08	0	0	1863 (.18)	1842 (.06)	811 (.18)	664 (.07)
Mean	7.75	10.64	0	0.44	1721 (.35)	1814 (.22)	882 (.20)	673 (.06)
SD	0.45	0.44	0	0.51	286 (.13)	289 (.11)	105 (.1)	42 (.08)

Note. LETT, word length in letters; BIGR, mean bigram frequency, log transformed (natural logarithm); N-SIZE, orthographic neighborhood size; CONT RULE, number of c, g and sc letters, that need the following letter context to assign the correct pronunciation; DOUBLE LETT, number of double letters; RT, mean pseudoword naming reaction time; % ERR, mean % error rate; DYSL, dyslexic children; YOUNG, younger children; SKILLED, skilled children; ADULTS, adult readers.

Appendix B

Words used in Experiment 2

		WORD FREQ	FAM	BIGR FREQ	LETT	*N*-SIZE	CONT RULE	RT (% ERR) DYSL	RT (% ERR) YOUNG	RT (% ERR) SKILLED	RT (% ERR) ADULTS
Derived											
autista	driver	27	6.27	10.81	7	2	0	1207 (.29)	1173 (.35)	718 (.12)	553 (0)
balletto	ballet	12	6.10	10.88	8	6	0	1265 (.06)	1269 (.06)	643 (.03)	588 (.03)
camminata	stroll	10	6.23	10.93	9	3	1	1160 (.12)	1172 (0)	621 (.03)	585 (.03)
cantante	singer	59	6.63	11.44	8	2	1	892 (0)	1144 (0)	593 (.03)	557 (.03)
cartina	map	17	6.30	11.19	7	5	1	1320 (0)	1089 (.06)	615 (0)	598 (0)
cassiere	cashier	6	6.27	11.15	8	2	1	1142 (.06)	1362 (0)	636 (0)	587 (0)
conoscenza	knowledge	47	5.93	10.92	10	1	3	1076 (.12)	1343 (.06)	708 (.06)	573 (0)
dentista	dentist	33	6.85	11.30	8	2	0	1098 (.18)	1195 (.24)	685 (.09)	582 (0)
dolcezza	sweetness	19	6.40	10.22	8	1	1	1236 (0)	1079 (0)	658 (0)	560 (0)
fioraio	florist	5	6.53	10.90	7	1	0	1102 (0)	1192 (.06)	716 (0)	533 (0)
gelataio	ice cream man	7	6.63	10.85	8	0	1	1201 (.18)	986 (.24)	630 (.03)	626 (0)
guerriero	warrior	23	6.85	10.74	9	3	1	1125 (.06)	1093 (.12)	671 (0)	613 (0)
importanza	importance	33	6.10	10.65	10	0	0	1105 (0)	1372 (.06)	749 (0)	592 (0)
insegnante	teacher	41	6.95	10.81	10	1	1	1214 (0)	1142 (0)	807 (0)	614 (0)
libreria	bookstore	11	6.95	10.88	8	2	0	1054 (.06)	1358 (.12)	744 (.09)	618 (0)
linguaggio	language	18	6.07	10.45	10	0	3	1229 (0)	1336 (0)	716 (0)	592 (0)
lupetto	cub scout	6	5.43	10.58	7	1	0	1057 (0)	985 (.06)	669 (.03)	544 (0)
maglione	pullover	29	6.73	11.00	8	1	2	1072 (0)	1016 (0)	606 (0)	611 (0)
mancanza	lack	32	5.67	10.81	8	1	1	1042 (.12)	1157 (.06)	656 (0)	571 (0)
negoziante	shopkeeper	14	6.30	10.44	10	1	1	945 (.12)	1236 (0)	667 (.03)	577 (0)
nuotata	swim	6	6.43	10.71	7	6	0	1123 (.06)	1190 (.06)	718 (0)	603 (0)
parolaccia	dirty word	12	6.53	10.97	10	0	2	1231 (.29)	1584 (.18)	872 (0)	627 (0)
passante	passer-by	22	5.83	11.08	8	1	0	925 (.12)	1108 (.06)	604 (.12)	606 (0)
pecorella	little sheep	11	6.13	11.22	9	1	1	1517 (0)	1264 (.24)	731 (.03)	635 (0)
pescatore	fisherman	34	6.70	11.20	9	2	2	1183 (.06)	1002 (0)	714 (.03)	542 (0)
piattino	saucer	14	6.55	11.22	8	1	0	934 (.12)	1183 (.24)	690 (.12)	618 (.03)

(*continued on next page*)

Appendix B (*continued*)

		WORD FREQ	FAM	BIGR FREQ	LETT	*N*-SIZE	CONT RULE	RT (% ERR) DYSL	RT (% ERR) YOUNG	RT (% ERR) SKILLED	RT (% ERR) ADULTS
scaletta	little ladder	5	5.97	11.11	8	1	2	1254 (.06)	1173 (.12)	784 (.03)	572 (0)
segnale	signal	42	6.17	10.96	7	5	1	1155 (0)	1148 (.06)	703 (0)	559 (0)
signorina	miss	56	6.63	11.02	9	3	1	1252 (.12)	1127 (.12)	779 (0)	605 (0)
speranza	hope	38	6.40	10.93	8	1	0	1098 (0)	1245 (.06)	723 (.03)	564 (0)
suonatore	instrument player	5	6.70	11.18	9	1	0	1453 (.18)	1356 (0)	706 (0)	550 (0)
terriccio	mold	6	4.63	10.92	9	0	2	1014 (.12)	1268 (.06)	677 (0)	625 (0)
trenino	small train	32	6.37	11.25	7	1	0	924 (.12)	1414 (.12)	691 (.03)	570 (0)
tristezza	sadness	28	7.00	10.52	9	1	0	1441 (.06)	1144 (.06)	788 (0)	576 (0)
vecchiaia	oldness	8	6.43	10.64	9	0	2	1213 (0)	1417 (.12)	676 (.03)	594 (0)
vetrina	shop window	43	6.50	11.02	7	3	0	840 (.06)	1034 (0)	604 (0)	548 (0)
vicinanza	proximity	11	6.55	10.71	9	1	1	1476 (.24)	1467 (.06)	788 (.15)	612 (0)
villetta	cottage	7	6.65	10.98	8	3	0	1153 (.12)	1087 (.24)	741 (.03)	589 (0)
Mean		22	6.35	10.91	8.37	1.74	0.84	1151 (.08)	1208 (.09)	697 (.03)	586 (0)
SD		15	0.46	0.27	1	1.59	0.89	159 (.08)	142 (.09)	64 (.04)	27 (.01)
Simple											
assassino	murderer	5	6.85	10.99	9	3	0	1135 (0)	1076 (.18)	614 (0)	589 (0)
battaglia	battle	38	6.95	10.71	9	1	1	897 (.12)	989 (.06)	605 (0)	568 (0)
cammello	camel	7	6.13	10.86	8	3	1	1071 (0)	923 (0)	617 (0)	586 (.03)
castagna	chestnut	29	6.53	10.86	8	3	2	1150 (0)	1175 (0)	680 (0)	588 (0)
coccinella	ladybug	19	5.97	11.10	10	1	3	1519 (.18)	1267 (.06)	755 (.03)	620 (0)
continente	continent	38	6.70	11.40	10	2	1	1843 (.06)	1511 (.12)	768 (.03)	595 (0)
corteccia	bark	16	5.43	10.96	9	0	3	1272 (.06)	1202 (.12)	713 (.06)	575 (0)
discorso	discourse	56	6.33	11.01	8	1	1	1026 (0)	1432 (0)	746 (.03)	586 (0)
documento	document	15	6.33	10.68	9	2	0	1250 (0)	1030 (.06)	713 (0)	576 (.03)
funerale	funeral	11	6.33	11.03	8	1	0	1448 (.06)	1498 (.06)	721 (0)	553 (0)
ginocchio	knee	50	6.53	10.8	9	3	1	1252 (0)	1606 (.12)	702 (0)	610 (.03)

gorilla	gorilla	5	6.85	10.98	7	0	1	1396 (0)	1188 (.06)	652 (0)	569 (0)
indirizzo	address	19	6.57	10.41	9	2	0	1145 (.06)	1162 (0)	673 (0)	565 (0)
intervallo	interval	30	6.41	10.98	10	1	0	1061 (0)	1164 (0)	728 (0)	608 (0)
labirinto	labyrinth	16	5.73	10.86	9	1	0	1299 (.06)	1209 (.18)	639 (.09)	610 (0)
lavagna	blackboard	34	6.85	10.83	7	2	1	923 (0)	1008 (.06)	612 (0)	581 (.03)
lombrico	earthworm	8	5.90	10.64	8	0	1	1229 (.06)	1343 (0)	726 (.03)	588 (0)
materasso	matress	7	6.77	11.12	9	1	0	2107 (.29)	1305 (.12)	686 (0)	599 (0)
metallo	metal	22	6.33	11.10	7	1	0	1391 (.24)	1300 (.29)	653 (.12)	583 (0)
narciso	daffodil	5	4.30	10.84	7	3	1	1249 (.06)	1510 (.12)	681 (.12)	601 (0)
nostalgia	nostalgia	24	5.80	10.73	9	1	1	1325 (.06)	1304 (.12)	799 (.06)	587 (0)
panorama	landscape	17	6.17	11.23	8	1	0	1249 (.06)	1314 (.12)	648 (0)	570 (0)
paradiso	paradise	24	6.90	11.02	8	1	0	1082 (.06)	1308 (.12)	605 (0)	570 (0)
parrucca	wig	12	6.10	10.36	8	0	2	1109 (.18)	1078 (.18)	618 (0)	588 (0)
patrimonio	property	8	5.67	10.98	10	1	0	1409 (0)	1474 (.41)	691 (.24)	632 (0)
pergamena	papyrus	5	5.07	10.74	9	1	1	1510 (.06)	1447 (.24)	807 (.09)	655 (0)
sacerdote	priest	16	5.93	10.75	9	1	1	1634 (.06)	2348 (.29)	760 (.09)	570 (0)
salsiccia	sausage	8	6.50	10.63	9	0	2	1395 (0)	1240 (.47)	721 (.09)	587 (0)
scaffale	shelf	15	5.83	10.83	8	1	2	1262 (0)	1156 (0)	742 (.03)	582 (.03)
siringa	syringe	23	6.40	10.75	7	0	1	1382 (.12)	2014 (.24)	753 (.03)	618 (0)
stipendio	salary	10	6.30	10.98	9	1	0	1613 (.06)	2229 (.12)	860 (0)	609 (0)
tartaruga	turtle	53	6.57	10.43	9	0	1	1124 (.06)	903 (0)	606 (0)	611 (0)
tragedia	tragedy	23	5.93	10.73	8	1	1	1918 (.24)	1361 (.18)	813 (.06)	586 (0)
tramonto	sunset	18	6.60	11.11	8	2	0	1135 (.06)	1082 (.06)	678 (0)	604 (0)
valanga	avalanche	11	5.97	10.82	7	1	1	1242 (.29)	1214 (.24)	644 (.12)	595 (0)
valigia	suitcase	28	6.95	10.87	7	1	1	1040 (0)	1174 (.06)	657 (.03)	577 (0)
vergogna	shame	22	6.20	10.31	8	3	2	1291 (0)	1222 (0)	655 (0)	570 (0)
vicenda	event	37	6.30	10.82	7	2	1	1304 (.12)	1334 (.06)	645 (0)	572 (0)
Mean		21	6.24	10.85	8.37	1.29	0.89	1308 (.07)	1318 (.12)	694 (.03)	590 (0)
SD		14	0.54	0.23	0.94	0.96	0.83	259 (.08)	312 (.11)	65 (.05)	21 (.01)

Note. WORD FREQ, word frequency out of 1 million occurrences; FAM, rated word familiarity (7-point scale); LETT, word length in letters; BIGR FREQ, mean bigram frequency, log transformed (natural logarithm); N-SIZE, orthographic neighborhood size; CONT RULE, number of *c*, *g* and *sc* letters, that need the following letter context to assign the correct pronunciation; RT, mean pseudoword naming reaction time; % ERR, mean% error rate; DYSL, dyslexic children; YOUNG, younger children; SKILLED, skilled children; ADULTS, adult readers.

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