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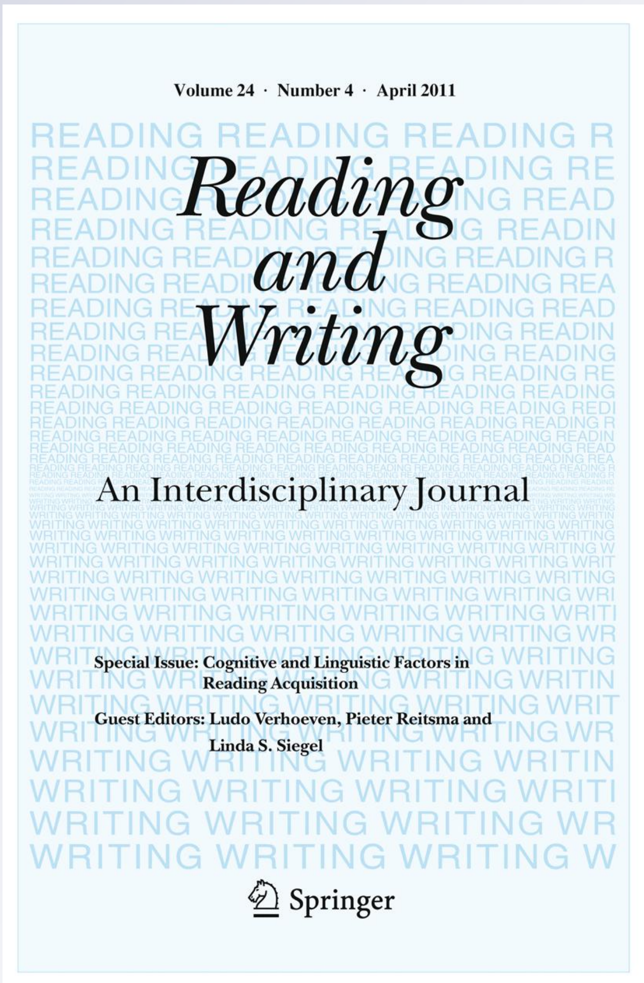
Reading and Writing
An Interdisciplinary Journal

ISSN 0922-4777
Volume 24
Number 4

Read Writ (2011) 24:443-461
DOI 10.1007/
s11145-010-9236-0



Springer

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Lexical stress assignment in Italian developmental dyslexia

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Published online: 16 May 2010

Abstract Stress assignment to Italian polysyllabic words is unpredictable, because stress is neither marked nor predicted by rule. Stress assignment, especially to low frequency words, has been reported to be a function of stress dominance and stress neighbourhood. Two experiments investigate stress assignment in sixth-grade, skilled and dyslexic, readers. In Experiment 1, skilled readers were not affected by stress dominance. Dyslexic children, although affected by word frequency, made more stress regularisation errors on low frequency words. In Experiment 2, stress neighbourhood affected low frequency word reading irrespective of stress dominance for both skilled and dyslexic readers. Words with many stress friends were read more accurately than words with many stress enemies. It is concluded that, in assigning stress, typically developing and developmental dyslexic Italian readers are sensitive to the distributional properties of the language.

Keywords Developmental dyslexia · Stress assignment · Stress dominance · Stress neighbourhood · Word frequency

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Introduction

In languages with lexical stress, where the position of stress varies, such as Italian, Greek or Spanish, stress assignment is essential for correct pronunciation. In these languages stress may be assigned on the basis of lexical, sublexical (a default rule), or visual-orthographic (marks-diacritics, see Protopapas, 2006) information. Despite the importance of stress assignment for polysyllabic word reading, lexical stress has been to a great extent neglected by current theories of reading. Crucially, the role of stress assignment in reading acquisition, development, and its impairments is fairly unknown.

Italian is a language with a transparent orthography, because at the segmental level it is characterised by an almost perfect grapheme to phoneme correspondence. However, there is some unpredictability at the supra-segmental level, as Italian is a language with lexical stress. That is, the position of stress on three—(or more-) syllable words is neither orthographically marked nor predicted by rule and varies. Most three- and four-syllable Italian words are stressed on the penultimate syllable, which is regarded as the dominant (or "regular") stress. A smaller proportion of polysyllable words are stressed on the antepenultimate syllable (non-dominant or "irregular" stress). On the basis of this disproportionate distribution, it has been suggested that stress assignment in Italian can be a source (perhaps the only one) of irregularity, such as the one described in the literature for deeper scripts, like English (see Colombo, 1992).

Colombo (1992) found that Italian adult readers read words with dominant stress faster and more accurately than words with non-dominant stress, but this difference held only for low—and not high—frequency words. This finding was interpreted as a tendency to read sublexically and assign the most frequent stress pattern (by default) to low frequency words (see also Rastle & Coltheart, 2000). For high frequency words, access to the lexicon is fast and efficient. Low frequency words with non-dominant stress are read slower and less accurately than words with dominant stress, because of the incongruence between lexical information and the default rule for placement of stress (see Colombo, 1992; Rastle & Coltheart, 2000).

Particularly for low frequency words, it has been suggested that stress assignment is determined by the number of words that share the same stress pattern and final orthographic/phonological sequence (referred to as stress neighbourhood) (Burani & Arduino, 2004; Colombo, 1992; see also Arciuli & Cupples, 2006; Kelly, Morris, & Verekkia, 1998 for similar effects in English). That is, the word final sequence (the vocalic nucleus of the penultimate syllable and the last syllable) is correlated with a certain proportion of words that carry either dominant or non-dominant stress.

Although there is only weak evidence for stress assignment by default (or the effect of stress dominance) in Italian adult readers, it is possible that young readers show greater sensitivity to stress dominance in reading, possibly due to limited lexical knowledge compared to adult readers. Absence of lexical information on stress position and therefore reliance on sublexical processing may favour stress assignment by default on the penultimate syllable (the dominant/most frequent stress pattern). There is little available evidence for the effect of stress dominance in Italian children (see Zoccolotti et al., 1999), whereas the effect of stress neighbourhood has never been investigated in Italian developmental dyslexic readers. The question of interest is whether stress is assigned on the basis of lexical or sublexical information by typically developing and especially developmental dyslexic children, who have been hypothesised to over-rely on nonlexical reading (De Luca, Borelli, Judica, Spinelli, & Zoccolotti, 2002; Zoccolotti et al., 1999, 2005).

Previous studies have shown that Italian developmental dyslexic readers are characterised by a reading speed deficit (Tressoldi, Stella, & Faggella, 2001; Zoccolotti et al., 1999) and great sensitivity to stimulus length (Spinelli et al., 2005; Zoccolotti et al., 2005). The impairment is not specific to nonword reading, but equally affects words and nonwords (Brizzolara et al., 2006). This description was confirmed by eye-movement studies, in which dyslexic readers showed a high number of long duration fixations with a prevalence of small amplitude saccades both in text reading and in reading lists of words and nonwords (De Luca et al., 2002; De Luca, Di Pace, Judica, Spinelli, & Zoccolotti, 1999; see also Hutzler & Wimmer, 2004 for similar results in German, also a highly regular orthography). Overall, Italian developmental dyslexics seemed to fit the profile of surface dyslexics (Castles & Coltheart, 1993; Zoccolotti et al., 1999; see also Patterson, Marshall, & Coltheart, 1985).

The types of errors expected from surface dyslexics include among others: regularisation errors in grapheme to phoneme correspondences, confusion between homophones, and stress assignment (regularisation) errors in polysyllable word reading (Patterson et al., 1985). The latter are the only type of errors that may be relevant to Italian, due to the absence of irregular words and word homophones (Zoccolotti et al., 1999). Zoccolotti et al. (1999) reported that three out of four dyslexic children in their study showed stress regularisation errors. Although these errors were quantitatively few, when compared to the control group, they were considered to indicate a (severe) deficit. Correct stress assignment can contribute to the assessment of whether and to what extent Italian young, skilled and dyslexic, readers employ fluent lexical reading (see Orsolini, Fanari, Cerracchio, & Famiglietti, 2009).

Developmental studies in transparent orthographies with lexical stress, such as Spanish and Greek, showed that stress assignment depends on both lexical and sublexical information for stress placement. In Spanish, stress sensitivity and knowledge of stress rules have been reported to affect reading and improve reading fluency (Gutierrez-Palma & Palma Reyes, 2007). In Greek, Protopapas, Gerakaki, and Alexandri (2006) showed that a default metrical pattern (on the penultimate syllable) was applied in the absence of lexical and visual-orthographic (i.e., the written diacritic, see Protopapas, 2006) information. The authors concluded that all these sources of information (i.e., lexical and orthographic information as well as a default metrical strategy), contribute to stress assignment in reading aloud in Greek (see also Protopapas, Gerakaki, & Alexandri, 2007).

Studies on the production of polysyllabic words in English speaking children have shown effects of morphological knowledge, with correct placement of stress being affected by the characteristics of stems and affixes (Jarmulowicz, Taran, & Hay, 2008). Orthographic/syllabic cues have also been shown to affect stress placement generalising to polysyllabic nonword reading in young readers of English (Duncan & Seymour, 2003). In a recent study of stress assignment to disyllabic nonwords, young English speaking children tended to apply the most frequent stress pattern (on the first syllable) (Monaghan, Arciuli, & Seva, 2008). However, older children relied more on orthographic cues for stress assignment (beginning and ending predictors of stress position). In the same study, a developmental computational model mapping orthography onto stress position for disyllabic English words confirmed the results. The model learned to place stress to both words and nonwords based only on the orthographic cues. Similarly to children, the model initially showed a bias to assign first syllable stress, but progressively relied more on word endings as stress position predictors.

In this study we investigate the role of stress assignment in reading development in relation to the factors that have been shown to influence placement of stress in Italian adult proficient readers, namely stress dominance and stress neighbourhood. In a first experiment, we examine the relationship between stress dominance and word frequency. Low frequency words are likely to be read sublexically by young readers, resulting in stress dominance effects. Specifically, developmental dyslexic readers, who are prone to rely on grapheme-to-phoneme correspondences (Zoccolotti et al., 1999; 2005), may rely on sublexical sources of information for stress assignment (especially to low frequency words) and assign the most frequent stress pattern by application of a default rule. Reliance on sublexical information would result in more stress regularisation errors than skilled readers. In a second experiment, we are concerned with the issue of how stress is assigned to low frequency words by manipulating stress neighbourhood (number of stress friends/enemies). Activation of stress friends and enemies may be a question of lexical knowledge, in which case young readers—skilled and especially impaired—may not be as efficient as adults in activating large stress neighbourhoods in order to accurately read low frequency multi-syllabic words.

Experiment 1: Stress dominance by word frequency

Experiment 1 examines the interaction between stress dominance and word frequency. Word frequency was expected to influence reading of both typically developing and developmental dyslexic readers on the basis of previous findings (Barca, Burani, Di Filippo, & Zoccolotti, 2006; Barca, Ellis, & Burani, 2007; see also Paizi, Zoccolotti, & Burani, 2010). Dyslexics, however, may rely more heavily than controls on sublexical processing (Spinelli et al., 2005; Zoccolotti et al., 1999; 2005) and thus an advantage of dominant stressed words may be expected. Should there be a default stress pattern in Italian, an interaction between stress pattern (dominant vs. non-dominant) and word frequency may be expected, with the effect of stress dominance holding only for low frequency words, as reported for adults (Colombo, 1992). Here, as opposed to Colombo, an effort was made to control both dominant and non-dominant stress low frequency words for number of stress friends and enemies, so as to have a larger proportion of stress friends than enemies in the stress neighbourhood of each word set, and thus similar probabilities of being read with the correct stress.

Methods

Participants

The participants were 12 dyslexic (8 boys and 4 girls) with mean age: 11.6 years (SD 0.4) and 12 chronological age-matched typically developing children (mean age: 11.3 years, SD 0.3), all sixth grade students. The participants were the same for both experiments (Experiments 1 & 2).

Criteria for inclusion in the dyslexic group were scores of at least two standard deviations (SD) below norms for either speed or accuracy in a standardised for Italian reading level examination (MT Reading test, Cornoldi & Colpo, 1995). During this examination the children had to read two meaningful passages of text. The participants read aloud the first passage within a 4-min time limit; speed (seconds per syllable) and accuracy (number of errors adjusted for the amount of text read) were scored. To measure comprehension, the participants had to read the second passage without a time limit and respond to multiple-choice questions.

Of the 12 dyslexic children, 2 were below the cut-off for both speed and accuracy and ten for accuracy only. Previous studies in Italian have reported that developmental dyslexics are mainly impaired in reading speed (e.g., Zoccolotti et al., 1999). Still most children in our sample were impaired in reading accuracy; consequently, accuracy rates are the focus here. Performance was well within normal range in reading comprehension and Raven's Coloured Progressive Matrices (Raven, Raven, & Court, 2003) for all children according to Italian normative data (Pruneti, 1985). All participants had normal or corrected to normal visual acuity. The two groups were matched for chronological age, sex, and nonverbal IQ levels based on their scores on Raven's Coloured Progressive Matrices. Summary statistics and mean scores on screening tests for dyslexic and control participants are given in Table 1.

Materials

A list of high- (HF) and a list of low frequency (LF) words were used. Frequency was based on child printed frequency counts (Marconi, Ott, Pesenti, Ratti, &

Table 1 Summary statistics (mean age in years and months, with range in parentheses; *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 the two groups of participants (dyslexic and typically developing readers) tested in the experiments

	Age	Male (*N*)	Female (*N*)	Raven test	Reading speed	Reading accuracy
Dyslexics	11.6 (11.1–12.3)	8	4	30.2 (SD = 3.1)	−1.5 (SD = 1.2)	−3.4 (SD = 1.7)
Controls	11.3 (10.9–11.9)	8	4	30.4 (SD = 2.5)	0.3 (SD =0.4)	0.2 (SD = 0.6)

Tavella, 1993). Half of the words in each frequency set (HF-LF) were stressed with the dominant stress on the penultimate syllable, and half were stressed on the antepenultimate syllable (non-dominant stress). There were 17 items in each condition for a total of 68 items. The words in each frequency condition (HF dominant stress—HF non-dominant stress; LF dominant stress—LF non-dominant stress) were matched so as not to differ significantly (t-tests) for subjective age of acquisition (AoA) (see Juhasz, 2005) and rated familiarity (a subjective measure of how much a word is frequent in everyday life; see Barca, Burani, & Arduino, 2002). All four word sets were matched for: imageability, orthographic neighbourhood size, length (in letters and syllables), bigram frequency, orthographic complexity, and initial phoneme (see "Appendix"). Note that both the words with dominant and non-dominant stress had more stress friends than enemies, because they included final orthographic sequences that predominantly occurred in dominant or non-dominant stress words, respectively. The measures of frequency, AoA, familiarity, and imageability were drawn from LEXVAR database (available online at: http://www.istc.cnr.it/material/database/) (Barca et al., 2002).

Procedure

The stimuli were presented in three blocks, two of which had 23 trials and one 22. Each block had a similar number of HF and LF words and words with dominant and non-dominant stress. The presentation order of the blocks (as well as the order of the trials within each block) was randomised. There was a practice block of 8 words, half with dominant and half with non-dominant stress.

The participants were instructed to read aloud as fast and accurately as possible the stimuli that appeared in the centre of the computer screen. Before the presentation of each stimulus, a fixation cross was displayed in the centre of the screen for 500 ms (ms). A voice key connected to the computer measured reaction times (RTs) in ms at the onset of pronunciation. Each stimulus disappeared at the onset of pronunciation or after 4,000 ms had elapsed. There was an interstimulus interval of 1,500 ms. A native Italian speaker noted and recorded the errors.

Results

Due to the large number of trials with either pronunciation or stress assignment errors, only accuracy measures (not RTs) were considered for the statistical analyses.

The mean percentages of pronunciation and stress errors, for both groups of participating readers, are presented in Fig. 1.

The total percentage of errors was divided in pronunciation and stress assignment errors. Errors were classified as pronunciation errors when the participant did not accurately pronounce the word at the segmental level (e.g., by substituting, omitting or inserting phonemes), whereas they were classified as stress errors when the error consisted only in the incorrect placement of stress (by either assigning dominant stress to non-dominant stressed words, or non-dominant stress to dominant stressed words). This classification was done in an effort to disentangle errors at the segmental and the supra-segmental level, since they can be informative about different components of reading accuracy. Separate ANOVAs were conducted on the percentages of pronunciation errors and the percentages of stress errors by participants with frequency (high vs. low) and stress type (dominant vs. non-dominant) as repeated factors and group (dyslexics vs. controls) as fixed factor and by items with frequency and stress type as fixed factors and group as repeated factor.

In the analyses on the percentages of pronunciation errors, there was an effect of group [by participants F_1 (1, 11) = 6.17, $p < .05$; and by items F_2 (1, 64) = 27.53, $p < .0001$], with dyslexics making more errors than controls, and word frequency [F_1 (1, 11) = 35.20, $p < .001$; F_2 (1, 64) = 24.96, $p < .0001$], with more errors on low frequency words. There was no main effect of stress type [both $F_s < 0.1$]. The interaction between group and frequency was significant [F_1 (1, 11) = 5.03, $p < .05$; F_2 (1, 64) = 6.79, $p < .05$]. Tukey a posteriori comparisons showed that the interaction was because high frequency words were read more accurately than low frequency words only by dyslexics ($p < .01$) and not by controls ($p = .16$). No other interactions were significant including the interaction between group and stress type [both Fs < 1] and that between stress type and word frequency [both Fs < 1].

Due to ceiling performance of both groups on high frequency words (see Fig. 1), the ANOVAs on the percentages of stress assignment errors were conducted on low frequency words only. The analyses on the percentages of stress assignment errors showed an interaction, significant by participants, between group and stress type [F_1 (1, 22) = 6.09, $p < .05$; F_2 (1, 32) = 2.56]. The interaction was because, although the two groups performed similarly on words with dominant stress (dyslexics: 3.3%, controls: 3.8%), dyslexics made more errors on words with non-dominant stress (7.9%) than controls (1.6%, $p < .05$, Tukey test).

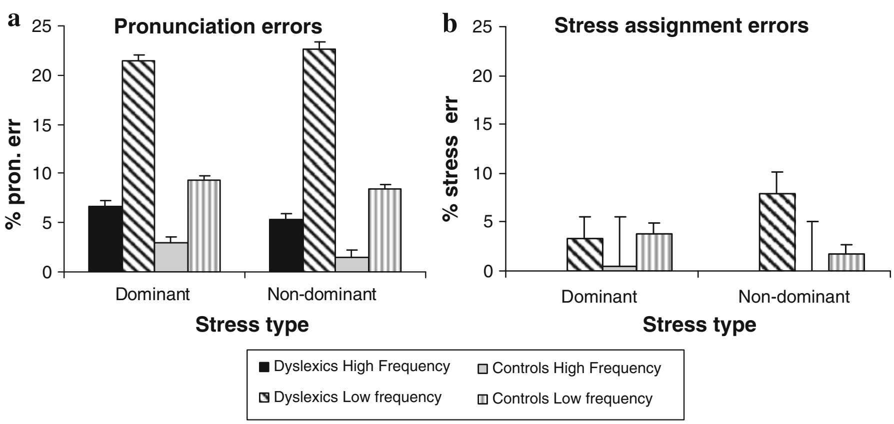

Fig. 1 Stress dominance × word frequency: mean percentages of **a** pronunciation and **b** stress assignment errors for dyslexics and controls. *Error bars* represent standard error

Both dyslexics and typically developing readers read high frequency words more accurately than low frequency words. The frequency effect was significant only for dyslexics, presumably due to the very high performance of the controls. Despite their overall accurate performance on high frequency words, dyslexic readers made several pronunciation errors on low frequency words, irrespective of stress dominance. Dyslexics also made more errors of stress assignment on low frequency words with non-dominant stress. No main effect of stress dominance was found, indicating that, when words with different stress patterns are controlled for number of stress friends and enemies, the dominant stress type does not facilitate reading more than the non-dominant one.

Although the percentages of errors in this experiment were low, dyslexics were generally more inaccurate than controls. They tended to assign the most frequent stress pattern to low frequency words (regularisation errors), possibly because they are more prone than skilled readers to reading by rule.

Experiment 2: Stress neighbourhood × stress dominance

In Experiment 2 we focus on the stress neighbourhood effect. Adult readers are sensitive to the orthographic cues to stress assignment (Arciuli & Cupples, 2006; Kelly et al., 1998). In Italian, stress neighbourhood mainly determined stress assignment to low frequency words (Burani & Arduino, 2004; Colombo, 1992), but it has never been investigated in developmental dyslexic children.

As opposed to Experiment 1, in which the variety of final sequences were only controlled for number of stress friends and enemies, in this experiment we manipulated stress neighbourhood (i.e., the proportion of stress friends vs. enemies in a neighbourhood of words sharing the final orthographic/phonological sequence). For instance, a large proportion (about 81%) of Italian words ending in—*oro* carry dominant stress on the penultimate syllable, whereas a smaller proportion (about 19%) of words have the non-dominant stress on the antepenultimate syllable. Consequently, a dominant stress word ending in—*oro* has many stress friends with the same (dominant) stress. Similarly, most words (about 77%) ending in—*ola* carry non-dominant stress, whereas a much smaller proportion carry dominant stress (about 23%). Thus, a word like *b'ambola* (doll) carries non-dominant stress, but has many (non-dominant stressed) stress friends. In contrast, the word *pist'ola* (gun) carries dominant stress, but has many (non-dominant stressed) stress enemies (i.e., words with the same final sequence, but different stress pattern).

The manipulation of the number of stress friends versus enemies was designed to systematically investigate how stress is assigned to low frequency words by typically developing and dyslexic children. If children can activate sufficiently large-size stress neighbourhoods to allow use of the most informative units (final sequences) for stress placement, an influence of stress neighbourhood in favour of words with many stress friends would be expected. As opposed to typically developing readers, dyslexics were found (Experiment 1) to be particularly inaccurate when assigning stress to low frequency words with non-dominant stress. In case dyslexics are affected by stress neighbourhood, an interaction between stress neighbourhood and stress dominance may be expected: the words with non-dominant stress and many stress enemies may be the most difficult to read resulting in many stress regularisation errors.

Methods

Participants

The same as in Experiment 1.

Materials

Four sets of 14 three- and four-syllable low frequency words (nouns and adjectives) varying on stress type (dominant/non-dominant) and stress neighbourhood (many friends/many enemies). The words in each of the two contrasting sets (i.e., stress dominant-many friends vs. stress non-dominant-many enemies; stress non-dominant-many friends vs. stress dominant-many enemies) had the same orthographic final sequences. The final sequences were selected so as to maximise the difference in the proportion of friends versus enemies. The stimuli were 6–9 letters long. The sets were matched on: Word frequency, N-size, length in letters and syllables, orthographic complexity, bigram frequency, and initial phoneme (see “Appendix”).

A list of 56 medium-to-high frequency filler-words was added to the 56 low frequency experimental words, in order to increase possibilities for lexical processing by the presence of familiar items. Half of the filler-words were stressed on the penultimate and half on the antepenultimate syllable. The filler-words were matched with the experimental items on grammatical category and length, but had different orthographic final sequences.

Procedure

The 112 items were presented in four blocks of 28 stimuli each, half experimental and half filler-words. In each block there was an equal number of words with dominant and non-dominant stress. The order of blocks (as well as the order of the trials within each block) was automatically randomised. There was a practice block of ten items (5 with dominant stress and 5 with non-dominant stress), different from the experimental items, and with different orthographic final sequences. The instructions, the experimental sequence, and data recording were the same as in Experiment 1.

In order to avoid any possible repetition effect (owed to the small overlap in experimental items between Experiments 1 & 2), Experiment 2 was administered at least a month after Experiment 1 had been conducted.

Results

As in Experiment 1, due to the large number of trials with either pronunciation or stress assignment errors, only accuracy measures (not RTs) were considered for the statistical analyses.

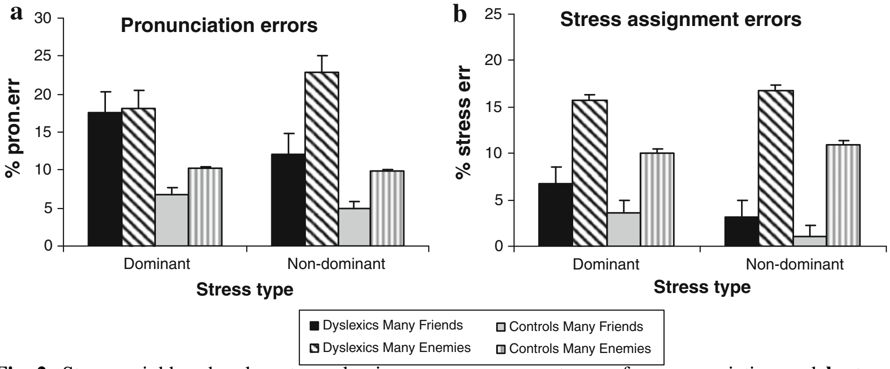

Fig. 2 Stress neighbourhood × stress dominance: mean percentages of **a** pronunciation and **b** stress assignment errors for dyslexics and controls. *Error bars* represent standard error

The mean percentages of pronunciation and stress errors, for both groups of participating readers, are presented in Fig. 2.

ANOVAs were carried out on percentages of pronunciation and stress errors, by participants with stress type (dominant vs. non-dominant) and stress neighbourhood (many friends vs. many enemies) as repeated factors and group as a fixed factor, and by items with stress type and stress neighbourhood as fixed factors and group as repeated factor.

The analyses on the percentages of pronunciation errors revealed an effect of group [F_1 (1, 11) = 7.37, $p < .05$; F_2 (1, 52) = 30.03, $p < .0001$] and stress neighbourhood [F_1 (1, 11) = 16.28, $p < .01$; F_2 (1, 52) = 4.44, $p < .05$]. There was no effect of stress dominance [both Fs < 1] and there were no significant interactions.

The analyses on the percentages of stress assignment errors showed a main effect of group [F_1 (1, 11) = 4.66, $p = .05$; F_2 (1, 52) = 7.60, $p < .05$] and stress neighbourhood [F_1 (1, 11) = 47.04, $p < .0001$; F_2 (1, 52) = 9.74, $p < .05$]. No effect of stress dominance was found [both Fs < 1]. There were no significant interactions.

Low frequency word reading of both skilled and dyslexic children was affected by stress neighbourhood. Words with many stress friends were read more accurately than words with many stress enemies regardless of stress pattern (dominant or non-dominant). A high numerosity of stress friends in the neighbourhood increased possibilities for correct placement of stress not only for typically developing, but also for developmental dyslexic readers, indicating that developing readers (of differing reading skills) are able to rely efficiently on the orthographic cues, the final sequences, for stress assignment.

Discussion

The objective of this study was to investigate the effect of stress dominance and its relationship with word frequency (Experiment 1) as well as the effect of stress neighbourhood on low frequency words (Experiment 2) in Italian typically developing and developmental dyslexic children.

Despite the fact that there are not strong indications in favour of stress assignment by default for adults (see Colombo, 1992), children might be more sensitive to stress dominance because, especially in regular orthographies, they are supposed to rely heavily on sublexical reading (Ziegler & Goswami, 2005). Had there been a default stress pattern in Italian, it would have been easier to detect it in children than adults. In our study skilled young readers were only affected by word frequency and not by stress dominance, indicating that they assigned stress on both high and low frequency words lexically and not by rule, consistent with the findings for adult readers (Burani & Arduino, 2004). Both dyslexic and skilled children showed a very similar and almost perfect performance on high frequency words. Performance on low frequency words differentiated the groups, even though stress assignment errors were quantitatively few, as in Zoccolotti et al. (1999). The (small) stress dominance effect for dyslexics found in Experiment 1 was not replicated in the second study (Experiment 2).

Dyslexic children tended to assign the dominant stress pattern to low frequency words with non-dominant stress (regularisation errors) (in Experiment 1), in accordance with the characterisation of surface dyslexics. However, this result alone does not constitute evidence for over-reliance of Italian dyslexics on sublexical grapheme-to-phoneme correspondences and impairment specific to lexical access. That is, in the present study dyslexics were affected by word frequency, as they read high frequency words more accurately than low frequency words. Moreover, they did not show regularisation errors on high frequency words carrying non-dominant stress, consistently with studies on lexical effects, such as word frequency (Barca et al., 2006) and lexicality (Zoccolotti, De Luca, Judica, & Spinelli, 2008; see also Paizi et al., 2010).

Italian developing readers seemed to rely mainly on lexical information to assign stress, unlike young skilled readers of other of transparent scripts with lexical stress, such as Greek, and Spanish. Greek typically developing children applied a default metrical pattern, on the penultimate syllable, to nonwords (Protopapas et al., 2006). In Spanish an effect of syllabic structure was found, indicating stress assignment by a phonological rule (Gutierrez-Palma & Palma Reyes, 2004). Spanish skilled children also showed stress sensitivity which influenced reading fluency and stress assignment (Gutierrez-Palma & Palma Reyes, 2007). In the aforementioned studies the application of a default rule was assessed with use of nonwords. In our experiments, application of the rule may have been overpowered by lexical knowledge.

The differentiation between the sources of information for stress assignment in Greek or Spanish and Italian could be attributed to stress diacritics. In Greek stress diacritics are always marked and their absence is considered a spelling error (see Protopapas, 2006). However, it has been demonstrated that young readers do not rely efficiently on the decoding of the diacritic to assign stress to nonwords (Protopapas et al., 2006). In Spanish stress diacritics are used to mark irregular stress position. In this respect, stress assignment in reading in Italian may be more demanding of lexical resources than reading in Greek or Spanish. That is, placement of stress in Italian three or more syllable words requires lexical knowledge, because it is neither predictable nor orthographically marked.

In order to gain an insight into stress assignment to unfamiliar (low frequency) words, we manipulated stress neighbourhood. Our results showed that words with many stress friends were read more accurately than words with many stress enemies, irrespective of stress pattern, as has been previously found for adults (Burani & Arduino, 2004). Stress assignment to low frequency words was found to be mainly determined by the composition of the stress neighbourhood for both dyslexic and typically developing readers. This pattern indicates activation of stress friends and enemies as well as efficient reliance on the orthographic cues (final sequences) for stress assignment in young readers irrespective of reading ability.

It might be thought that dyslexics are less efficient than controls in accessing lexical information for stress assignment. Experiment 1 provided some evidence for the application of a default rule by dyslexics. However, this did not mean that they were unable to access lexical knowledge that may facilitate stress assignment to unfamiliar words, namely stress neighbours (stress friends), when they were prompted to do so. In Experiment 1 a variety of final sequences was used and the number of stress friends was controlled so as to give the same probabilities to all items of being stressed correctly. In Experiment 2, stress neighbourhood was manipulated by use of those final sequences that are more extreme as to their stress friends-to-enemies ratio. In this way, the activation of extremely large families of friends as opposed to enemies was maximised, and the reliance on largely shared orthographic/phonological final sequences to assign stress was favoured.

The fact that stress neighbourhood similarly affected the performance of Italian young readers of different reading skills has some implications for the nature of the stress neighbourhood effect. Burani and Arduino (2004) interpreted stress neighbourhood effects in terms of activation of stress friends and enemies in the lexicon. If that were the case, the results presented here would indicate lexical activation similar for typically developing and developmental dyslexics.

However, stress neighbourhood effects may not be necessarily attributed to lexical access. Stress neighbourhood effects could also be interpreted as resulting from sensitivity to visual-orthographic cues for stress assignment, specifically word endings, in a sense similar to the cues that drive stress assignment in English (Arciuli & Cupples, 2006; Kelly et al., 1998; Monaghan et al., 2008). Consequently, the effect of stress neighbourhood, irrespective of stress pattern, in our study could be interpreted in terms of efficient reliance on the predictors for stress placement and particularly on word endings to assign stress to low frequency words. The idea that young, skilled and impaired, Italian readers are sensitive to the (final) constituents of stimuli, is also compatible with recent findings concerning sensitivity to morphemic constituents (roots and affixes) that facilitated nonword reading (Burani, Marcolini, De Luca, & Zoccolotti, 2008).

Monaghan et al. (2008) suggested a developmental computational model that maps orthography onto stress position for English disyllabic words. The model successfully accounted for young readers' increasing—with reading experience—reliance on orthographic cues for stress assignment and the statistical properties of their language without access to lexical information. In this framework, it could be hypothesised that correct stress assignment on the basis of the final sequences as predictors for stress position, would be possible and independent of reading skill. That is, both skilled and dyslexic children would be able to correctly assign stress to unfamiliar words based on the statistical distribution of their language, irrespective of lexical knowledge.

Overall, our results showed that typically developing readers seem to assign stress similarly to adults (Burani & Arduino, 2004). Developmental dyslexics, although affected by word frequency, were also slightly affected by stress dominance in reading unfamiliar words, indicating a somewhat greater reliance than skilled readers on sublexical processing. However, when the effect of stress neighbourhood was assessed by maximising the possibility of relying on stress friendship the two groups showed an equivalent performance. Consequently, and consistently with findings from other languages (see Duncan & Seymour, 2003; Monaghan et al., 2008), both skilled and dyslexic readers are able to rely successfully on the statistical properties of their language, including the visual-orthographic cues for stress assignment, when they are appropriately prompted to do so. Whether stress neighbourhood effects may arise as a consequence of lexical activation, or whether they could be due to sensitivity to the statistical properties of the words is still an open question. The two alternative explanations may also turn out not to be mutually exclusive, but somehow complementary (i.e., readers' sensitivity to orthographic cues depends on reading experience with several words, in order to be able to extract statistical regularities in the input language). However, further research is necessary, in order to precisely define the nature of the stress neighbourhood effect.

Acknowledgments This work was supported by an EU Sixth Framework Marie Curie Research Training Network (MRTN-CT-2004-512141): Language and Brain (RTN: LAB, http://www.hull.ac.uk/RTN-LAB/). We are grateful to Linda Siegel for her comments on a previous version of the manuscript.

Appendix

See Tables 2 and 3.

Table 2 Words used in Experiment 1

Words HF	English	AOA	FAM	IMAG	FRQ	NSIZE	BIGR.FRQ	SYL	LET	ORT.COM.
Dominant stress										
ARGENTO	silver	3.45	6.36	5.18	73	0	10.87	3	7	0.30
CARAMELLA	candy	1.52	6.93	6.48	103	1	11.24	4	9	0.30
CARNEVALE	carnival	2.48	6.75	5.25	310	0	10.97	4	9	0.30
ELEFANTE	elephant	2.45	6.57	6.50	103	1	10.84	4	8	0.00
FAMIGLIA	family	2.39	6.84	5.61	706	0	10.63	3	8	0.48
FARINA	flour	2.75	6.70	6.05	88	1	11.12	3	6	0.00
MULINO	mill	3.64	6.20	5.59	51	0	10.73	3	6	0.00
NEGOZIO	shop	2.95	6.70	5.66	227	0	10.13	3	7	0.30
OSPEDALE	hospital	3.00	6.77	5.98	113	0	10.70	4	8	0.00
PARETE	wall	3.50	6.50	5.57	81	1	11.26	3	6	0.00
PRIGIONE	prison	3.52	6.50	5.48	61	0	11.02	3	8	0.30
PAROLA	word	2.48	6.64	3.82	512	0	11.26	3	6	0.00
PATATA	potato	2.18	6.77	6.27	66	1	11.32	3	6	0.00
PISCINA	swimming pool	2.73	6.64	6.14	60	0	10.97	3	7	0.48
STAGIONE	season	3.20	6.66	4.27	202	1	11.15	3	8	0.30
TARTARUGA	tortoise	2.57	6.45	6.45	57	0	10.44	4	9	0.30
CERVELLO	brain	3.50	6.61	5.41	64	0	10.88	3	8	0.30
Mean		2.84	6.62	5.63	169.24	0.35	10.91	3.29	7.41	0.20
SD		0.58	0.18	0.74	183.26	0.49	0.32	0.47	1.12	0.18
Words LF		**AOA**	**FAM**	**IMAG**	**FRQ**	**NSIZE**	**BIGR.FRQ**	**SYL**	**LET**	**ORT.COM.**
Dominant stress										
URAGANO	hurricane	4.59	5.86	4.73	12	0	10.76	4	7	0.30
CALAMITA	magnet	3.80	5.77	5.52	0	1	11.15	4	8	0.30
EREDE	heir	5.39	5.61	3.48	8	0	11.34	3	5	0.00
FANALE	headlight	4.67	5.55	5.57	0	4	11.12	3	6	0.00
FURGONE	van	4.23	6.39	5.75	19	0	10.23	3	7	0.30
LABIRINTO	labyrinth	3.93	5.73	5.52	19	0	10.86	4	9	0.00
MUNICIPIO	municipality	5.36	5.48	4.70	12	0	10.44	4	9	0.30
USIGNOLO	nightingale	3.98	4.98	5.39	8	0	10.54	4	8	0.30
PADELLA	frying pan	3.11	6.50	6.30	14	1	11.12	3	7	0.00
PALATO	palate	3.66	5.59	4.93	0	5	11.36	3	6	0.00
PARRUCCA	wig	3.73	6.30	5.66	19	0	10.36	3	8	0.48
PATTUGLIA	patrol	5.30	5.18	4.45	0	0	10.67	3	9	0.48
PINGUINO	penguin	2.89	6.23	6.16	19	0	10.69	3	8	0.30
POMATA	ointment	3.36	5.95	5.59	0	1	11.18	3	6	0.00
SCAFFALE	shelf	4.14	5.82	5.39	20	0	10.51	3	8	0.30
TAMBURO	drum	3.95	6.16	5.91	25	0	10.32	3	7	0.48
ZANZARA	mosquito	2.36	6.66	6.09	10	0	10.34	3	7	0.00
Mean		4.03	5.87	5.36	10.88	0.71	10.76	3.29	7.35	0.21
SD		0.85	0.46	0.71	8.54	1.49	0.38	0.47	1.17	0.19

Table 2 continued

Words HF	English	AOA	FAM	IMAG	FRQ	NSIZE	BIGR.FRQ	SYL	LET	ORT. COM.
Non-dominant stress										
ANGOLO	corner	3.52	6.16	4.43	173	1	10.73	3	6	0.30
CARATTERE	character	3.98	6.00	2.82	281	0	11.41	4	9	0.30
FEMMINA	female	2.55	6.91	5.41	120	0	10.48	3	7	0.00
FAVOLA	tale	1.70	6.57	4.30	72	1	10.86	3	6	0.00
IMMAGINE	image	4.23	6.07	3.84	79	0	10.68	4	8	0.30
LUCERTOLA	lizard	2.59	6.57	6.11	60	0	10.73	4	9	0.30
MACCHINA	machine	2.23	6.91	6.39	807	0	10.89	3	8	0.48
ORIGINE	origin	5.14	5.70	2.52	60	0	10.89	4	7	0.30
PAGINA	page	2.89	6.61	5.48	139	1	10.96	3	6	0.30
PECORA	sheep	2.18	6.73	6.00	80	0	11.22	3	6	0.30
PENTOLA	pot	3.11	6.61	6.18	52	0	11.37	3	7	0.00
PERICOLO	danger	2.82	6.55	3.45	133	0	11.21	4	8	0.30
POLVERE	dust	2.84	6.59	4.89	61	0	10.85	3	7	0.00
PRINCIPE	prince	2.57	6.39	4.68	329	0	10.79	3	8	0.30
SCATOLA	box	2.73	6.61	5.84	137	0	11.24	3	7	0.48
TAVOLO	table	1.98	6.82	6.16	129	2	10.92	3	6	0.00
ZUCCHERO	sugar	2.07	6.80	6.23	71	0	10.02	3	8	0.48
Mean		2.89	6.51	4.98	163.71	0.29	10.90	3.29	7.24	0.24
SD		0.89	0.34	1.25	183.05	0.59	0.34	0.47	1.03	0.17

Words LF		AOA	FAM	IMAG	FRQ	NSIZE	BIGR.FRQ	SYL	LET	ORT.COM.
Non-dominant stress										
COCOMERO	watermelon	2.70	6.48	6.48	0	0	11.17	4	8	0.48
EDICOLA	newsstand	3.73	6.34	6.25	14	0	11.13	4	7	0.30
FASCINO	charm	5.25	6.02	3.48	12	0	10.88	3	7	0.48
FULMINE	lightning	2.93	6.64	5.93	25	0	10.31	3	7	0.00
IDOLO	idol	5.05	5.48	3.77	8	0	10.86	3	5	0.00
INCUDINE	anvil	4.98	4.80	4.68	0	0	10.71	4	8	0.30
LAPIDE	tombstone	5.23	5.16	5.89	0	0	10.83	3	6	0.00
MANDORLA	almond	3.39	6.27	5.75	22	0	10.96	3	8	0.00
PETTINE	comb	2.36	6.68	6.20	11	0	11.17	3	7	0.00
PILLOLA	pill	3.68	6.18	5.57	13	0	11.12	3	7	0.00
PIRAMIDE	pyramid	4.09	5.95	6.11	8	0	10.76	4	8	0.00
POLLICE	thumb	2.25	6.41	6.30	21	1	11.05	3	7	0.30
PONTEFICE	pope	5.25	5.66	5.41	0	0	10.71	4	9	0.30
PUGILE	boxer	3.86	6.41	5.68	0	0	10.51	3	6	0.30
SCANDALO	scandal	5.41	6.20	2.84	0	0	11.05	3	8	0.48
TENEBRA	darkness	5.07	5.27	4.05	15	0	10.72	3	7	0.00
ZINGARO	gypsy	3.93	6.02	5.14	14	0	10.23	3	7	0.30
Mean		4.07	6.00	5.27	9.59	0.06	10.83	3.29	7.18	0.19
SD		1.09	0.55	1.11	8.54	0.24	0.29	0.47	0.95	0.20

Table 3 Words used in Experiment 2

Words	English	FRQ	SYL	LET	BIGR.FRQ	ORT.COM.
Dominanat stress: Many friends						
ALLORO	bay leaf	7	3	6	11.30	0.00
CANORA	singing	2	3	6	11.53	0.30
CASTORO	beaver	0	3	7	11.23	0.30
DECORO	decorum	6	3	6	11.23	0.30
DIMORA	dwelling	18	3	6	11.26	0.00
EREMITA	hermit	3	4	7	11.13	0.00
FALLITA	unsuccessful	6	3	7	11.03	0.00
FERITA	wound	20	3	6	11.02	0.00
GRANITA	granite	0	3	7	10.92	0.30
MALORA	ruin	1	3	6	11.27	0.00
PAPIRO	papyrus	0	3	6	10.69	0.00
PARASSITA	parasite	3	4	9	11.05	0.00
RISTORO	refreshment	2	3	7	11.13	0.00
VAMPIRO	vampire	3	3	7	10.58	0.00
Mean		5.07	3.14	6.64	11.10	0.09
SD		6.33	0.36	0.84	0.25	0.14

Words	English	FRQ	SYL	LET	BIGR.FRQ	ORT.COM.
Dominanat stress: Many enemies						
BADILE	shovel	0	3	6	10.74	0.0
BARILE	cask	3	3	6	10.94	0.0
BESTIOLA	little creature	1	3	*8*	10.93	0.0
CAPRIOLA	somersault	0	4	8	11.06	0.3
CAZZUOLA	float	1	3	8	10.28	0.3
FUCILE	rifle	20	3	6	10.49	0.3
MOLLICA	breadcrumb	3	3	7	11.03	0.3
MOVIOLA	slow-motion	3	3	7	10.91	0.0
OSTILE	hostile	10	3	6	11.03	0.0
PIGNOLO	fussy	1	3	7	10.74	0.3
SEDILE	seat	17	3	6	11.2	0.0
TAGLIOLA	trap	0	3	8	10.95	0.5
USIGNOLO	nightingale	1	4	8	10.53	0.3
VESCICA	gall	5	3	7	10.88	0.6
Mean		4.64	3.14	7.00	10.84	0.21
SD		6.46	0.36	0.88	0.25	0.20

Table 3 continued

Words	English	FRQ	SYL	LET	BIGR.FRQ	ORT.COM.
Non-dominanat stress: Many friends						
ATOMICA	atomic	1	4	7	11.12	0.30
BETTOLA	greasy spoon	0	3	7	10.87	0.00
BIETOLA	chard	0	*3*	7	10.80	0.00
BUSSOLA	compass	5	3	7	10.45	0.00
FERTILE	fertile	5	3	7	10.88	0.00
FOSSILE	fossil	2	3	7	10.82	0.00
MENSOLA	shelf	2	3	7	10.98	0.00
MUSCOLO	muscle	4	3	7	10.51	0.48
OSTACOLO	obstacle	21	4	8	10.89	0.30
PASCOLO	pasture	2	3	7	10.94	0.48
PUGILE	boxer	9	3	6	10.51	0.30
RETTILE	reptile	1	3	7	11.08	0.00
TATTILE	tactile	0	3	7	11.19	0.00
TIPICA	typical	17	3	6	10.63	0.30
Mean		4.93	3.14	6.93	10.83	0.15
SD		6.51	0. 36	0. 47	0. 23	0. 19

Words	English	FRQ	SYL	LET	BIGR.FRQ	ORT.COM.
Non-dominanat stress: Many enemies						
BIBITA	drink	1	3	6	10.32	0.00
CANFORA	camphor	1	3	7	10.87	0.30
DECREPITA	decrepit	0	4	9	10.57	0.30
DIASPORA	diaspora	2	*3*	8	11.09	0.00
FOSFORO	phosphorus	2	3	7	10.25	0.00
IPOCRITA	hypocrite	6	4	8	10.5	0.30
MESCITA	pouring	0	3	7	11.02	0.48
METAFORA	metaphor	11	4	8	10.69	0.00
ORBITA	orbit	8	3	6	10.42	0.00
PECORA	sheep	11	3	6	11.22	0.30
PORPORA	crimson	4	3	7	10.81	0.00
RENDITA	profit	4	3	7	11.2	0.00
SEMAFORO	traffic light	9	4	8	10.6	0.00
TORTORA	turtledove	4	3	7	11.23	0.00
Mean		4.50	3.29	7.21	10.77	0.12
SD		3.90	0. 47	0. 89	0. 34	0. 17

Note. AOA: Age of acquisition, IMAG: Imageability, FRQ: Written frequency, on 1 million occurrences, Nsize: Orthographic neighbourhood size, BIGR.FRQ: Bigram frequency, SYL: number of syllables, LET: Number of letters, ORT.COM: Orthographic complexity (see Burani, Barca, & Ellis, 2006), log transformed. Age of acquisition and imageability are given as 7-point subjective ratings. Bigram frequency values are transformed on the basis of the natural logarithm

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