Reading and Writing (2006) 19:171–198
DOI 10.1007/s11145-005-4023-z

On the use and usefulness of stress diacritics in reading Greek

A. PROTOPAPAS
Institute for Language & Speech Processing, Maroussi, Greece

Abstract. The assignment of stress when reading Greek can be based on lexical and orthographic information. One hundred and seventy seventh-grade children read lists of isolated words and pseudowords. A large proportion of stress assignment errors were made in pseudoword reading, especially on the items that do not follow the most frequent penultimate stress pattern. Analysis of text corpora indicates that ignoring written stress diacritics would result in less than 1% errors, without taking into account disambiguating effects of context. It is tentatively suggested that, in reading Greek, stress assignment is primarily lexical. The results are consistent with a hypothesis that the bisyllabic trochee is the default metrical frame in Greek.

Key words: Default metrical frame, Greek, Lexical route, Metrical patterns, Pseudowords, Reading, Stress, Stress diacritic, Stress errors, Stress minimal pairs, Text corpora

Introduction

Reading words entails, among other things, assembly of the phonological code making up the word's pronunciation. In addition to putting together the appropriate string of phonemes, on the segmental level, stress must affect the output on the metrical level. In a language with lexical stress that can vary its position on the word, stress assignment cannot be a standard routine but must be lexically informed. Therefore, for each word, the reader has to determine the correct stress location and modify the pronunciation plan for the corresponding syllable accordingly. If the written form of the language provides diacritics indicating stress position, it is reasonable to expect that these diacritics will be typically used by the readers to enhance reading performance.

However, it is not possible to characterize the typical usage of diacritics based on words: because lexical representations must include stress assignment, external sources of stress information (such as written diacritics) cannot be distinguished from internal sources (such as stored information in the mental lexicon). Pseudowords, on the other hand,

which have no lexical representations, are expected to be read via a standard decoding routine on the basis of the written information, which is the only available source (as long as the pseudowords do not resemble words sufficiently to be read by analogy). Here I present evidence, from schoolchildren reading pseudowords, suggesting that stress diacritics are not fully utilitized, that is, that stress assignment is sometimes made without regard to the written diacritic. I relate this counterintuitive result to analyses of stress assignment statistics in Greek text, the results of which call into question the reliability of stress diacritics.

Stress in modern Greek

In Standard Modern Greek (henceforth plainly "Greek"), the stress domain is the *phonological word* (Malikouti-Drachman & Drachman, 1989; Petrounias, 2002), which includes one content word plus any adjacent clitics (closed-class words) that attach themselves metrically to it. For example, /ˈspi.ti/ ("house")-/to.ˈspi.ti.mu/ (the house my → "my house"). Each phonological word carries stress on one syllable, which must be one of the last three syllables.[1] A second stress on the same phonological word emerges when clitics attaching to the end of a content word would result in a violation of the three-syllable constraint (Holton, Mackridge, & Philippaki-Warburton, 1997), for example if the content word was already stressed on the antepenultimate: /pa.ˈɾa.θi.ɾo/ ("window")-/to.pa.ˈɾa.θi.ˈɾo.mu/("my window"). This *enclitic* stress results in doubly-stressed words.

Stress position is lexical, that is, it may vary and it contributes to lexical identity. Many word pairs exist that differ only in stress, for example/ˈɟɛ.ɾos/ ("old man")-/ɟɛ.ˈɾos/ ("strong"). That is, the same sequence of phonemes, syllabified in the same way, may be stressed on either of two syllables, thus forming two distinct words, or a stress-based minimal pair.

In written Greek, stress is indicated by a special diacritic (similar to the French acute), which is placed over the vowel of the stressed syllable on written words with more than one syllable. Contemporary spelling rules dictate that every word with two or more syllables obligatorily bears a stress diacritic; omission of the diacritic is a spelling error. Therefore there is always an orthographic indication of the correct stress position. In contrast, a stress diacritic is never indicated on monosyllables, except for 3 specific cases: the *wh*-words πού ("where") and πώς ("how"), which are marked to distinguish from the segmentally identical complementizers, and the disjunctive ή ("or"), to distinguish from the feminine definite article.[2] These stress marking rules, based on the number of syllables, apply regardless of whether a word is a content word (and hence bears

phonological stress) or a closed-class word, such as a clitic (in which case it bears no stress, because it attaches phonologically to an adjacent content word). Double (enclitic) stress is also marked orthographically, with a second identical stress diacritic; thus "my window" is spelled το παράθυρό μου (cf.παράθυρο "window").

This stress marking system has been called "illogical" (Petrounias, 2002) because it introduces inconsistencies between orthography and phonology, neglecting the role of the phonological word and depending on the number of written syllables. However, in reading single Greek words with more than one syllable, the written diacritic permits flawless stress assignment and perfect lexical disambiguation in cases of stress minimal pairs. Thus, it is not suprising that stress errors do not figure prominently in the subjective impressions of educators regarding reading performance of students, including the performance of poor readers. Informal questioning reveals that stress assignment errors in reading aloud are considered infrequent, if at all noted. However, this observation has not been empirically tested and, moreover, is relevant only for word reading, typically in context, Pseudowords are rarely used in practice for reading assessment, therefore educators and learning disability professionals have little, if any, experience with them.

Stress assignment in reading

In a language with lexical stress, such as Greek, pronouncing a word correctly requires proper stress assignment. Reading models have rarely addressed the need to incorporate metrical information in assembling (or retrieving) the phonological word (Duncan & Seymour, 2003). A notable exception comes from the set of rules by Rastle and Coltheart (2000), which can be applied in the context of a dual route-based model to assign stress and reduce vowels in reading English. Unfortunately, this approach cannot be applied directly to reading Greek because of the written source of stress assignment information, the diacritic, which does not exist in English. That is, in addition to word stress information presumably stored in the mental lexicon, Greek permits a transparent decoding route, at least for single multisyllabic words. Moreover, in contrast to English, there are no phonological constraints (e.g., heavy syllables) or distributional asymmetries related to stress in Greek, that is, there is no report in the literature that the segmental phonological form of a word is predictive of its stress position.

Regardless of the source (or sources) of stress information, phonological stress assignment must occur at some point prior to producing a

word's pronunciation in reading aloud. In the word production model of Levelt, Roelofs, and Meyer (1999), segmental information specifying a word is combined with a corresponding *metrical frame* to form the full phonological specification. The metrical frame "specifies the lexical word's number of syllables and main stress position" (p. 21). In agreement with autosegmental formulations, a word's metrical form is parallel with, not inherently attached to, the segmental specification. Metrical and segmental spell-out "occur in parallel and require about the same amount of time" (p. 28). Whether a metrical frame is assigned by default, by the segmental word form, or by other sources of information (such as external diacritics on the printed word), an important point implicit in this characterization is that stress assignment errors can occur independently of segmental errors. An omitted or mispronounced segment does not entail a distorted metrical foot; conversely, a mis-stressed word can be perfectly well pronounced on the segmental level.

The separability of stress assignment from segmental level decoding in reading is supported by evidence from Italian individuals with aphasia presenting selective impairments in lexical stress assignment. Patient GM of Cappa, Nespor, Ielasi, and Miozzo (1997) made stress errors on approximately 20% of lexically stressed words when reading them or naming pictures, but no errors when the stress pattern of a word was predictable from the phonological structure (stressed heavy penultimate syllable). Patient MS of Laganaro, Vacheresse, and Frauenfelder (2002) misplaced word stress approximately 11% of the time when naming pictures, repeating words, or reading them aloud. This is more than double the proportion of segmental errors made in the same tasks ("phonemic paraphasias"). Although it would be unwise to conclude that stress assignment is a distinct brain function, it does seem to be the case that a distinct cognitive process must be involved, which can be adversely affected by brain injury. Thus, reading models must include a stress assignment routine, and make contact with the corresponding "metrical frame" of word production models.

Levelt et al. (1999) make a strong claim about storage of stress position in the mental lexicon: that a stress-assigning language encodes stress position in the mental lexicon only for "nonregular" lexical items (cf. Schiller, Fikkert, & Levelt, 2004). That is, there is a default metrical frame for the language, and only words not stressed according to this frame are specified for stress. Although the theory has been tested for English and Dutch, which have very different stress properties from Greek, the strong claim concerns all stress-assigning languages. Linguistic studies of stress in Greek indicate that the bisyllabic trochee may be the default metrical frame (Malikouti-Drachman, 2002; Malikouti-Drachman & Drachman,

1989). Thus the default stress pattern might correspond to a two-syllable word-final foot stressed on the penultimate, a hypothesis consistent with developmental data as well (Kappa, 2002).

Languages with lexical stress that is noted in the writing system include Portuguese (Nunes, Roazzi, & Buarque, 2003) and Spanish (Gutiérrez Palma, 2003). The two systems are not identical, but they share with Dutch the important notion of a default stress assignment, coincident with the most frequent metrical pattern of the language (penultimate stress). Written diacritics are used in these two languages when a word departs from the regular pattern. However, what is regular for each word may vary according to phonological properties of the word, therefore the default pattern is not always orthographically unmarked. Still, correct stress assignment is always possible on the basis of the orthography. In Italian, the same default pattern applies (penultimate stress) but the exceptions are not noted orthographically and must be lexically identified (Burani & Arduino, 2004; Colombo, 1992). Phonological constraints apply probabilistically in certain cases but not always. Hence, correct stress assignment when reading requires knowledge of the words. In Portuguese, readers exploit their lexical knowledge to place stress correctly, shifting stress to avoid nonword readings (Nunes et al., 2003, p. 101). In Spanish and Italian, however, reading studies have showed strong effects attributable to the regular pattern (Gutiérrez Palma, 2003, 2004; Colombo, 1992, although stress neighborhood effects were also observed in the latter). More recent experiments in Italian suggest that the effects may have been entirely due to metrical consistency, a true stress neighborhood effect (Burani & Arduino, 2004). Hence, it remains an open question whether regular default patterns are active in reading processes and whether they arise from distrubutional (frequency) or structural (metrical phonology) properties of the language.

Consistent with the hypothesis that default stress patterns are not global but depend on lexical regularities, Gutiérrez Palma (2003) found no reading time facilitation in Spanish for words with the most frequent penultimate stress pattern over words stressed on the final syllable (Experiments 1, 9, and 10), whereas a facilitation was found for words stressed consistently with the dominant pattern for their syllabic structure (''regular''), whether penultimate or final, as compared with words stressed on the least frequent position for their syllabic structure (Experiment 2). Inappropriate presence or absence of the stress diacritic resulted in longer word reading times (Experiment 3) but not in reduced priming until target latencies exceeded 66 ms (Experiments 4–7), indicating a possible lexical mediation of the effect. On the other hand, both Gutiérrez Palma (Experiment 8) and Dominguez and Cuetos (2001,

unpublished manuscript) found that stress pattern match facilitated lexical decision as much as segmental orthographic overlap, even at very short latencies: The presence of a stress mismatch (in certain conditions based only on the written diacritic) was sufficient to reduce repetition priming significantly in lexical decision tasks at latencies of 32–33 ms. Apparently, stress assignment in Spanish can be rapidly computed prelexically, on the basis of syllabic structure (a cue with high validity) and the written diacritic or its absence (a cue with perfect validity). However, the use of words from stress minimal pairs in the latter experiments minimized the possible role of lexical effects in these experiments and highlighted nonlexical sources of stress information.

Stress assignment in pseudowords

Pseudowords have no lexical specification and no stored stress assignment. To read a pseudoword correctly, the decoding route must be used, both for segments and for stress (unless resemblance to a word permits reading by analogy). According to the spelling rules of Greek, for a pseudoword with two or more syllables, a "stress error" would be any reading in which stress assignment is not on the syllable indicated by the written stress diacritic. If the written diacritic is typically used to guide stress assignment in *word* reading, then stress errors should be rare even when reading pseudowords, as they are when reading words, because the same strategy can be applied. In contrast, if stress diacritics are typically ignored, and stress assignment is primarily lexically determined in word reading, then stress decoding on the basis of the diacritics would not be very well practiced and thus would not be very efficient. Particularly difficult pseudowords might then be stressed arbitrarily, regardless of any stress diacritics, when cognitive resources are scarce and careful decoding of the diacritics too slow to keep up with segments. Thus the extent to which stress assignment errors are frequent in pseudowords and are modulated by item difficulty indicates the extent of reliance on the lexical source when reading words. This hypothesized effect should be stronger for poorer readers, who are less efficient and less practised in decoding.

Assuming imperfect use of the stress decoding strategy, a default metrical pattern would be revealed as an asymmetry in stress assignment errors: Pseudowords marked for stress on the default position would be pronounced correctly, whereas pseudowords marked on any other syllable might often be pronounced incorrectly (with stress assigned on the default position).

Informal observations of children's reading behavior has led to the conclusion that such a pattern may in fact correctly describe the underlying

stress assignment mechanism during reading. Therefore, in the following sections, I first present an analysis of written Greek regarding the frequency of stress on different positions and the probability that the written diacritic will in fact be necessary to avoid a reading error. In the second part of the article I present data from single word and pseudoword reading tests, in which clear error patterns emerge. These data were collected in the course of testing an assessment battery to validate software-based screening of learning disability (Protopapas & Skaloumbakas, in press). The errors are shown to vary depending on lexical status, syllabic position, and phonological complexity of the item, consistent with some interesting interpretations. The two parts together suggest that 12–13-year-old children may often pay insufficient attention to the stress diacritics because it is rarely necessary to attend to them for adequate reading performance.

Stress frequency analysis

The statistical properties of stress assignment can be measured on a large representative corpus of written texts. It is difficult to define representativeness, because reading habits can vary greatly, and it is even more difficult to judge representativeness for a given corpus. News articles and popular books are probably among the most widely read types of text. In addition, they are more likely accessible in electronic form, amenable to automatic processing, than other genres. In this section, I present analyses of the distribution of stress positions in written text corpora and analyses of the occurrence of stress minimal pairs, that is, words, segmentally identical, that differ only in stress position.

Corpora

Stress analysis was performed on two distinct corpora, to examine possible effects of very low frequency words (present in only one of the two corpora) and to assess the extent and consequences of typographical errors (more numerous in the larger, less edited, corpus).

A very large corpus was made up entirely of journalistic texts, based on the online content of news sources. A list of all space-separated tokens (strings) was created and the number of occurrences of each unique item was determined. This list included 1,017,946 items totalling approximately 272 million occurrences. After removing items containing numbers, punctuation, and words in latin characters, the remaining strings were converted to their phonetic form by an automatic phonetic

transcriber (Bakamidis & Carayannis, 1987). The phonetic transcriptions were parsed into approximate syllables (based on vowels), further rejecting illegal patterns. Rejected strings made up 8.6% of the unique items but accounted for only 1.4% of the total occurrences. The 930,755 remaining unique items accounted for a total of approximately 268 million occurrences in the original text corpus. This set likely includes misspellings, incorrectly stressed words, foreign words, names, and a large proportion of very rare words. It can be considered a reasonably realistic corpus, with all the imperfections expected from everyday texts found in newspapers and comparable (minimally proofread) sources. This will be henceforth referred to as the L corpus (for "large").

A second corpus was derived from the "Hellenic National Corpus," (HNC; Hatzigeorgiu et al. 2000, http://hnc.ilsp.gr/) a collection of journalistic, legal, and literary texts including more than 34 million words, collected, processed and maintained at the Institute for Language and Speech Processing (ILSP). The list of all space-separated tokens from this corpus was distilled into 374,075 unique items totalling approximately 31 million occurrences. For this smaller corpus, each item was checked against a large electronic dictionary containing 1,622,668 entries. This dictionary, from the ILSP spelling- and grammar-checking software "Symfonia," (Stathis & Carayannis, 1999, http://www.ilsp.gr/correct_eng.html) includes derived morphological variants for each lemma, thus covering the full range of morphological types found in the Greek language. Rejected out-of-dictionary strings made up 41% of the unique items but accounted for only 5.3% of the total occurrences. The resulting corpus thus includes only clearly legal and correctly spelled items, although it is impossible to ascertain the extent to which words in the original text may have been misspelled as different existing words. The 217,664 unique items in this corpus accounted for a total of approximately 30 million occurrences. This set is deprived of extremely rare words, and of most names and foreign words, which are not found in the dictionary, but it is also free from spelling errors. Therefore it constitutes an approximation to conservative, mainstream, well-proofread sources. This will be henceforth referred to as the C corpus (for "correct").

Stress position

Table 1 shows the relative proportions of each stress position in the two corpora. The differences between the two corpora are negligible, therefore these values can be taken as reasonable estimates of stress position distribution in Greek texts.

As shown in Table 1, there is a clear, but not overwhelming, preponderance of penultimate-stress items among words that bear a stress diacritic. Monosyllables make up a larger proportion of the text than penultimate-stress items, but they bear no stress diacritic. Moreover, most monosyllables are in fact closed-class words and as such carry no phonological stress. Therefore they cannot be compared to the open-class (content) items that make up the vast majority of stress-bearing categories.

Stress minimal pairs

In the 217,664 unique items of the C corpus, 11,043 stress minimal pairs were identified, of which 6486 form double-stress pairs (that is, pairs of one content word regularly stressed on the antepenultimate and the same word with a second stress on the final syllable, arising from clitics attaching phonologically to the end of this content word). The remaining 4557 pairs correspond to word pairs differing only in stress, and account for a total of 5% of all occurrences in the corpus. It would thus appear that 5% of written text needs to be disambiguated by a stress diacritic in order to be read correctly; or, conversely, that for 95% of written text the diacritic is not necessary for correct reading.

Further analysis, however, suggests that 5% is an overestimate. Examination of a random sample (10%) of the 4557 minimal stress pairs in this corpus (excluding the double-stress cases) reveals that 71% of the pairs concern words with alternative stress patterns (mostly depending on formal vs. colloquial style) largely interchangeable in current texts (e.g.,άσκοπων–ασκόπων, both meaning "pointless" in genitive plural). Only 24% of the pairs corresponded to two distinct lexical entries, that is, two words with different meanings (e.g., μέτρο "meter" vs. μετρό "metro"), including morphological differences (e.g.,ξέχνα, 2nd person singular imperative, vs. ξεχνά, 3rd person singular indicative, of the verb meaning "to forget"). These "true" stress minimal pairs account for 71% of the

Table 1. Proportion of word occurrences (percent) bearing each type of stress. Monosyllables carry no stress diacritic; double-stress items carry two diacritics.

Stress position	L corpus	C corpus
Final	18.9	18.6
Penultimate	27.5	27.8
Antepenultimate	16.1	15.5
Monosyllable	37.0	37.8
Double-stress	.4	.4

occurrences of both members of all pairs. Therefore the percentage of stress-ambiguous words in text can be estimated at .71×.05, or approximately 3.6%.

In the 930,755 items of the L corpus, 60,744 stress minimal pairs were identified, of which 15,610 form double-stress pairs. The vast majority of the 45,134 stress minimal pairs occur because of mis-stressed tokens in the corpus. Although the contribution of very rare words should not be dismissed, the effect of (low-frequency) typographical errors becomes obvious if items occurring only once or twice (in 268 million) are removed from the calculation, in which case the number of stress minimal pairs drops in half. Alternatively, close examination of a random (1%) sample of the 45,134 matches reveals that 22% of the matches are alternative stress patterns for the same word, 41% are due to errors in the corpus text (misplaced stress diacritic), 26% concern rare foreign names with uncertain stress, and only 11% of the matching pairs reflect genuine stress-based lexical differences. These latter matches account for 5.7% of the approximately 173 million total occurrences of matching items. Therefore the estimated percentage of truly stress-ambiguous words in text is estimated from the L corpus at 3.7%, in close agreement with the estimate from the C corpus.

A complementary approach to assessing the importance of stress minimal pairs is to calculate the proportion of words that would be incorrectly read if there were no stress diacritics and no context bias to lexical disambiguation. In this case the sole source of stress assignment might be derived lexically, from the most frequent segmentally compatible entry in the lexicon. In other words, for each stress minimal pair we assume that all occurrences of both items would be stressed in the position that is correct for the most frequent of the two. Thus, for each pair, the least frequent would always be mis-stressed, and its frequency would be added to the overall rate of mis-stressing. The total number of occurrences of all the minimum-frequency pair members is 2.1 million, amounting to only .8% of the corpus text.

So, if one had no stress diacritics at all and one always read every word with the stress pattern, lexically determined, corresponding to its most frequent variant, one would be wrong less than 1% of the time. Taking into account that many of the detected pairs occur because of typos (i.e., low-frequency mis-stressings, 41% in the random 1% sample, accounting for at least .6% of total occurrences), it becomes evident that such a lexical strategy would distort as often as it would correct the reading of this kind of text. In addition, the assumption that context plays no role in lexical selection is certainly incorrect. If the lexical strategy is allowed to be

influenced by context, rather than by highest frequency alternative alone, the proportion of actual reading errors would drop much further.

Word and pseudoword reading

Given that the necessity of the written diacritic is comparable to its unreliability, it was interesting to examine the actual use of stress diacritics in reading Greek. Pseudowords were used, for which no lexical information is available and therefore the diacritics necessarily serve as the only valid cue to stress position. Errors in stress assignment when reading pseudowords will indicate imperfect processing of the diacritics. Errors can be analyzed with respect to personal attributes (such as reading ability) and stimulus features (such as phonological complexity or conformance to a default stress pattern), in order to identify aspects of the stress assignment mechanism during the reading process. A word reading task was also employed in order to estimate individual reading ability and also as a baseline for stress assignment performance in the presence of lexical information.

Method

Subjects

One hundred and seventy seventh-grade children (89 boys) from 6 schools participated in the study. The schools were selected to cover a wide range of socioeconomic status, from the province of Attiki (which includes Athens). The mean ($\pm\sigma$) age of the participants was 151 ± 6 months and their mean performance on Raven's Standard Progressive Matrices test of nonverbal intelligence (full 60-item version) was 37 ± 10 (raw score). Participants were self-selected in that only children who returned a consent form signed by their parents were tested. However, it was evident from the results of the full testing battery (not reported here) that the full range of ability and academic performance was represented in the sample.

Materials

Twenty pseudowords were taken from Maridaki-Kassotaki (1998), originally constructed to test working memory, designed to not resemble real words or particular word types, while respecting the phonotactic constraints of Greek. They ranged in length from 2 to 5 syllables (mean length 3.53 ± 1.17) and contained 0 to 2 consonant clusters (mean number $1.15 \pm .49$; see list in Table 4). Stress position, always indicated by a diacritic, was on the antepenultimate for 7 items, on the penultimate for 9 items, and on the final syllable for the remaining 3 items (mean position

2.21 ± .71). The 20 items were printed in lowercase, in order of increasing length (the same for all participants), on a sheet of paper in a single column with Times New Roman (Greek) font size 14 pt.

The word list included 84 words, ranging in length from 1 to 7 syllables, including a variety of parts of speech and morphological types, and covering a wide range of printed frequency. The noun-to-verb ratio was approximately 3:1. Length proportions were: 42% 3-syllable items, 21% 2-syllable, 15% each 1- and 4-syllable, and only a few of greater lengths. Printed word frequency was taken from the HNC. Most of the test items were medium-frequency words, with 12–99 appearances in the 34-million-word corpus; high- and low-frequency words were also included. The 84 items were printed in lowercase, in random order (the same for all participants), on a sheet of paper in three 24-item columns with Times New Roman (Greek) font size 14 pt. Because stress assignment errors are not possible on monosyllables, all results reported below are based on the 71 items with two or more syllables (mean length 3.13 ± 1.00 syllables) and 0–2 consonant clusters (mean number .70 ± .62), of which 21 were stressed on the antepenultimate, 30 on the penultimate, and 20 on the final syllable (mean position 2.01 ± .77). The full word list can be found in the Appendix.

Procedure

Students were tested individually in a quiet space at the school, in the course of a full testing battery lasting a total of approximately 75 min, usually with one break. For the particular tests presented here, which took less than 5 min, children were given each item list sheet (separately; pseudowords first and words later) and asked to read all items "carefully and quickly, but not rushing, to avoid mistakes." The tests were administered by trained graduate students and recorded on tape. Reading was timed, using a handheld stopwatch, starting with the experimenter's signal "Go!" and ending with the completion of the last item. In case of self-corrections, the last attempt was used.

Students' errors (or entire productions, in case of great deviation from the target) were noted on a rater's sheet at the time of test administration. All responses, error counts, and timing were later verified against the recording and corrected if necessary.

Results

Reading times ranged between 56 and 307 s for the (entire, 84-item) word list (mean 97 ± 33 s, median 90 s) and between 25 and 162 s for the (20-item) pseudoword list (mean 45 ± 17 s, median 41 s).

Table 2 shows the total number and proportion of segmental errors (i.e., items produced with a phoneme sequence deviating from the correct sequence corresponding to the printed item) and stress-assignment errors (or simply stress errors; i.e., items produced with stress assigned on a syllable other than the one marked with the diacritic on the written item) for each test. Stress errors were much more frequent for pseudowords than for words (nine times more likely). Moreover, stress errors were more frequent than segmental errors for pseudowords (58% of the total number of errors), whereas they only made up about a third of the total number of errors for words; the difference in proportion was highly significant ($\chi^2(1) = 39.94$, $P < .0005$).

Table 3 shows the distribution of stress assignment errors by position of the incorrectly stressed syllable. This difference between words and pseudowords in proportions of error positions was statistically significant ($\chi^2(2) = 106.71$, $P < .0005$). It appears that the penultimate syllable was incorrectly stressed in about 85% of all pseudoword stress assignment errors. This does not reflect a higher proportion of pseudowords with a correct stress assignment on syllables other than the penultimate. In fact, of the 19 unambiguously syllabified pseudowords,[3] 9 carried penultimate stress (see Table 4 for details). Therefore, of the $10 \times 170 = 1700$ total readings of pseudowords not stressed on the penultimate, about 24% were incorrectly pronounced with penultimate stress. In comparison, of the 9×170 readings of penultimate-stressed pseudowords, less than 5% were incorrectly pronounced with stress on other syllables. This disproportionate amount of incorrect penultimate stress assignment appears to reflect a stress bias which cannot be accounted for by other known properties of the test items. A slight "preference" for the penultimate is evident, but nowhere nearly as strong, in the word reading test: 1.4% misstressed penultimate-stress items vs. 1.7% with stress on other syllables.

For pseudowords (items analyses), the number of *stress* errors in items stressed on the penultimate was lower than in items stressed on either the antepentultimate or the final syllable ($F(1,18) = 13.71$, $P = .002$). There was

Table 2. Total number of errors, and frequency of errors (percent, in parentheses) by error type, made by 170 schoolchildren reading aloud 71 words and 20 pseudowords.

	Stress	Segmental	Both
Words	195	294	22
	(1.6%)	(2.4%)	(.18%)
Pseudowords	487	355	98
	(14.1%)	(10.1%)	(2.83%)

Table 3. Number of stress errors, and relative proportion (percent, in parentheses) by syllable of incorrect stress assignment.

	Antepenultimate	Penultimate	Final
Words	30 (15.4%)	101 (51.8%)	64 (32.8%)
Pseudowords	51 (10.5%)	412 (84.6%)	24 (4.9%)

Table 4. Relevant properties and total number of stress assignment and segmental errors for each pseudoword.

Pseudoword spelling	Pseudoword pronunciation	Stress position	Number of syllables	Number of clusters[a]	Total number of errors		
					Stress	Segmental	Both
μνέζο	'mnɛ.zo	2	2	1	0	5	0
σπλέβο	'splɛ.vo	2	2	2	0	16	0
βιγδός	vi.'ɣðos	1	2	1	34	9	3
χριπό	xɾi.'po	1	2	1	16	9	1
γκροβλόν	gɾo.'vlon	1	2	2	9	18	4
έτοβλι	'ɛ.to.vli	3	3	1	26	8	2
σκεδάτις	sce.'ða.tis	2	3	1	4	5	1
βλουμέδια	vlu.'mɛ.ðja[b]	2 (or 3)	3 (or 4)	1	7	7	1
έσματο	'ɛ.zma.to	3	3	1	18	8	3
δατρόλι	ða.'tɾo.li	2	3	1	2	8	0
καγιστρένι	ka.ɟi.'stɾɛ.ni	2	4	2	0	19	0
ιρενίζο	i.ɾɛ.'ni.zo	2	4	0	3	8	0
σγολέτορδι	zɣo.'lɛ.toɾ.ði	3	4	2	78	45	25
εψανόλους	ɛ.psa.'no.lus	2	4	1	3	8	0
αξόρβεσι	a.'ksoɾ.vɛ.si	3	4	2	50	60	16
λαγδιλέταρου	la.ɣði'.lɛ.ta.ɾu	3	5	1	42	17	6
χνουρεσέπαδι	xnu.ɾɛ.'sɛ.pa.ði	3	5	1	49	20	12
πακιθεσγάνο	pa.ci.θɛ.'zɣa.no	2	5	1	20	44	4
αψοτουχνίο	a.pso.tu.'xni.o	2	5	2	33	14	1
εσπιγκίετι	ɛ.spi.'ɟi.ɛ.ti	3	5	1	93	27	19

[a]Two-consonant clusters; a cluster of three consonants counts as two.

[b]Alternatively, /vlu.'mɛ.ði.a/; both readings are legal for the given spelling.

no corresponding statistically significant difference in the number of *segmental* errors for pseudowords ($F(1,18) = 1.70$, $P = .209$) or in the number of either type of errors for words (both $F < 1$). For stress errors, the two-way interaction between type of item (word vs. pseudoword) and stress position (penultimate vs. other) was also highly significant ($F(1,87) = 40.83$, $P < .0005$). In examination of the error counts, the proportion of stress errors in items stressed on the penultimate was lower than in items stressed on either the antepentultimate or the final, both for words ($\chi^2(1) = 14.41$, $P < .0005$) and for pseudowords ($\chi^2(1) = 241.58$, $P < .0005$). However, the proportion of segmental errors in items stressed on the penultimate was lower than in items stressed on either the penultimate or the final only for pseudowords ($\chi^2(1) = 21.32$, $P < .0005$); there was no corresponding difference for words ($\chi^2 = .000$). The relative proportions of pseudoword and word errors in items stressed on the penultimate vs. on other syllables were significantly different both for stress assignment errors ($\chi^2(1) = 39.30$, $P < .0005$) and for segmental errors ($\chi^2(1) = 9.84$, $P = .002$).

Item properties affecting performance

How can we best explain this pattern of performance? Errors might occur because of item difficulty, defined in terms of length (number of syllables) and syllabic complexity (number of consonant clusters, presence of codas); or they might depend on the location of the stress diacritic. For words, familiarity with each item (insofar as it can be estimated by printed frequency) might also have modulated performance. Therefore, to examine the contribution of these potential sources of error, the number of errors (segmental and stress errors separately) for each item was regressed onto the corresponding number of syllables, number of consonant clusters, additional syllabic complexity (presence of codas; for pseudowords only), and position of correct stress assignment. For words, the log frequency of the corresponding lemma was also included.

For word reading (see Table 5), the number *of segmental* errors was significantly correlated only with number of syllables. Accordingly, only the number of syllables contributed significant variance to the regression equation, regardless of the order in which variables were entered. None of the variables were significantly correlated with the number *of stress* errors.[4] Although the proportion of word readings with both segmental and stress-assignment errors (.18%, see Table 2) is almost five times higher than would be expected if the two types of errors were statistically independent, the correlation between the two types of errors ($r = .16$) did

Table 5. Results of linear regression analysis to predict segmental (top) and stress (bottom) errors in word reading on the basis of relevant item properties. Correlations are Pearson's product-moment coefficients ($n = 71$). Part correlations exclude variance accounted for by the other variables.

	Standardized β	Zero-order correlation	Part correlation
Syllables	.24	.29	.21
Cons. clusters	.09	.12	.09
Stress position	.03	.16	.03
Log frequency	−.09	−.20	−.08
Syllables	.04	.03	.03
Cons. clusters	.03	.03	.03
Stress position	−.09	−.06	−.08
Log frequency	−.09	−.09	−.08

not reach statistical significance ($P = .19$). A contribution of general word reading difficulty to stress errors cannot be entirely dismissed, but if it exists it cannot be very large.

For pseudoword reading (see Table 6), the number of *segmental* errors was significantly correlated with all measures of phonological complexity. Accordingly, 53% of the total variance in segmental errors can be accounted for by these variables; stress position adds a nonsignificant 2%. Conversely, if stress position is entered first (accounting for 15% of the variance), the phonological complexity measures add a significant 40%. Therefore it appears that segmental errors in reading pseudowords is primarily a question of phonological difficulty, as expressed in the usual

Table 6. Results of linear regression analysis to predict segmental (top) and stress (bottom) errors in pseudoword reading on the basis of relevant item properties ($n = 20$). Correlation information as in Table 5.

	Standardized β	Zero-order correlation	Part correlation
Syllables	.42	.44	.32
Cons. clusters	.33	.53	.27
Syllabic codas	.33	.36	.26
Stress position	.18	.38	.14
Syllables	.36	.52	.28
Cons. clusters	.18	.37	.14
Syllabic codas	.30	.22	.23
Stress position	.39	.56	.32

measures. Additional variance might be attributable to syllable frequencies but no such measure is available for Greek.

In contrast, for *stress* errors in pseudowords, 32% of the variance could be accounted for by the position of the correct stress assignment alone; an additional 23% of unique variance could then be contributed by the 3 phonological complexity variables combined. However, if stress position were not initially entered in the regression, then 45% of the stress assignment error variance would be accounted for by phonological complexity; with stress position contributing an additional significant 10% in the next step. Therefore, and consistent with observation of the raw error counts (combined segmental and stress assignment errors, at 2.8%, were twice as many as would be expected if the two types of errors were independent), stress assignment errors in pseudowords can be attributed both to phonological complexity and to correct stress position. Figure 1 shows these trends most clearly and allows comparisons between words and pseudowords. The point for final-stressed easy items seems to escape the trend, being lower than the corresponding penultimate-stress point, but this most likely reflects the fact that only 2-syllable pseudowords existed with final syllable stress, whereas longer items were included in all the other points.

The words did not differ from the pseudowords in mean number of syllables ($F(1,89) = 2.04$, $P = .157$) or mean stress position ($F < 1$); accordingly, they also did not differ in the proportions of items with each number of syllables ($\chi^2(5) = 9.13$, exact $P = .097$, two-tailed) or each stress position ($\chi^2(2) = 1.43$, $P = .475$). They did, however, differ in mean number of

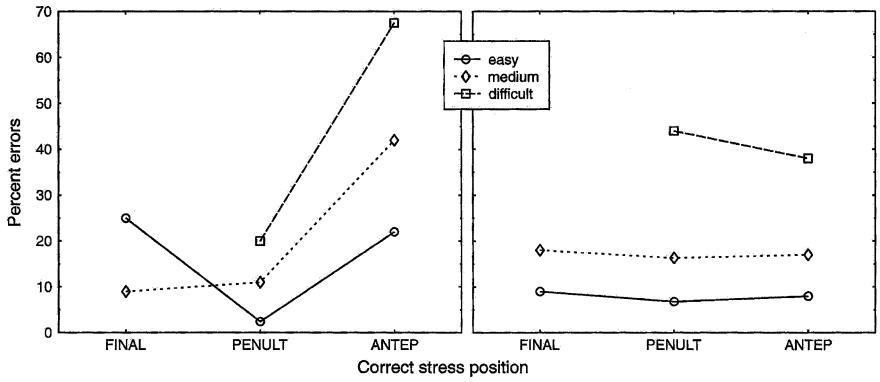

Figure 1. Proportion of pseudoword reading errors in stress assignment (left) and segmental identity (right) as a function of correct stress position and phonological difficulty. PENULT means stress on the penultimate syllable; ANTEP on the antepenultimate. The three categories of difficulty are defined on the basis of the total number of segmental errors made by all schoolchildren on each item. "Easy:" 0–9 errors (10 items); "medium:" 10–19 errors (5 items); and "difficult:" 20 or more errors (5 items).

clusters ($F(1,89) = 8.81$, $P = .004$) and corresponding item proportions ($\chi^2(2) = 8.66$, $P = .013$). This difference could not account for the difference in preponderance of stress assignment errors between words and nonwords: considering only items with at least one consonant cluster (44 words and 19 pseudowords), which are statistically indistinguishable in number of syllables ($F(1,61) = 1.56$, $P = .216$), mean stress position ($F < 1$), and number of clusters ($F < 1$), the proportion of stress assignment errors remains practically unchanged, at 14.9% for pseudowords and 1.6% for words. Therefore no factor other than lexical status itself appears to account for the observed performance pattern, i.e., for the much greater proportion of stress errors in pseudowords than in words.

In sum, segmental errors in word reading are accounted for to some extent by length (number of syllables), whereas stress errors in word reading seem to be primarily influenced by uncontrolled lexical factors. Segmental errors in pseudoword reading are accounted for by phonological complexity, including length and consonant clusters, whereas stress errors in pseudoword reading are significantly affected by both stress position and phonological complexity. Since the word and nonword sets did not differ significantly in their proportions of items with different lengths and stress positions, the distinct patterns of stress error relations can be taken to indicate the different processing routes underlying word and pseudoword stress assignment. The most obvious relevant difference is the lack of a lexically determined stress pattern for pseudowords.

Relation to reading ability

It is worth considering the hypothesis that stress assignment errors are made mainly by the poorest readers, because that would indicate that stress assignment based on the written diacritic is particularly difficult or inefficiently carried out for schoolchildren with relatively poor reading skills. Figure 2 shows the distribution of children over numbers of segmental and stress assignment errors in pseudowords. About one quarter of the children make no errors in either case; in other words, the great majority of children make at least one error of each type, and almost half of the children make over two errors in each case (both medians are equal to 2). Therefore the errors are not made disproportionately by some small, presumably impaired, group.

Reading ability is typically assessed via accuracy and speed measurements, using reading lists. Unfortunately, no standardized tests of reading ability exist for Greek, therefore it was not possible to obtain measures of reading age for these children. However, isolated word reading accuracy and speed are, in combination, excellent indices of

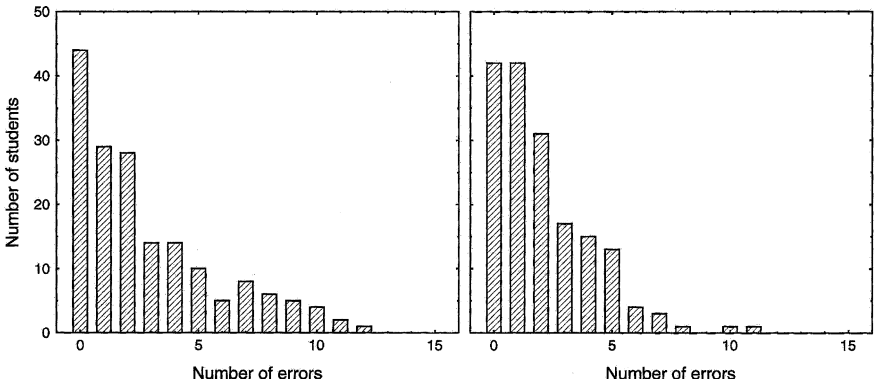

Figure 2. Distribution of the children over the total number of personal pseudoword reading errors in stress assignment (left) and segmental identity (right).

reading disability. In fact, reading measures from the particular word list used here have been found to distinguish a clinical sample rich in learning disabled 7th graders from the corresponding general school population ($\eta^2 = .17$ both for speed and accuracy, second only to text reading speed, for which $\eta^2 = .28$) (Protopapas & Skaloumbakas, in press).

Therefore, if the majority of stress assignment errors were made by the poorest readers, a large proportion of stress assignment performance variance should be attributable to word reading speed and accuracy. The following analysis was conducted after transforming the variables (errors via natural logarithm, times via inverse) in order to bring their distributions closer to normality. In the present sample, word reading time was positively correlated with number of word reading segmental errors ($r = .50$, $P < .0005$), therefore both index reading ability and there is no speed-accuracy tradeoff. Linear regression of pseudoword stress assignment errors onto word reading speed (time) and accuracy (errors) combined accounted for 12% of the variance. The correlation of pseudoword stress assignment errors was $r = .34$ ($P < .0005$) with word segmental errors and $r = .26$ ($P = .001$) with word reading time. Figure 3 depicts the (untransformed) relation with reading time. These relations are not negligible; they are an indication that more skilled readers tended to make fewer stress errors. However, they are rather weak and thus seem insufficient to support the hypothesis that pseudoword stress assignment errors are largely restricted to schoolchildren with poor reading skills. It appears, then, that stress assignment errors for this age are common across reading skill.

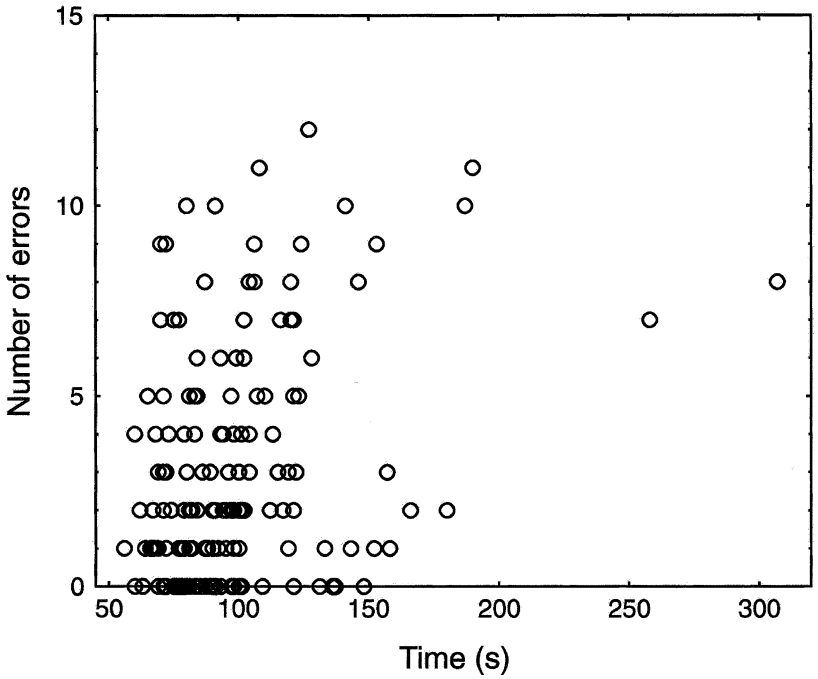

Figure 3. Relation of the total number of stress assignment errors in pseudoword reading to word reading speed, a standard index of general reading ability. Each circle corresponds to one student.

Discussion

It seems clear that, at the age of 12–13 years, stress assignment when reading is not entirely based on the clearly visible diacritic. The very large number of stress assignment errors in reading pseudowords suggests that straightforward decoding of the diacritic may not be the default reading strategy for these children. Certainly, it cannot be claimed that diacritics are not used at all, because most pseudowords were usually stressed correctly, including the longest and most complex ones. However, the relation of pseudoword stress assignment accuracy both to the individual pseudoword difficulty and to general word reading ability indicates that a resource limitation may play an important role.

A possible conclusion is that, even though diacritics are simple and unambiguous cues to stress position, it is costly to decode them. Certainly it is costlier than not decoding them, especially if (a) lexical access is typically *accurate* without regard to the stress diacritic and (b) stress assignment is derived *easily* from the internal lexical representation following lexical access. As far as the accuracy of lexical access is concerned,

the preceding analysis of text corpora indicated that it does not depend very much on the diacritic. And it is reasonable to assume that once a word is accessed, all information related to it, including stress assignment, is automatically available at little or no resource cost.

It is possible that stress assignment decoding is a difficult, resource-straining process, and readers fail to complete it when they are occupied with otherwise demanding material. An alternative interpretation is that stress diacritics add little information to the lexical knowledge already activated by the sight vocabulary of the experienced reader. That is, perhaps readers can relatively easily and reliably guess the correct phonological form of a word (including its stress) based on the orthographic representation and cumulative (phrase and pragmatic) context. Italian and Russian readers do it, without the aid of stress diacritics; why not also Greek readers? If this is the case, then it might be beneficial to preferentially ignore external stress assignment information, which can be "easily" guessed or derived, and focus on segmental information, which must be computed, especially in computationally intensive cases, when resources are limited or inefficiently deployed.

General discussion

The experimental measures indicate that 12–13-year-old readers, when reading, sometimes assign stress with little regard for the clearly written stress diacritic. Informal observations by educators (primary and secondary education teachers) indicate that an increasing (still small) proportion of schoolchildren do not use the stress diacritic when writing, thus misspelling every word with more than one syllable. The growing trend of omitting stress diacritics in informal writing is most obvious in the domain of electronic communication, where a sizeable proportion of adult computer users seem to prefer not to be bothered with typing the diacritic. It remains to be determined whether as readers they are also not bothered by the lack of diacritics.

Three observations together suggest that, at this age, stress assignment in reading Greek may be primarily lexical: First, pseudowords were often stressed incorrectly, indicating that the written diacritic was not the primary source of information. If readers typically use the diacritics in word reading, why would they abandon them in pseudowords, where they are needed most? Second, the correlations with item complexity and individual reading ability suggest that more stress assignment errors were made on the more difficult (phonologically complex) pseudowords, and poorer readers made more stress assignment errors (and more segmental

errors, of course) than better readers, together indicating that decoding the stress diacritic into the corresponding metrical frame is a resource demanding process. And third, the much fewer stress assignment errors in word reading were made predominantly on certain items, transparently attributable to lexical factors (similar words), and were not related to word frequency or phonological complexity. Although methodological considerations can be raised against each of these observations individually, the three together make a strong case that is at least worth further study.

The analysis of text corpora indicated that a small, but not negligible, proportion of printed words are spelled with incorrect stress. The .6% estimate is an absolute minimum and does not take into account illegal or lacking stress marking, because such items were rejected in the original parsing. Therefore, the proportion of words that need the stress diacritics in order to be read correctly is comparable to the proportion of words that would be read incorrectly based on the diacritics, at least for newspaper text. There is no reason to expect lower typographical error rates in nonprofessional texts (but perhaps the situation is different for books). Thus it seems that readers of Greek may be justified to base their reading in large part on their mental lexicon.

The availability of internal information sources about stress assignment renders the decoding option potentially dependent on processing constraints, such as cue validity and cue cost. Cue validity refers to ''the information value of a given [linguistic] form'' whereas cue cost refers to the ''amount and type of processing associated with the activation and deployment of a given linguistic form'' (Bates, Wulfeck, & MacWhinney, 1991, p. 127). If decoding a written diacritic is more difficult, or slower, than lexical assignment, then the internal route(s) would be preferred, especially in cases of increased load or poor efficiency. Similarly, if the written diacritic adds little or unreliable information, then the lexical and default routes might become prominent, particularly as uncertainty increases.

Calculation of cue validity and cue cost is not straightforward, however, because a full specification of processes is needed. For example, the resource demands of decoding the position of the diacritic are not limited to visual recognition of the clear visual mark. A full metrical frame has to be assembled, or retrieved, on the basis of relating this visual mark to the corresponding phonological syllable. Establishing which syllable is the correct one, on the basis of the spatial position of the visual mark over the nucleus (vowel) grapheme, may be substantially more complex than applying a metrical pattern which may become automatically activated as soon as the lexical entry is determined.

The notions of cue validity and cost have proven very useful in aphasia research and can also be relevant for studying reading. Recent developments indicate common patterns of language breakdown among patients with aphasia and neurologically intact individuals under stressful conditions (Dick et al., 2001), That is, brain injury does not typically create specific deficits unrelated to processing considerations, but what is difficult for the general population is even more difficult, often impossible, in certain types of neural impairment. Therefore, the same factors affect normal as well as impaired processing, to a different extent or perhaps in different proportions. Likewise, the present findings, from the general student population, are consistent with observations of the reading performance of persons with dyslexia in Mexico; similar in pattern but less severe in magnitude. Specifically, Leal and Suro (2002) reported that children with dyslexia make many more word reading errors at the suprasegmental level (up to 25% incorrectly stressed single words) than at the segmental level. As a result of this observation, Leal and Suro (2003, unpublished manuscript) recommended that the standard phonological hypothesis of developmental dyslexia, and the assessment instruments, be revised to include suprasegmental levels of phonological representation, and processes of phonological integration.

The existence of a default metrical frame may complicate the picture: If a default frame exists, then the Greek reader has (a) a general strategy of assigning the default pattern, (b) a lexical strategy of assigning a stored pattern, and (c) a decoding strategy for assigning the pattern indicated in writing with the diacritic. The overwhelming proportion of errors made towards penultimate stress in pseudoword reading stands strongly in favor of a default frame in Greek, identical to the Portuguese, Spanish, and Italian default. The origin of the default frame is difficult to ascertain. If it arises as a result of distributional properties, that is, from the preponderance of penultimate-stress words in the language, then it may be more difficult to explain in Greek, where the majority is clear but only relative. Relying on the default pattern would be more often erroneous than correct, because even though penultimate stress is more frequent than any other pattern it is less frequent than the two other patterns together. In any case, the findings of Burani and Arduino (2004) for Italian strongly support current notions of sensitivity to all kinds of distributional properties in a language. If local consistency can override the presumed global ''default'' then (a) there is no reason to ascribe the default to anything other than overall statistics and (b) ''regularity'' effects can be expected even on the basis of relative proportions only. As noted in the introduction, the hypothesis that default stress patterns are

not global but depend on lexical regularities is also consistent with the findings of Gutiérrez Palma (2003).

Lexical sources of stress assignment information need not be all-or-none. Consistent with the findings on structural regularities from Italian and Spanish, it is possible that sublexical frequency effects may play an important role. In the highly inflected Greek language, morphological resemblance may provide additional cues to stress assignment. The effects of unambiguously stressed word endings (morphologically determind) can be investigated using nonwords constructed to resemble selected inflectional forms but no particular words. Thus, future studies can determine the degree to which item-level and distributional lexical sources contribute to stress assignment in reading. In addition, response time studies will be needed to discern the time course of stress assignment when different sources of information are present, in agreement or in conflict with one another.

The present study was conducted in the context of very little relevant background, since stress assignment remains a largely neglected aspect of the reading process. As such, it raises more questions that it may answer. If the phenomenon observed here, of imperfect processing of stress diacritics, is replicated and extended to adult readers, it will then be important to investigate developmentally the role of stress diacritics in the various stages of learning to read, from the first grade through adulthood.

In conclusion, in this article I have presented evidence that Greek schoolchildren at the 7th grade do not base their stress assignment entirely on stress diacritics when reading. Statistical analyses of text corpora justify imperfect reliance on the diacritics because they are rarely necessary to disambiguate words (and as frequently incorrect). This is by no means an endorsement of an inattentive reading strategy or of officially omitting stress diacritics when writing. On the one hand, participants clearly paid at least some attention to the diacritics, because they read even pseudowords correctly more often than not. On the other hand, the effect of the diacritics on reading efficiency remains unknown, and is worth investigating. Further research is needed to clarify the role of alternative sources of stress assignment information and the cognitive processes involved in assembling the phonological words from the segmental and metrical frames when reading. Future study should also identify where difficulties may arise from, when processing stress assignment during reading, and then help develop and teach optimal reading strategies.

Acknowledgements

The author is indebted to Svetlana Gerakaki and Stella Alexandri, for transcribing all the taped reading tests, and counting and categorizing the errors, and to Aimilios Chalamandaris and Nick Hatzigeorgiou, for help with obtaining and processing the text corpora. Thanks are due to Nicolás Gutiérrez Palma and Fernando Leal for useful discussions and comments on the manuscript, and to Christos Skaloumbakas for his long-time collaboration on learning disability assessment, which produced the data that led to the observation underlying this article.

Notes

1. Certain dialectal variations allow, in rare cases, stress on the syllable preceding the antepenultimate (Petrounias, 2002), but these do not concern us in the present article, which deals with the "standard" dialect as spoken, e.g., in Athens.
2. Personal pronoun pre-clitic monosyllables are also optionally marked with a stress diacritic when it is judged that they might be confused with the identical possessive pronouns.
3. One of the items could be read either with four syllables, or with three syllables after optional palatalization. This affects the calculation of intended and actual stress assignment syllable but not the judgment of correct or incorrect stress. Only 7 stress errors were made in total on this item, therefore none of the proportion calculations reported here are substantially affected. Post-hoc, the low error rate suggests that the intended 3-syllable reading was in fact preferred.
4. Examination of the 10% of the items (words) most frequently mis-stressed suggested that they were similar to frequent words with different stress patterns or had alternative pronunciations. They were δικάστε (21 errors), γωνία (20), εξοφλούμενος (18), περνώ (13), μαλθακά (13), κέδρινος (13), αντιλόπες (10), and βολβός(9). These 8 items accounted for 60% of all word stress assignment errors. Therefore it appears that the main source of stress assignment errors was itself lexical.

Appendix

Word list

δε	ðɛ	καθιστός	ka.θi.'stos	σπογγαλιεία	spo.ga.li.'i.a
αναδάσωση	a.na.'ða.so.si	πυρ	pir	εξοφλούμενος	e.kso.'flu.mɛ.nos
φαρμακείο	far.ma.'ci.o	γη	ji	ως	os
παρέα	pa.'rɛ.a	συν	sin	οπορωπωλείο	o.po.ro.po.'li.o
τέσσερις	'tɛ.sɛ.ris	μαλθακά	mal.θa.'ka	αλχημείας	al.çi.'mi.as
σανίδα	sa.'ni.ða	αντιλόπες	a.di.'lo.pes	γονάτισα	ɣo.'na.ti.sa
βραχοπλαγιά	vra.xo.pla.'ja	μετρήθηκε	mɛ.'tri.θi.cɛ	πως	pos
ένας	'ɛ.nas	αφώτιστος	a.'fo.ti.stos	ας	as
παρελθόν	pa.rel.'θon	ατρόμητος	a.'tro.mi.tos	βόλια	'vo.ʎa
πυρκαγιά	pir.ka.'ja	τυφλόμυγα	ti.'flo.mi.ɣa	κέδρινος	'ce.ðri.nos
εκδίδω	ek.'ði.ðo	ανασαίνω	a.na.'sɛ.no	φως	fos
άρχισα	'ar.çi.sa	φτερών	ftɛ.'ron	φρονίμεψε	fro.'ni.mɛ.psɛ
παρεμβατικότητα	pa.rem.va.ti.'ko.ti.ta	ζωτικός	zo.ti.'kos	νταντεύω	da.'dɛ.vo
ρε	rɛ	ασεβώς	a.sɛ.'vos	φαίνομαι	'fɛ.no.mɛ
καλόγουστα	ka.'lo.ɣu.sta	χαράμι	xa.'ra.mi	κόσμημα	'ko.zmi.ma
μην	min	μπάμια	ba.mɲa	χορευτής	xo.rɛ.'ftis
φτιάχτηκαν	'ftça.xti.kan	προτείνεις	pro.'ti.nis	γωνία	ɣo.'ni.a
ιδίως	i.'ði.os	παίρνω	'pɛr.no	έλασμα	'ɛ.la.zma
πυγμαχώ	piɣ.ma.'xo	δείγμα	'ðiɣ.ma	πουλάω	pu.'la.o
καθαρός	ka.θa.'ros	πας	pas	έκφραση	'ek.fra.si
αφορώ	a.fo.'ro	βολβός	vol.'vos	μόκα	'mo.ka
χειροτόνηση	çi.ro.'to.ni.si	ιστός	i.'stos	σκονίζει	sko.'ni.zi
προβάλλουν	pro.'va.lun	και	cɛ	ξάπλωμα	'ksa.plo.ma
ταγή	ta.'ji	αντί	a.'di	φίλαθλος ;	'fi.la.θlos
δύση	'ði.si	θλίψη	'θli.psi	βράσε	'vra.sɛ
δικάστε	ði.'ka.stɛ	διεθνής	ði.ɛ.'θnis	ναι	nɛ
αφού	a.'fu	σχετικά	sçɛ.ti.'ka	βύσμα	'vi.zma
περνώ	pɛr.'no	συνθήκη	sin.'θi.ci	πράος	'pra.os

References

Bakamidis, S., & Carayannis, G. (1987). 'Phonemia': A phoneme transcription system for speech synthesis in Modern Greek. *Speech Communication*, *6*, 159–169.

Bates, E., Wulfeck, B., & MacWhinney, B. (1991). Cross-linguistic research in aphasia: An overview. *Brain and Language*, *41*, 123–148.

Burani, C., & Arduino, L. S. (2004). Stress regularity or consistency? Reading aloud Italian polysyllables with different stress patterns. *Brain and Language*, *90*, 318–325.

Cappa, S. F., Nespor, M., Ielasi, W., & Miozzo, A. (1997). The representation of stress: Evidence from an aphasic patient. *Cognition*, *65*, 1–13.

Colombo, L. (1992). Lexical stress and its interaction with frequency in word pronunciation. *Journal of Experimental Psychology: Human Perception and Performance*, *18*, 987–1003.

Dick, F., Bates, E., Wulfeck, B., Utman, J. A., Dronkers, N., & Gernsbacher, M. A. (2001). Language deficits, localization, and grammar: Evidence for a distributive model of language breakdown in aphasic patients and neurologically intact individuals. *Psychological Review*, *108*, 759–788.

Dominguez, A., & Cuetos, F. (2001). *Lexical stress in visual word recognition: contrastive valve in Spanish*. Unpublished manuscript, University of La Laguna, Departamento de Psicología Cognitiva, Spain.

Duncan, L.G., & Seymour, P.H.K. (2003). How do children read multisyllabic words? Some preliminary observations. *Journal of Research in Reading*, *26*, 101–120.

Gutiérrez Palma, N. (2003). *El acento léxico y su función en el reconocimiento de palabras escritas en adultos y en niños* [Lexical stress and its role in written word recognition by adults and children]. Unpublished doctoral dissertation, Universidad de Granada, Spain.

Gutiérrez Palma, N. (2004, June). *Prosodic cues to visual word recognition by Spanish children*. Paper presented at the Eleventh Annual Meeting of the Society for the Scientific Study of Reading, Amsterdam.

Hatzigeorgiu, N., Gavrilidou, M., Piperidis, S., Carayannis, G., Papakostopoulou, A., Spiliotopoulou, A., Vacalopoulou, A., Labropoulou, P., Mantzari, E., Papageorgiou, H., & Demiros, I. (2000, 31 May-2 June). Design and implementation of the online ILSP corpus. In *Proceedings of the second international conference of language resources and evaluation (LREC)* (Vol. 3, pp. 1737–1740). Athens, Greece.

Holton, H., Mackridge, P., & Philippaki-Warburton, I. (1997). *Greek: A comprehensive grammar of the modern language*. London: Routledge.

Kappa, I. (2002). On the acquisition of syllabic structure in Greek. *Journal of Greek Linguistics*, *3*, 1–52.

Laganaro, M., Vacheresse, F., & Frauenfelder, U. H. (2002). Selective impairment of lexical stress assignment in an Italian-speaking aphasic patient. *Brain and Language*, *81*, 601–609.

Leal, F., & Suro, J. (2002, November). *A phonological analysis of reading performance in two dyslexic children*. Paper presented at the 53rd Annual Conference of the International Dyslexia Association, Atlanta, GA.

Leal, F., & Suro, J. (2003). *The phonological hypothesis of dyslexia: A constructive critique*. Unpublished manuscript, Universidad de Guadalajara, Maxico.

Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*, 1–75.

Malikouti-Drachman, A. (2002). Greek phonology: A contemporary perspective. *Journal of Greek Linguistics*, *2*, 187–243.

Malikouti-Drachman, A., & Drachman, G. (1989). Τονισμός στα ελληνικά [Stress in Greek]. *Studies in Greek Linguistics*, *9*, 127–143.

Maridaki-Kassotaki, A. (1998). Ικανότητα βραχύχρονης συγκράτησης φωνολογικών πληροφοριών και επίδοση στην ανάγνωση: Μια προσπάθεια διερεύνησης της μεταξύ τους σχέσης [Evaluation of the relationship between phonological working memory and reading ability in Greek-speaking children]. *Psychologia*, *5*, 44–52.

Nunes, T., Roazzi, A., & Buarque, L. L. (2003). Learning to mark stress in written Portuguese. *Revue de Linguistique*, *22*, 99–108.

Petrounias, E. V. (2002). *Νεοελληνική γραμματική και συγκριτική ανάλυση, Τόμος Α* : *Φωνητική και εισαγωγή στη φωνολογία* [Modern Greek grammar and comparative analysis, Vol A: Phonetics and introduction to phonology]. Thessaloniki: Ziti.

Protopapas, A., Skaloumbakas, C. (in press). Traditional and computer-based screening and diagnosis of reading disabilities in Greek. *Journal of Learning Disabilities*.

Rastle, K., & Coltheart, M. (2000). Lexical and nonlexical print-to-sound translation of disyllabic words and nonwords. *Journal of Memory and Language*, *42*, 342–364.

Schiller, N. O., Fikkert, P., & Levelt, C. C. (2004). Stress priming in picture naming: An SOA study. *Brain and Language*, *90*, 231–240.

Stathis, C. & Carayannis, G. (1999, October). Εμπλουτισμός μορφολογικών λεξικών με όρους και υποστήριξη κειμένων εντάσεως όρων σε διαδικασίες διόρθωσης λαθών [Enriching morphological dictionaries with terms and supporting term-intensive texts in error correction procedures]. In *Praktika 2ou sinedriou ''elliniki glossa kai orologia''* (pp. 157–165). Athens, Greece.

Address for correspondence: A. Protopapas, Institute for Language & Speech Processing, Artemidos 6 & Epidavrou, Maroussi, 15125, Greece
E-mail: protopap@ilsp.gr