Word length and the location of primary word stress in Dutch, German, and English

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Abstract

This study addresses the question as to what extent the location of primary stress in Dutch, German, and English monomorphemic words is affected by the number of syllables in the word. We present analyses of the monomorphemic words in the CELEX lexical data base, which show that penultimate stress is less frequent in Dutch and English trisyllabic than quadrisyllabic words of a certain phonological structure. In addition, we discuss paper-and-pencil tests in which native speakers were asked to assign primary stress to trisyllabic and quadrisyllabic pseudo words. These experiments replicate the results from the Dutch and English lexical analyses, and show that also in German the number of syllables in the word affect the location of primary stress. The effect of word length appears to be driven by a preference of the three languages for stressed word-initial syllables and an alternating pattern of stressed and unstressed syllables in the word. Our results thus challenge the "primary stress first" analyses.[1]

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1. Introduction

Most analyses of primary word stress in Dutch, German, and English assume that the location of primary stress is assigned before or independent of secondary stress (explicitly stated in Van der Hulst 1992; Van der Hulst & Kooij 1992). Mainly depending on the phonological structure of the three final syllables of the word, a prosodic foot is built with the antepenultimate, the penultimate, or the final syllable as the head, and this syllable is assigned primary word stress (e.g., Neijt & Zonneveld 1982; Van der Hulst 1984; Kager 1989; Vennemann 1990; Neijt & Van Heuven 1992; Van der Hulst & Kooij 1992; Nouveau 1994; Hayes 1995; Féry 1998). The footing of the preceding syllables are assumed to play no role.

Gussenhoven (to appear) recently called these "primary stress first" analyses into question for Dutch. He claimed that the phonological structure of all syllables in the word are relevant to the location of primary stress. The footing of the syllables preceding primary stress would affect the location of the right-most foot in the word, and thus the location of primary stress.

In this paper, we further address the question as to whether the preceding syllables affect the location of primary stress, by investigating the effect of the number of syllables in the word. If the location of primary stress is determined only on the basis of the three final syllables, we may expect that the number of syllables in the word is irrelevant. Trisyllabic and quadrisyllabic words ending in the same three syllables would have primary stress on the same syllable (counting from the right edge). If, in contrast, the footing of all syllables in the word would affect the location of primary stress, we may expect a difference between trisyllabic and quadrisyllabic words, because of the preferred distribution of stresses over the word. Word stresses in Dutch, German, and English, as in many other languages, tend to be distributed such that the stressed and unstressed syllables alternate, and the word does not contain stress clashes or lapses of unstressed syllables (e.g., Kager 1989; Van der Hulst & Kooij 1992; Wiese 1996, Prince 1983; Selkirk 1984; Hayes 1984; Hung 1994). In addition, word-initial syllables tend to be stressed in Dutch, German, and English, a tendency that speakers transfer to pseudowords (Baker & Smith 1976), and that listeners use in speech segmentation (Cutler & Norris 1984) and in phonetic judgments (SlootWeg & Rietveld 1989). The preference for stressed initial syllables in combination with the

preference for alternating patterns of stressed and unstressed syllables favor penultimate primary stress in quadrisyllabic words ($_{|}\sigma\sigma^{|}\sigma\sigma$, with $^{|}$ indicating primary and $_{|}$ indicating secondary word stress) but not in trisyllabic words, in which initial secondary stress and penultimate primary stress would result in a stress clash ($_{|}\sigma^{|}\sigma\sigma$).

A first indication that the location of primary stress may be affected by the number of syllables in the word comes from Nouveau (1994: 105). She asked twenty speakers of Dutch to read aloud a number of pseudowords, including trisyllabic merotak and dapiton, and quadrisyllabic monitaron. The three words merotak, dapiton, monitaron end in syllables of the same phonological structure (open - open - closed), but monitaron differs from the two others in the number of syllables. Nouveau found that whereas the trisyllabic words received penultimate stress in only 10% and 5% of the realizations, respectively, the quadrisyllabic word was assigned penultimate stress in 40% of cases ($\chi^2_1 = 3.333, p = 0.068; \chi^2_1 = 5.161, p = 0.023$, respectively), which suggests that word length affects primary stress assignment.

In the present paper, we investigate the role of word length in the location of primary stress first in existing words of Dutch, German, and English (section 2). We then report paper-and-pencil experiments in which we investigated the effect of word length in pseudo words of Dutch, German, and English (section 3).

2. Lexical statistics

2.1 General method

The CELEX lexical database (Baayen, Piepenbrock & Gulikers 1995) contains phonological and morphological descriptions of thousands of Dutch, German, and English words. We collected all monomorphemic trisyllabic and quadrisyllabic words in CELEX, and we investigated whether the location of primary stress is affected by the number of syllables in the word. In addition to word length, we considered as independent variables the factors that have been identified as relevant to the location of primary stress in the literature, that is, the phonological structure of the three final syllables for all three languages, as well as word class for English.

2.2 Dutch

In Dutch, primary stress tends to fall on the penultimate syllable (e.g. 1ab), except in three types of words (see e.g., Neijt & Zonneveld 1982; Van der Hulst 1984; Kager 1989; Nouveau 1994; Gussenhoven to appear). Primary stress necessarily falls on the final syllable of monosyllabic words, and it falls on the final syllable of words ending in a tense vowel or a diphthong and at least one coda consonant, or in a lax vowel and at least two coda consonants (i.e., words ending in superheavy syllables, e.g., 1cd). Furthermore, primary stress tends to fall on the antepenultimate syllable of words with an open penultimate syllable and a final syllable ending in a lax vowel and one consonant (e.g., 1ef). In Dutch, as in many other languages, syllables with schwa never bear stress. These generalizations indicate that for Dutch, the distinction between syllables with schwa, open syllables, closed syllables (ending in a lax vowel and one consonant), and superheavy syllables (ending in a tense vowel or diphthong and at least one consonant, or a lax vowel and at least two consonants) is relevant.

(1) Examples of Dutch stress patterns. Syllable boundaries are indicated by ".".

a. a.ˈman.del	'almond'	d. ar.gu.ˈment	'argument'
b. an.ˈdij.vie	'endive'	e. ˈma.ra.thon	'marathon'
c. ma.ga.ˈzijn	'warehouse'	f. ˈcar.na.val	'carnival'

We collected all monomorphemic words consisting of three or four syllables from the Dutch part of the CELEX lexical database. The resulting list contained 837 words, most of them non-native. We classified the location of primary stress in these words (antepenult, penult, or final), as given in CELEX, and we classified the final three syllables as containing a schwa, as open, as closed, or as superheavy. Tense vowels and diphthongs do not appear in closed syllables, since closed syllables with tense vowels or diphthongs and a coda consonant are superheavy. Lax vowels do not appear in open syllables, since syllables, all lax vowels are followed by at least one consonant in word-final syllables, and they are presumably followed by at least an ambisyllabic consonant in word-medial syllables (see the literature starting

with Van der Hulst 1985). Furthermore, we classified the words as consisting of three or four syllables (Word length).

We analyzed the data set with a Classification and Regression Tree Analysis (CART, Breiman, Friedman, Olshen, and Stone 1984). This technique divided the data set into groups, with words of the same type, that is, which are identical in their length and in the phonological structure of their three final syllables, being grouped together. The types of words in a group are similar in their preference for the location of primary stress, and the characterization of the groups therefore provides information on which factors affect the location of primary stress. CART is a non-parametric statistic procedure that is not very sensitive. This implies that it can be applied to data of all distributions, but that factors may not emerge as predictors even though they are relevant.

Table 1 lists the seven groups created by CART, as well as the percentages of words with antepenultimate, penultimate, and final primary stress in these groups. The type of the antepenultimate syllable is not part of the characterization of any group, which confirms the observation in the literature that only the final and the penultimate syllable affect the location of primary stress in Dutch (see above). The CART analysis also supports the observation that the unmarked location of primary stress is on the penultimate syllable (Groups 1, 3, 4, 6). If this syllable contains schwa, and consequently cannot bear stress, primary stress falls equally often on the antepenultimate and on the final syllable (Group 2). Also, as described in the literature, primary stress tends to fall on the final syllable, if this syllable is superheavy (Group 7).

INSERT TABLE 1 ABOUT HERE

The CART analysis does not support the observation that for primary stress to fall on the antepenultimate syllable, the final syllable has to be closed and the penultimate syllable to be open. If the final syllable is closed, the length of the word appears to be a more important predictor of the location of primary stress than the phonological structure of the penultimate syllable (compare Groups 5 and 6). The percentage of words ending in closed syllables with penultimate stress is larger among the quadrisyllabic (53.0%) than the

trisyllabic (7.6%) words. A chi-squared test confirms that we are not observing a random pattern ($\chi^2 = 8.577, p = 0.003$).

Importantly, we observe exactly the same patterns of results, if we restrict our data set to words that have at least two non-reduced vowels in their final three syllables (these results are not included in the table). Only in these words, the location of primary stress is not completely fixed by the phonological structure of the final three syllables. We conclude that word length affects the location of primary stress in Dutch, at least in words of a certain phonological structure.

The higher percentage of words with penultimate stress among the quadrisyllabic words shows that penultimate stress is favored in words in which word-initial secondary stress does not clash with penultimate primary stress. This suggests an important role for secondary stress in the location of primary stress in Dutch.

2.3 German

The Dutch and German stress systems are similar in that also in German primary stress tends to fall on superheavy final syllables (2ab), and on the penultimate syllable of words without superheavy final syllables (2cd). According to Wiese (1996), antepenultimate stress primarily occurs in words with an open penultimate syllable, while Féry (1998) states that antepenultimate stress can be found among all words ending in non-superheavy syllables (see 2ef). Féry (1998) also explicitly states that there is no difference with respect to the location of primary stress between trisyllabic and quadrisyllabic words, except for words that sound as compounds or are grammatical terms.

(2) Examples of German stress patterns. Syllable boundaries are indicated by ".".

a. A.pa.ˈrat	'apparatus'	d. A.ˈre.na	'arena'
b. Ma.nus.ˈkript	'manuscript'	e. ˈPa.pri.ka	'pepper'
c. In.ˈspek.tor	'inspector'	f. ˈKa.bel.jau	'cod'

We collected all German words that consist of three or four syllables and are coded as "monomorphemic" in the CELEX lexical data base. We purged this list manually of the large number of words that are obviously morphologically complex (e.g., Abwesenheit, Entstalinisierung, Reinmachefrau). We also removed the words with unclear synchronic morphological status from the data set of which the Dutch equivalents do not occur in the Dutch data set, such that the final German data set is well comparable to the Dutch data set. The resulting German data set is much smaller (359 words) than the Dutch data set (837 words), which is not surprising since the German part of CELEX contains fewer lemmas (51,728 lemmas) than the Dutch part (124,136 lemmas). For all words in the data set, we classified the location of primary stress (antepenult, penult, or final), as given in CELEX, and the number of syllables. Given the generalizations on German stress in the phonological literature, we classified the three final syllables as containing schwa, as open, as closed, or as superheavy, as we did for Dutch.

INSERT TABLE 2 ABOUT HERE

We analyzed this data set with a Classification and Regression Tree Analysis. Table 2 lists the resulting 6 groups, as well as the percentages of words with antepenultimate, penultimate, and final stress in these groups. The CART classification shows that penultimate stress is the most frequent stress pattern in German words ending in a syllable with schwa (Groups 1–3), while final stress is most common among words ending in superheavy syllables (Groups 5, 6). In the words ending in open or closed syllables (Group 4), stress is almost equally distributed among the three final syllables, with a slight disadvantage for final stress.

What is important for our research question is that none of the groups of words are characterized by the number of syllables in the word. If we restrict the data set to words which contain at least two final syllables (out of three) with non-reduced vowels, we obtain approximately the same grouping of words. We conclude that CART presents no evidence for an effect of word length on the location of primary stress in German. Given the small number of words in the data set and the low sensitivity of CART, this result is not very surprising.

2.4 English

As in Dutch and German, syllables containing schwa and syllables without vowel (e.g, the final syllable of apostle) do not bear stress in English. In English, primary stress falls on word-final syllables with long vowels. For words ending in syllables without long vowels, word class is an important predictor (e.g., Kager 1989, Jensen 1993). In nouns and some adjectives, primary stress falls on the antepenult syllable, if the penultimate syllable ends in a short vowel (3ab). If not, it falls on the penultimate syllable (3cd). In verbs and other adjectives, primary stress falls on the final syllable, if this syllable contains at least two coda consonants. Otherwise the penultimate syllable is stressed (e.g., 3ef). Kager (1989) noted that some words, especially some nouns, behave special in that they have primary stress on the penultimate syllable if their final syllable ends in a short vowel, and on the final syllable otherwise. Remark that penultimate syllables with a short vowel and a simple coda (VC) pattern with syllables with two coda consonants (heavy syllables) in nouns, while final syllables of the same phonological structure (VC) pattern with syllables ending in a short vowel (light syllables) in verbs.

(3) Examples of English stress patterns. Syllable boundaries (".") appear in front of ambisyllabic consonants.

a. ˈla.by.rinth	d. A.ri.ˈzo.na
b. A.ˈme.ri.ca	e. a.ˈsto.nish
c. a.ˈgen.da	f. i.ˈlli.cit

We collected all 750 monomorphemic words consisting of at least three syllables from the English part of the CELEX lexical database. The vast majority are nouns. We marked the location of primary stress in these words (antepenult, penult, or final) as given in CELEX, and classified syllables as superlight if their nucleus contained a schwa or a syllabic consonant, and as light if their rimes consisted only of a short vowel, and as heavy if their rimes contained a long vowel or two or more consonants. Syllables ending in a short vowel and a simple coda formed a category by themselves (VC), since the literature showed that they group with either

the heavy or the light syllables depending on word class and the position of the syllable in the word. Furthermore, we classified the words as Nouns, Verbs, or Adjectives/Adverbs, and as consisting of three or four syllables.

We analyzed also this data set with a Classification and Regression Tree Analysis. Table 3 lists the seven groups representing the CART tree, as well as the number of words in these groups, and the percentages of words with antepenultimate, penultimate, and final stress. Groups (1–2) show that primary stress tends to fall on non-light penultimate syllables, while Groups (3–6) show that words with light or superlight penultimate syllables typically have antepenultimate stress. If the antepenult is superlight and the penult is light or superlight, primary stress tends to fall on the penultimate syllable (Group 7).

INSERT TABLE 3 ABOUT HERE

Word class and the number of syllables in the word do not play part in the characterizations of the seven word groups. These factors may emerge as predictors, however, if we focus on the words that have full vowels in at least two of their three final syllables. Only in these words more than one stress pattern is possible. The results of a CART analysis of just these 328 words are given in Table 4. Word class, word length, the type of the penultimate syllable, and the type of the final syllable emerge as predictors. The location of primary stress is affected by word class for words with a light penultimate syllable and a final syllable that is light or ends in a short vowel and a consonant (Groups 1 and 2). Stress tends to fall on the penultimate syllable in adverbs/adjectives and verbs (Group 1), and on the antepenult syllable in nouns (Group 2). This difference between verbs and nouns corresponds to the difference between nouns and verbs with light penultimate syllables as formulated in the literature. According to our CART-analysis, word class does not play a role for words with another phonological structure, which is possibly due to the small number of verbs in the data set. In words of all classes, primary stress tends to fall on antepenultimate syllables that are followed by light penultimate syllables and heavy final syllables (Group 3), a generalization that according to the literature holds for nouns only. Finally, the CART analysis shows that word length has an effect on words with a heavy or VC penultimate syllable (Groups 4 and 5). All quadrisyllabic words of this type bear primary stress on the penultimate syllable,

whereas only 57.8% of the trisyllabic words have penultimate stress. This difference between tri- and quadrisyllabic words is statistically significant ($\chi^2 = 4.949, p = 0.026$), and thus forms evidence of an effect of word length on the location of primary stress in English.

INSERT TABLE 4 ABOUT HERE

We conclude that Dutch and English provide evidence of an effect of word length on the location of primary stress, and therefore against "primary stress first" theories. Primary stress falls more often on the penultimate syllable of quadrisyllabic than of trisyllabic words of a certain phonological structure. This effect of word length favors words with stressed initial syllables but without stress clashes, which suggests a role of secondary stress in the assignment of primary stress.

3. Productivity in pseudowords

3.1 Introduction

The vast majority of trisyllabic and quadrisyllabic words in the languages under investigation are non-native, and the observed effect of word length on the location of primary stress may therefore originate from the phonological adaption of these words. If so, the observed effect of word length is part of the contemporary grammars of Dutch and English. It is also possible, however, that the stress patterns of the relevant words reflect older stages of Dutch and English, that these words adhere to their stress patterns in the source languages (primarily Greek, Latin, and French), or that the stress patterns of the tri- and quadrisyllabic words happen to have different origins.

In a series of production experiments, we investigated the contemporary status of the effect of word length on the location of primary stress. Speakers of Dutch, German, and English were presented with orthographic representations of non-existing, but possible, words and were asked to indicate the most likely location for primary stress. If the effect of word length on the location of primary stress is part of the contemporary grammars of these languages, we expect a difference between the trisyllabic and quadrisyllabic pseudo words.

3.2 Dutch

Materials. The CART analysis of the Dutch data set (section 2.2) shows that word length affects the location of primary stress in existing words ending in closed syllables. We investigated whether also pseudowords ending in closed syllables show this effect of word length. We created forty quadrisyllabic words obeying the phonotactic restrictions of Dutch. Their three initial syllables consist of a simple onset and a long vowel, while their final syllable is closed (e.g. [tapodabɑx]). From these words, we created forty trisyllabic versions by removing the initial syllable ([podabɑx]). If word length affects the location of primary stress, we may expect that the quadrisyllabic versions more often receive penultimate primary stress than the trisyllabic versions.

In addition, we created forty quadrisyllabic and forty trisyllabic versions ending in open syllables from the initial two sets of words, by removing the final consonant and changing the final lax vowel into the corresponding tense vowel ([tapodaba, podaba]). Each word thus has four versions (quadrisyllabic and trisyllabic with a closed final syllable, and quadrisyllabic and trisyllabic with an open final syllable). Given the lexical statistics discussed in section 2.1, we do not expect any difference between quadrisyllabic and trisyllabic versions ending in open syllables.

All experimental items are listed in the appendix. They were spelled in the International Phonetic Alphabet, such that their representations unambiguously reflect the intended pronunciations.

We created three master lists containing one version of each experimental word. In each list, ten words appeared as quadrisyllabic and ten words as trisyllabic items ending in closed syllables, and ten words appeared as quadrisyllabic and ten words as trisyllabic items ending in open syllables. For each of these lists, we created three complementary lists, such that these three lists also contained ten tokens of every item type, and together with the corresponding master list contained all experimental items. This procedure resulted in 12 experimental lists.

Participants. Forty-eight native speakers of Dutch participated in the experiment. They

were all students of Dutch at the University of Nijmegen, and mastered the International Phonetic Alphabet. They had not yet received any education in stress theory or the stress rules of Dutch.

Procedure. Each participant received one of the twelve lists with forty experimental items. Each item was printed three times on the same line. The antepenultimate syllable was underlined in the left most token of the word, the penultimate syllable in the middle token, and the final syllable in the right most token (see 4). The underlining indicated the location of primary stress. Participants were told that the words were nouns, and they were asked to encircle for each word the token representing their favorite pronunciation.

(4) First three lines of an experimental list

pesoɣofa	pesoɣofa	pesoɣofa
ɣedafoke	ɣedafoke	ɣedafoke
tozadɑp	tozadɑp	tozadɑp

Results and Discussion. Table 5 lists the absolute numbers and percentages of responses with antepenultimate, penultimate, and final primary stress broken for the type of the item (quadrisyllabic/trisyllabic, closed/open final syllable). We analyzed the proportion of responses with penultimate stress versus non-penultimate stress for every experimental word using a log-linear analysis with as independent variables Word length (trisyllabic or quadrisyllabic) and the Type of final syllable (open or closed). This analysis revealed significant main effects for both variables (Word length: $F(1, 158) = 5.54, p = 0.019$; Type of final syllable: $F(1, 157) = 130.28, p < 0.001$). Participants assigned penultimate stress more often to quadrisyllabic words than to trisyllabic words, and more often to words ending in open syllables than to words ending in closed syllables. In addition, we found an interaction of Word length by Type of final syllable ($F(1, 156) = 5.86, p = 0.016$). Word length affected only the words ending in closed syllables (Word length for words ending in closed syllables: $F(1, 78) = 13.234, p < 0.001$; Word length for words ending in open syllables: $F(1, 78) = 0.03, p > 0.1$).

INSERT TABLE 5 ABOUT HERE

In summary, the participants' responses show an effect of word length on the location of primary stress in pseudo words ending in closed syllables. This result is in line with the lexical statistics in section 2.2, which also showed that quadrisyllabic words ending in closed syllables are more likely to have penultimate stress than their trisyllabic counterparts. The effect of word length on the location of primary stress is apparently a synchronic characteristic of Dutch, which applies both to existing and to new words.

3.3 German

We now turn to German. The analysis of the German monomorphemic words in section 2.3 did not reveal an effect of the number of syllables in the word on the location of primary stress. This may be due to the low number of words in the data set, and we carried out a production experiment also with native speakers of German. This experiment was identical to the Dutch experiment, except that the pseudo words conformed to the phonotactics of German, and that we spelled the words in the conventional spelling of German, rather than in the International Phonetic alphabet.

Materials. We created forty quadrisyllabic words obeying the phonotactic restrictions of German. Their three initial syllables are open, while their final syllable is closed (e.g. Zautaputasch). From these forty words, we created forty quadrisyllabic items ending in open syllables (Zautaputa), forty trisyllabic items ending in closed syllables (Taputasch), and forty trisyllabic items ending in open syllables (Taputa), along the lines described for the Dutch experiment. We created twelve experimental lists with these items, also following the procedure described for the Dutch experiment. The items were spelled in the conventional spelling of German, because we did not know whether all our participants would sufficiently master the International Phonetic Alphabet. The items are listed in the Appendix.

Participants. Forty-eight native speakers of German, recruited at the Universities of Cologne,

Duisburg, and Kiel, participated in the experiment.

Procedure. The procedure was identical to that of the Dutch experiment.

Results and Discussion. Table 6 lists the absolute numbers and percentages of responses with antepenultimate, penultimate, and final stress broken for item type. We analyzed the proportion of responses with penultimate stress versus non-penultimate stress for every experimental word using a log-linear analysis with as independent variables Word length (trisyllabic or quadrisyllabic) and the Type of final syllable (open or closed). Both independent variables emerged as significant (Word length: $F(1, 156) = 18.066, p < 0.001$; Type of final syllable: $F(1, 155) = 6.387, p = 0.012$), without interaction ($F(1, 154 = 0.017, p > 0.1$). The frequency of penultimate stress was higher among words ending in open syllables and among quadrisyllabic words.

We conclude that word length affects the location of primary stress in these German pseudo words. As in Dutch and English, penultimate stress is more frequent in quadrisyllabic than in trisyllabic words. An effect of word length is part of the grammar of contemporary German.

3.4 English

Materials. The analysis of the English trisyllabic and quadrisyllabic existing words described in section 2.3 showed that word length affects the location of primary stress in words with heavy penultimate syllables. This analysis was mainly based on nouns, and given the positive results from the paper-and-pencil experiments in Dutch and German, we therefore also expect an effect of word length in English, at least in pseudo nouns. In order to see whether the effect of word length may be restricted to nouns, we intended our pseudo words in the paper-and-pencil experiment as verbs.

We constructed thirty-five pseudo verbs, obeying the phonotactic constraints of English. The verbs started with three open syllables and ended in a heavy syllable, that is, the final syllable contained a long vowel (e.g., potabovoo), or ended in a short vowel and two

consonants. From these quadrisyllabic verbs, we created trisyllabic items by cutting off the initial syllables (tabovoo). In addition, we created quadrisyllabic versions ending in syllables with a short vowel and one coda consonant (potabovock), and their trisyllabic counterparts (tabovock). All experimental items are listed in the appendix. We presented them to participants in the conventional orthography of English, since our participants did not master the International Phonetic Alphabet. As a consequence, we could not completely control the weight of the penultimate syllable as perceived by the participant.

We created three master lists, each containing one version of every experimental word, and eight or nine tokens of every item type. From each of these lists, we created three complementary lists, such that the complementary lists also contained eight or nine tokens of every item type, and together with the master list they contained all experimental items. This procedure resulted in 12 experimental lists.

Participants. Forty-four native speakers of English, recruited at the University of Birmingham, participated in the experiment. They had not received any education in stress theory or the stress rules of English.

Procedure. The procedure was identical to the procedure of the experiments in Dutch and German, except that the participants were told that the pseudo words were verbs.

Results and Discussion. Table 7 lists the absolute numbers and percentages of responses with antepenultimate, penultimate, and final stress broken for item type (quadrisyllabic or trisyllabic items with heavy or VC final syllables). We analyzed the proportion of responses with penultimate stress versus non-penultimate stress for every experimental word, again using a log-linear analysis with Word length (trisyllabic or quadrisyllabic) and the Type of final syllable (heavy or VC) as independent variables. We observed a significant main effect for Word length ($F(1, 137) = 15.572, p < 0.001$) and a marginal effect for Type of final syllable ($F(1, 136) = 3.193, p = 0.074$). Quadrisyllabic verbs elicit penultimate stress more often than trisyllabic verbs, and verbs ending in VC syllables seem to elicit penultimate stress more often than verbs ending in heavy syllables. We found no interaction of Word length by Type

of final syllable ($F(1, 135) = 0.733, p > 0.1$), which indicates that Word length affects words ending in heavy syllables and words ending in VC syllables similarly. We conclude that the effect of word length on the location of primary stress is a characteristic of contemporary English, and applies to both nouns and verbs.

INSERT TABLE 7 ABOUT HERE

4 General discussion

This study addresses the question as to whether the location of primary stress in Dutch, German, and English monomorphemic words is affected by the number of syllables in the word. Such an effect may result from the preferences of these languages for word-initial syllables with primary or secondary stress and for an alternating pattern of stressed and unstressed syllables. We carried out statistical analyses of the monomorphemic words included in the CELEX lexical data base, taking into account the phonological structure of the three final syllables, as well as word class for English. In the German data set, we found no effect of word length, possibly because of scarcity of the data. Both the Dutch and the English data set showed that penultimate stress is less frequent among trisyllabic than quadrisyllabic words of a certain phonological structure. Penultimate primary stress in combination with word-initial secondary stress leads to a stress clash in trisyllabic words. In quadrisyllabic words, in contrast, it leads to a perfect alternation of stressed and unstressed syllables. The effect of word length on the location of primary stress in Dutch and English may therefore indeed be driven by the preferred distribution of stresses over the word.

In a series of paper-and-pencil tests, we investigated whether the observed effect of word length on the location of primary stress in existing words reflects a property of the contemporary grammars of the languages. We presented pseudo words to native speakers of the three languages, asking them to indicate for every word to which syllable they would assign primary stress. The Dutch pseudo words were nouns. Half of the items were of the phonological structure for which we had attested an effect of word length in the lexical analysis, and precisely these pseudo words mirrored the effect of word length in the Dutch existing words.

The pseudo words in the German experiment were of the same phonological structure as the Dutch pseudo words, and they all showed an effect of word length. Again quadrisyllabic words received more often penultimate stress than trisyllabic words. Finally, the English pseudo words were all of the phonological structure for which we had attested an effect of word length in the lexical analysis. However, whereas the majority of the words in the lexical analysis were nouns, the words in the experiment were intended as verbs. Also these English verbs mirrored the word length effect. We conclude that the location of primary stress is affected by word length also in pseudo words, and in the same way as in existing words. An effect of word length on the location of primary stress is part of the contemporary grammars of Dutch, German, and English.

This effect of word length on the location of primary stress calls into question the "primary stress first" approach (e.g., Van der Hulst 1984; Van der Hulst & Kooij 1992). The effect suggests that the location of primary stress is not independent of the location of secondary stresses, and therefore that primary stress assignment and secondary stress assignment cannot be regarded as separate algorithms. Our results support the claim by Gussenhoven (in press) that regular primary stress cannot be satisfactorily described if the section of the word before the primary stress is ignored.

The lexical analyses and also the Dutch paper-and pencil-experiments indicate that the effect of word length on the location of primary stress is restricted to words of a certain phonological structure. In words of a different structure, the location of primary stress is probably fixed by highly ranked preferences for, for instance, stress on heavy or superheavy syllables. The effect of word length appears to be subordinate to these preferences.

The location of primary stress may well be accounted for in the framework of Optimality Theory, as shown by Gussenhoven (in press). The various preferences of Dutch, including the preference for word-initial stress and the preference for alternating patterns of stressed and unstressed syllables, may be translated into phonological constraints that are ranked in a hierarchy, and this hierarchy may account for the effect of word length as well as for the absence of the effect in words of a certain phonological structure. In addition, the location of primary stress may be accounted for in data-oriented approaches, in which the location of primary and secondary stresses on a given (new) word is based on the stress patterns in

phonologically or morphologically similar words (e.g., Baker & Smith 1976; Daelemans, Gilles & Durieux 1994). Several observations suggest that analogical mechanisms may outperform the analyses formulated in the framework of Optimality Theory. Thus Van der Hulst (1984), Kager (1989), Daelemans et al (1994), and Féry (1998), among others, have remarked that Dutch and German words ending in the same type of segments tend to share their stress patterns. More importantly, Baker and Smith (1976) and Wiese (1996) have shown that primary stress in English and German, respectively, is partly patterned on words that are considered similar by speakers on some grounds, which may result in stress patterns that are in conflict with the formulated deterministic rules or constraint hierarchies. Our results do not directly contribute to the debate on the advantages and disadvantages of accounts formulated within the framework of Optimality Theory and analogical accounts. We have shown that whatever theoretical framework is preferred, it should allow for an effect of the number of syllables in the word on the location of primary stress.

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Appendix

Experimental items for the Dutch paper-and-pencil experiment

	4 syll. closed	4 syll. open	3 syll. closed	3 syll. open
1	tapodabɑx	tapodaba	podabɑx	podaba
2	debokatɔs	debokato	bokatɔs	bokato
3	ketozadɑp	ketozada	tozadɑp	tozada
4	ɣedafokɛt	ɣedafoke	dafokɛt	dafoke
5	fakodaɣɔp	fakodaɣo	kodaɣɔp	kodaɣo
6	baɣotofɑx	baɣotofa	ɣotofɑx	ɣotofa
7	bafopasɛk	bafopase	fopasɛk	fopase
8	petaboxɔf	petaboxo	taboxɔf	taboxo
9	bepotavɛx	bepotave	potavɛx	potave
10	pefatodɛt	pefatode	fatodɛt	fatode
11	kaxofasɛp	kaxofase	xofasɛp	xofase
12	defapokɛt	defapoke	fapokɛt	fapoke
13	kefatedɔx	kefatedo	fatedɔx	fatedo
14	ɣetapotɑs	ɣetapota	tapotɑs	tapota
15	fapobebɔx	fapobebo	pobebɔx	pobebo
16	fobetozɑs	fobetoza	botezɑs	boteza
17	satadavɛʁ	satadave	tadavɛk	tadave
18	pedakotɑf	pedakota	dakotɑf	dakota
19	bekosafɑk	bekosafa	kosafɑk	kosafa
20	pesoɣofɑp	pesoɣofa	soɣofɑp	soɣofa

21	betokaɣɔs	betokaɣo	tokaɣɔs	tokaɣo
22	vekoɣapɛf	vekoɣape	koɣapɛf	koɣape
23	vekatobɔx	vekatobo	katobɔx	katobo
24	katokasɑf	katokasa	tokasɑf	tokasa
25	patosapɔs	patosapo	tosapɔs	tosapo
26	taɣopekɛt	taɣopeke	ɣopekɛt	ɣopeke
27	zapotepɛk	zapotepe	potepɛk	potepe
28	pazokevɔk	pazokevo	zokevɔk	zokevo
29	bavotepɛs	bavotepe	votepɛs	votepe
30	badozevɑx	badozeva	dozevɑx	dozeva
31	potaɣovɔk	potaɣovo	taɣovɔk	taɣovo
32	kotebetɑf	kotebeta	tebetɑf	tebeta
33	kaɣopotɔt	kaɣopoto	ɣopotɔt	ɣopoto
34	ɣebatokɔs	ɣebatoko	batokɔs	batoko
35	pevabekɔf	pevabeko	vabekɔf	vabeko
36	tevabetɛp	tevabete	vabetɛp	vabete
37	tepovadɛs	tepovade	povadɛs	povade
38	depobatɑx	depobata	pobatɑx	pobata
39	bekedopɔk	bekedopo	kedopɔk	kedopo
40	ɣafobadɛs	ɣofabode	fabodɛs	fabode

Experimental items for the German paper-and-pencil experiment

	4 syll. closed	4 syll. open	3 syll. closed	3 syll. open
1	Tapeedabapp	Tapeedaba	Tapeedabapp	Tapeedaba
2	Deibeekaekato	Deibeekaetoss	Beekaekato	Beekaetoss
3	Kautosadapp	Kautosada	Kautosadapp	Kautosada
4	Scädafokiff	Scädafokie	Scädafokiff	Scädafokie
5	Fakeedatopp	Fakeedato	Fakeedatopp	Fakeedato
6	Bapfatupasch	Bapfatupa	Bapfatupasch	Bapfatupa

7	Bafopaweck	Bafopawee	Bafopaweck	Bafopawee
8	Pietabäschoff	Pietabäscho	Pietabäschoff	Pietabäscho
9	Giepeetageck	Giepeetagee	Giepeetageck	Giepeetagee
10	Päfatodesch	Päfatodee	Päfatodesch	Päfatodee
11	Kaschofeesipp	Kaschofeesie	Kaschofeesipp	Kaschofeesie
12	Dupfapakett	Dupfapakee	Dupfapakett	Dupfapakee
13	Keifateedosch	Keifateedo	Keifateedosch	Keifateedo
14	Zautaputasch	Zautaputa	Zautaputasch	Zautaputa
15	Pfapodeebüsch	Pfapodeebü	Pfapodeebüsch	Pfapodeebü
16	Fäbeetosass	Fäbeetosa	Fäbeetosass	Fäbeetosa
17	Satodawett	Satodawee	Satodawett	Satodawee
18	Feideekutasch	Feideekuta	Feideekutasch	Feideekuta
19	Gaufusafack	Gaufusafa	Gaufusafack	Gaufusafa
20	Peisogeefapp	Peisogeefa	Peisogeefapp	Peisogeefa
21	Bauteekaschoss	Bauteekascho	Bauteekaschoss	Bauteekascho
22	Zakogapiff	Zakogapie	Zakogapiff	Zakogapie
23	Vauschateesock	Vauschateeso	Vauschateesock	Vauschateeso
24	Fabokasaff	Fabokasa	Fabokasaff	Fabokasa
25	Fateesaposs	Fateesapo	Fateesaposs	Fateesapo
26	Tageepukesch	Tageepukee	Tageepukesch	Tageepukee
27	Zaupotapitt	Zaupotapie	Zaupotapitt	Zaupotapie
28	Seepfakiewock	Seepfakiewo	Seepfakiewock	Seepfakiewo
29	Bäwotapesch	Bäwotapee	Bäwotapesch	Bäwotapee
30	Beudieguwasch	Beudieguwa	Beudieguwasch	Beudieguwa
31	Scätapawott	Scätapawo	Scätapawott	Scätapawo
32	Kautabotüff	Kautabotü	Kautabotüff	Kautabotü
33	Sceupodafütt	Sceupodafü	Sceupodafütt	Sceupodafü
34	Sceidasawoss	Sceidasawo	Sceidasawoss	Sceidasawo
35	Zeewabuwatt	Zeewabuwa	Zeewabuwatt	Zeewabuwa

36	Teifabatepp	Teifabatee	Teifabatepp	Teifabatee
37	Feipowadesch	Feipowadee	Feipowadesch	Feipowadee
38	Diepobatack	Diepobata	Diepobatack	Diepobata
39	Beepfiedawott	Beepfiedawo	Beepfiedawott	Beepfiedawo
40	Fateebadoss	Fateebado	Fateebadoss	Fateebado

Experimental items for the English paper-and-pencil experiment

	4 syll. heavy	4 syll. VC	3 syll. heavy	3 syll. VC
1	tasodapeat	tasodapish	posapeat	posapish
2	dibokatiece	dibokatass	bokatiece	bokatass
3	kotasodont	kotasodoth	tasodont	tasodoth
4	thodafokent	thodafokith	dafokent	dafokith
5	facodathay	facodathip	codathay	codathip
6	bafopasike	bafopasit	fopasike	fopasit
7	potabogatch	potabogat	tabogatch	tabogat
8	vusotavate	vusotavap	cotavate	cotavap
9	picatogaine	picatogock	catogaine	catogock
10	capofothobe	capofotholl	pofothobe	pofotholl
11	dafaponont	dafaponom	faponont	faponom
12	stobatadoy	stobatador	fabadoy	batador
13	kotasofasp	kotasofal	tasofasp	tasofal
14	fapobifown	fapobifon	pobifown	pobifon
15	sitadothike	sitadothull	tadothike	tadothull
16	fadakifow	fadakifock	dakifow	dakifock
17	pasogofimp	pasogofid	sogofimp	sogofid
18	slethokapace	slethokapoll	thokapace	thokapoll
19	clabothosape	clabothosal	bothosape	bothosal
20	vodapodench	vodapodesh	dapodench	dapodesh
21	grathogasay	grathogasish	thogasay	thogasish

22	patosadite	patosadar	tosadite	tosadar
23	clapotifoy	clapotifick	potifoy	potifick
24	pathokutaft	pathokutaff	thokutaft	thokutaff
25	blathopatatch	blathopatash	thopatatch	thopatash
26	tradovidotch	tradovidiff	dovidotch	dovidiff
27	potabovoo	potabovock	tabovoo	tabovock
28	chotasidorn	chotasitom	tasidorn	tasitom
29	pladopitidge	pladipatil	dopitidge	dipatil
30	prabosokipe	prabosokip	bosokipe	bosokip
31	dovabatorp	dovabatoth	vabatorp	vabatoth
32	thrapovadote	thrapovadosh	povadote	povadosh
33	dufobatope	dufobatock	fobatope	fobatock
34	buvodopox	buvodopod	codopox	codopod
35	fobasodoat	fobasodit	basodoat	basodit

Table 1: The CART groups (G.) of Dutch existing words, the number of words (NW) in each group, and the percentage (P.) of words with primary stress on the antepenultimate (Apenult), the penultimate, and the final syllable. The groups are characterized by the number of syllables (NSyll) in the words and the types of the penultimate and final syllables. An "-" indicates that the number of syllables or the type of the penultimate syllable is irrelevant.

Group		Characterization			Location primary stress		
G.	NW	NSyll	Penult	Final	P. Apenult	P. Penult	P. Final
1	273	-	-	Schwa	2.6%	97.1%	0.4%
2	16	-	Schwa	Open	50.0%	0.0%	50.0%
3	203	-	Open	Open	39.9%	47.3%	12.8%
4	61	-	Closed	Open	3.3%	86.9%	9.8%
5	118	Three	-	Closed	54.2%	7.6%	38.1%
6	17	Four	-	Closed	17.6%	53.0%	29.5%
7	149	-	-	Superheavy	10.1%	0.7%	89.2%

Table 2: The CART groups (G.) of German existing words, the number of words (NW) in each group, and the percentage (P.) of words with primary stress on the antepenultimate (Apenult), the penultimate, and the final syllable. The groups are characterized by the types of the antepenultimate, the penultimate, and the final syllables. An "-" indicates that the type of syllable is free.

Group		Characterization			Location primary stress		
G.	NW	Apenult	Penult	Final	P. Apenult	P. Penult	P. Final
1	75	Schwa, Closed	Schwa, Open	Schwa	8.0%	92.0%	0.0%
2	61	Open	Schwa, Open	Schwa	29.5%	70.5%	0.0%
3	64	-	Closed	Schwa	1.6%	98.4%	0.0%
4	87	-	-	Open, Closed	36.8%	36.8%	26.4%
5	22	-	Schwa, Closed	Superheavy	0.0%	0.0%	100.0%
6	50	-	Open	Superheavy	20.0%	4.0%	76.0%

Table 3: The CART groups (G.) of English existing words, the number of words (NW) in these groups, and the percentage (P.) of words with primary stress on the antepenultimate (Apenult), the penultimate, and the final syllable. The groups are characterized by the types of the antepenultimate, the penultimate, and the final syllables. "S.light" stands for superlight (a syllable with schwa or a consonantal nucleus) and an "-" indicates that the type of the final syllable is irrelevant.

Group		Characterization			Location primary stress		
G.	NW	Antepenult	Penult	Final	P. Apenult	P. Penult	P. Final
1.	143	not S.light	VC, heavy	-	23.8%	73.4%	2.8%
2.	78	S.light	VC, heavy	-	0.0%	100.0%	0.0%
3.	50	not S.light	light	VC, light	62.0%	28.0%	10.0%
4.	204	not S.light	light	S.light, heavy	85.8%	13.7%	0.5%
5.	161	not S.light	S.light	VC, heavy	79.5%	0.0%	20.5%
6.	81	not S.light	S.light	light S.light	100.0%	0.0%	0.0%
7.	33	S.light	light, S.light	-	3.0%	90.9%	6.1%

Table 4: The CART groups (G.) of English existing words with full vowels in at least two of the three final syllables, the number of words (NW) in these groups, and the percentage (P.) of words with primary stress on the antepenultimate (Apenult), the penultimate, and the final syllable. The groups are characterized by word class (Verb, Noun, Adverb/Adjective), by the number of syllables (NSyll), and by the type of the penultimate, and the final syllable. "S.light" stands for superlight, and an "-" indicates that the variable is free.

Group				Characterization		Location primary stress		
G.	NW	NSyll	Word Class	Penult	Final	P. Apenult	P. Penult	P. Final
1.	8	-	A, V	light	VC, light	12.5%	87.5%	0.0%
2.	42	-	N	light	VC, light	71.4%	16.7%	11.9%
3.	204	-	-	light	heavy	93.2%	5.6%	1.1%
4.	10	four	-	VC, heavy	-	0.0%	100.0%	0.0%
5.	64	three	-	VC, heavy	-	35.9%	57.8%	6.3%

Table 5: The absolute numbers and percentages of Dutch responses with antepenultimate, penultimate, and final stress for the quadrisyllabic and trisyllabic items with closed and open final syllables.

Item type		Location primary stress					
Final syllable	Word length	Antepenult		Penult		Final	
closed	4 syllables	213	43.2%	228	46.2%	52	10.5%
closed	3 syllables	265	55.3%	167	34.9%	47	9.8%
open	4 syllables	144	29.3%	326	66.3%	22	4.5%
open	3 syllables	145	28.9%	330	65.8%	27	5.4%

Table 6: The absolute numbers and percentages of German responses with antepenultimate, penultimate, and final stress for the quadrisyllabic and trisyllabic items with closed and open final syllables.

Item type		Location primary stress					
Final syllable	Word length	Antepenult		Penult		Final	
closed	4 syllables	202	14.0%	278	18.5%	112	7.5%
closed	3 syllables	223	16.2 %	200	13.8%	141	10.0 %
open	4 syllables	164	11.2 %	333	21.8%	106	7.0%
open	3 syllables	163	11.0 %	321	20.9%	124	8.1%

Table 7: The absolute numbers and percentages of English responses with antepenultimate, penultimate, and final stress for the quadrisyllabic and trisyllabic items with heavy and VC final syllables.

Item type		Location primary stress					
Final syllable	Word length	Antepenult		Penult		Final	
Heavy	4 syllables	166	43.5%	127	33.2%	89	23.3%
Heavy	3 syllables	184	48.9%	84	22.3%	108	28.7%
VC	4 syllables	156	41.4%	135	35.8%	86	22.8%
VC	3 syllables	176	45.8%	108	28.1%	100	26.0%