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Units of Analysis in Reading Dutch Bisyllabic Pseudowords

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Two experiments were carried out to explore the units of analysis used by children to read Dutch bisyllabic pseudowords. Although Dutch orthography is highly regular, several deviations from a one-to-one correspondence occur. In polysyllabic words, the grapheme *e* may represent three different vowels: /ɛ/, /e/, or /∂/. In Experiment 1, Grade 6 elementary school children were presented lists of bisyllabic pseudowords containing the grapheme *e* in the initial syllable representing a content morpheme, a prefix, or a random string. On the basis of general word frequency data, we expected the interpretation of the initial syllable as a random string to elicit the pronunciation of a stressed /e/, the interpretation of the initial syllable as a content morpheme to elicit the pronunciation of a stressed /ɛ/, and the interpretation as a prefix to elicit the pronunciation of an unstressed /∂/. We found both the pronunciation and the stress assignment for pseudowords to depend on word type, which shows morpheme boundaries and prefixes to be identified. However, the identification of prefixes could also be explained by the correspondence of the prefix boundaries in the pseudowords to syllable boundaries. To exclude this alternative explanation, a follow-up experiment with the same group of children was conducted using bisyllabic pseudowords containing prefixes that did not coincide with syllable boundaries versus similar

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pseudowords with no prefix. The results of the first experiment were replicated. That is, the children identified prefixes and shifted their assignment of word stress accordingly. The results are discussed with reference to a parallel dual-route model of word decoding.

Mental activities such as reading and writing require computation. When such computation has been carried out, it may often be advantageous to store the results for immediate retrieval from memory in the future. In research on both oral and written language processing, it has been claimed that those morphologically regular and phonologically and semantically transparent complex words with a high frequency, in particular, are stored in the mental lexicon. In oral language production, a high frequency of use and thus storage of the fully inflected form appears to protect inflected forms from mispronunciation (Stemberger & MacWinney, 1988). With respect to visual word recognition, various claims have been made: substantial storage (Seidenberg, 1987), minimal storage (Taft & Forster, 1975), and various intermediate degrees of storage (e.g., Berninger, 1994; Frauenfelder & Schreuder, 1992). With regard to visual word production, it was found that high-frequency forms of homophone pairs are more often intruders when spelling the low-frequency form than vice versa (e.g., Largy, Fayol, & Lemaire, 1996; Sandra, Frisson, & Daems, 1999).

In the process of learning to read and write, children must learn not only the relevant grapheme-to-phoneme correspondence rules but also the orthographic principles that apply within a particular language, such as the *isomorphism principle*, according to which morphemes receive a constant written form, irrespective of pronunciation. The statistical properties of orthography produce the assumption that bound morphemes can contribute to the resolution of ambiguities with regard to the pronunciation of inconsistent polysyllabic words. For children learning to read, orthographic syllabification has been found to be very difficult (Perfetti, 1998; Share, 1995; Treiman, 1992). Given that spelling rules are often not directly governed by the phonological syllable structure of the word or language in question, the learner must convert sounds into an underlying spelling representation for the further application of specific spelling adaptation rules independent of pronunciation. With respect to the processing of complex word forms, an important question is whether access to the lexicon is influenced by the fact that words may have differing internal morphological structure. In other words, To what extent do the constituents of morphologically complex words play a role in lexical access?

Different architectures have been proposed to account for the processing of complex word forms. According to the full listing model, all words are stored in memory irrespective of their morphological constituency (e.g., Butterworth, 1983; Henderson, 1985). The full listing model predicts the surface frequency of words to be a strong determinant of word recognition. An alternative model predicts that morphological decomposition plays a significant role in reading (e.g., Taft, 1979, 1991; Taft & Forster, 1975, 1976). According to such parsing model, words are recognized on the basis of their constituent parts. A parser identifies the constituents of complex words to compute the meanings of such words. According to the parsing model, prelexical parsing is obligatory—that is, without it no lexical access can occur. However, the parsing route can also seen as optional, allowing an alternative direct route involving the access of full-form representations (e.g., Burani & Caramazza, 1987; Burani & Laudanna, 1992). In the so-called cascaded version of this dual-route model (cf. Plaut, McClelland, Seidenberg, & Patterson, 1996), "known" words are processed via the direct route, whereas rare or complex words are processed via the parsing route, which is construed as a backup route. Schreuder and Baayen (1995) proposed a race model with fully parallel routes. Via the direct route, a full-form representation is accessed and mapped onto its associated lemma node, which then activates the relevant semantic representations. The parsing route runs parallel to the direct route and involves three stages: segmentation, licensing, and composition. During the segmentation process, the representations of affixes and stems are activated along with full-form representations. During the licensing process, the compatibility of the subcategorization features of the activated constituents is checked along with the assignment of word stress. During the composition process, the meaning of the complex word is computed from the meanings of its constituents. As part of the race model, an activation feedback mechanism is also proposed to account for the cumulative frequency effects observed for transparent complex words. The activation feedback mechanism predicts an advantage of the parsing route for transparent words.

The majority of the variance in measures of word identification is accounted for by word frequency. However, word naming measures have been found to be relatively insensitive to the underlying representations that contribute to the pronunciation of a word. Pseudowords can be seen as highly relevant stimuli for studying the (sub)lexical processing performed by both skilled readers (Andrews & Scarrat, 1998) and beginning readers (Laxon, Smith, & Masterson, 1995). The pronunciation assigned to pseudowords can also help us evaluate the preceding models of visual word recognition and provide insight into the underlying representations used to read a word aloud. In addition, systematic examination of pseudoword pronunciation provides insight into the ways in which children learn to store individual lexical items. The studies conducted to date have mainly addressed the reading of rhyme-based grapheme–phoneme correspondences in monosyllabic words (e.g., Brown & Deavers, 1999). With respect to the reading of polysyllabic pseudowords, the extent to which the underlying morphemes are identified can be examined with the identification of prefixes as a case in point. Surprisingly, there is very little systematic research with regard to the reading of polysyllabic pseudowords by children or adults.

In a previous study, Assink, Vooijs, and Knuijt (2000) provided evidence suggesting that sublexical access units are functionally involved in the process of word recognition in skilled readers of Dutch. In this study, the mechanisms underlying children's reading of Dutch complex pseudowords are examined. We explore to what extent a morpholexical route is operational during their reading aloud pseudowords. Given that the Dutch language is located at neither the "shallow" nor the "deep" ends of the dimension of transparency, the impact of various rules and analogy mechanisms on the reading of pseudowords can provide considerable insight (see Reitsma & Verhoeven, 1990). The conversion rules for Dutch orthography apply to phonemes and thus have morphemes as their main domain. Dutch phoneme to grapheme conversion rules apply to morphemes but are based on the phonological context. The conversion rules are fairly consistent with some exceptions that thus lead to non-isomorphemic written forms. With respect to polysyllabic words, the status of schwa (∂) as a central vowel is unclear. It is spelled in unstressed syllables by the letter *e* as in *geloof* 'belief' or *lopen* 'walk'. Another problem concerns the spelling of open versus closed syllables. Vowels which in closed syllables are spelled with reduplication (*aa, ee, oo, uu*) are represented by a single letter in open syllables—for example, *peer* 'pear' versus *peren* 'pears'. Stress assignment in Dutch polymorphemic words is fairly consistent. In Dutch words lacking an internal morphological structure, the main stress tends to be placed on the prefinal syllable. Depending on vowel length and syllable weight, however, the main stress may be placed on the final syllable at times (see Kooij, 1994). Prefixes are never stressed in Dutch.

In this study, we examine whether beginning readers also identify morphemes in bisyllabic Dutch pseudowords including the letter *e*. In Dutch polysyllabic words, this vowel can thus represent three different sounds. It was assumed that the pronunciation of the grapheme *e* can help the researcher to identify the morphemic status of a letter string: In a Dutch prefix it is pronounced as /∂/, in a stem ending with a consonant it is pronounced as /ε/, and in a morphomorphemic word with a single consonant intervening between the *e* and the vowel in the second syllable it is pronounced as */e/*. The identification of such morphological constituents in bisyllabic words including the vowel *e*—when found—would constitute clear evidence for the contribution of morphological skills to the process of reading. In our study, we therefore investigated the extent to which the distribution of pronunciations reflects the reading of particular embedded morphemes. Moreover, we wanted to explore to what extent the assignment of word stress is accompanied by the identification of an embedded morpheme. With respect to the reading of bisyllabic pseudowords, we predicted that the identification of a prefix in a pseudoword will shift the stress from the first to the second syllable. In a similar vein, we predicted the identification of a content morpheme in the first part of a pseudoword would lead to the placement of even greater stress on that part of the pseudoword. In other words, we expected an interpretation of the first syllable as a random string to elicit the pronunciation of a stressed /e/, an interpretation as a content morpheme to elicit the pronunciation of a stressed /ɛ/, and an interpretation as a prefix to elicit the pronunciation of an unstressed /∂/. It can be assumed that in the case of a stressed /ɛ/ the content morpheme will be a closed syllable—that is, including a consonant following the *e* in contrast to a prefix interpretation where the consonant following the *e* will belong to a different morpheme and syllable.

The pronunciations of two sets of experimental data by Grade 6 elementary school children were collected.

At this age, the children can be assumed to have sufficiently automatized word recognition. In Experiment 1, the children were exposed to bisyllabic pseudowords of the type CVCVC with the grapheme *e* in the first vowel position and either a content or grammatical morpheme or no morpheme at all in the first syllable. The unmarked case for sounding out the first syllable when reading words aloud is /e/ and was therefore expected to occur for those pseudowords containing no morpheme at all. For those pseudowords containing a content morpheme, the vowel sound /ɛ/ was expected.

For those pseudowords containing a grammatical morpheme, the vowel sound /∂/ was expected. These patterns were selected to shed light on the role of morphemes in word identification and the assignment of word stress. It was expected that the identification of a content morpheme would lead to increased placement of stress on the first syllable and the identification of a grammatical morpheme to a shift of stress from the first syllable. In the first experiment, moreover, the morpheme boundaries coincided with syllable boundaries.

EXPERIMENT 1

The primary goal of this experiment was to provide a body of data on the incidence of pronunciations for bisyllabic pseudowords with the letter *E* in first syllable that can be explained in terms of the Parallel Dual Route Model. Following this model, it is assumed that embedded morphemes in bisyllabic pseudowords will be identified and that a cumulative frequency effect operates for transparent word constituents. Schreuder and Baayen (1995) showed prefixes to be much more frequent in Dutch polysyllabic words than word stems. In keeping with this line of thought, we predicted that grammatical morphemes (i.e., prefixes) will be identified in pseudowords more often than content morphemes (i.e., word stems).

Method

Participants. The participants in this study were 33 children from two sixth-grade classrooms in an elementary school located in the east of the Netherlands: 14 boys and 19 girls with a mean age of 11.6 years. None of the children were reported to have any serious learning problems at school. The experiment took place at the beginning of the school year.

Stimuli and design. In the experiment a 3 (pseudoword type) × 2 (vowel in the second syllable) design was followed, resulting in six lists of pseudowords. For each list, 20 bisyllabic CVCVC pseudowords with the letter *e* in the first syllable and either the letter *e* or another vowel in the second syllable were constructed (see Appendix). With respect to the letter *e* in the first syllable, three different pronunciations: /e/, /∂/, or /ɛ/ can be elicited. The most probable is the /e/ because this pronunciation is the unmarked case for open syllables, as in the pronunciation of *vemer* as /vem∂r/. When the first syllable contains the pattern *be* (11 out of 20 items) or *ge* (9 out of 20 items), the pattern can be identified as a prefix and subsequently pronounced as /b∂/ or /g∂/ as in *bemer*—sounded out as /b∂m∂r/ or /b∂mɛr/. However, it should be mentioned that the word-initial patterns *be*- and *ge*- are not necessarily readable as prefixes as they occur as pseudo-prefixes even more often in Dutch than as prefixes. Finally, when the first CVC syllable boundary coincides with a content morpheme, it will be pronounced as /ɛ/ as in *remer* (*rem* means 'brake'), which is sounded out as /rɛm∂r/. With respect to the letter *e* in the second syllable, the pronunciation of /∂/ is the unmarked case. When the first syllable is identified as a prefix, the *e* in the second syllable may be pronounced as /ɛ/. For the purposes of this study, we are mainly interested in the pronunciation of the *e* in the first syllable, which can indicate the identification of a prefix, a content morpheme, or simply a random letter string. As a matter of control, the three lists of words containing the letter *e* (multiple pronunciations) in first and second syllable were supplemented by three lists of words containing the letter *e* in the first syllable and alternately the letter *a, i, o*, or *u* (respectively /ɑ/, /I/, /o/, and /∂/ as the only possible pronunciations) in the second syllable. In this way we could explore whether the letter *e* in the second syllable would induce the /e/ pronunciation more often than another vowel in the same position or would show an interaction with the word type factor.

Thus, six pseudoword lists were constructed, each list containing 20 pseudowords of the following types: *vemer*, *bemer*, *remer*, *vemur*, *bemur*, and *remur*. The pseudowords in the lists were compared with regard to their bigram frequencies, which were found to be highly similar across the lists with no exceptional bigram sequences occurring within the lists. The pseudowords were printed using an Arial font and a 12-point letter size on two separate cards: one for the pseudowords ending with *e* in the second syllable and one for the pseudowords ending with another vowel in the second syllable. The words with different vowels in the second syllable were displayed on separate cards to exclude effects due to the alternate representation of a different second vowel in the pseudowords. The order of the pseudowords on each card was randomized.

Procedure. The participants were tested individually in a separate room within the school. The experimenter explained the task and checked with some practice items to see that the child had understood the instructions. The children were told that the stimuli were nonsense words that the experimenter had made up and were asked to try to read them aloud. The children's pseudoword reading was audiorecorded. The participants were instructed to read the pseudowords into the microphone as if they were real Dutch words. Two breaks were included in the experiment: one between the practice and test lists of pseudowords, and one between the two lists of pseudowords. After each break, the participants were asked to continue whenever they were ready. The total duration of the experimental session was approximately 30 min.

After administration of the task, the recorded pronunciations were analyzed to see how the child had interpreted the word patterns. If the child corrected himself, the final response was validated. For each child, the percentage of absolute errors was computed. All three possible pronunciations of the letter *E* were considered correct. A pronunciation was considered incorrect when one or more graphemes were pronounced in any deviant manner. At this point, a criterion of 80% correct was taken as the cutoff point for inclusion of a child in the final analysis. Four of the original children pronounced more than 20% of the pseudowords incorrectly and were therefore excluded from any further analysis. Finally, which pronunciation of the letter *E* the child produced and which syllable the child stressed were identified. Analyses of variance with repeated measures were then used to analyze the data.

Results

On average, the participants pronounced 93.1% of the items correctly in that they produced pseudoword pronunciations in accordance with Dutch grapheme–phoneme correspondence rules. For these items, the assignment of word stress and the realization of /∂/, /ε/, or /e/ in the first syllable was then determined.

Figure 1 presents the proportions of /∂/, /ε/, or /e/ being realized in the first syllable for each of the six pseudoword lists. It can be seen that the unmarked /e/ is pronounced in the vast majority of cases of pseudowords not containing morphemes (*vemer*, *vemur*). In the pseudowords containing a content morpheme (*remer*, *remur*), the distribution of /e/ and /e/ is more or less equal. In the pseudowords containing a grammatical morpheme, there is a clear overrepresentation of /∂/.

Table 1 shows the distribution of stress assignment for the six types of words. A clear tendency to stress the second syllable in pseudowords containing a grammatical morpheme can be observed with the assignment of stress more evenly distributed across the two syllables in the other types of pseudowords. In addition, we

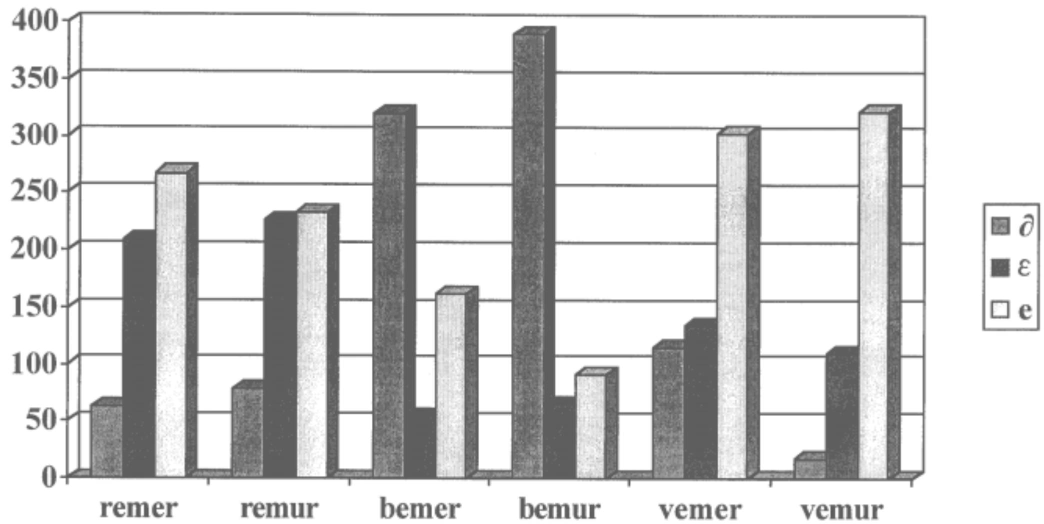

FIGURE 1 Distribution of /∂/, /ε/, or /e/ in the first syllable of bisyllabic Dutch nonwords, following a CVCVC pattern.

TABLE 1
Proportions of Stress Assignment to First and Second Syllable of Dutch Bisyllabic Nonwords

	First Syllable	*Second Syllable*
remer	.62	.38
bemer	.29	.71
vemer	.56	.44
remur	.42	.58
bemur	.18	.82
vemur	.42	.58

observe that the second syllable tends to be more stressed in pseudowords with another vowel than *e* in the second syllable as compared to pseudowords with *e* in the second syllable. For pseudowords containing a content morpheme, the pattern of stress assignment is not consistent—for pseudowords of the type *remer* stress is mainly given to the first syllable, whereas for pseudowords of the type *remur* stress is mainly assigned to the second syllable.

Table 2 shows the realization of /∂/ in the first syllable to be clearly related to word type and stress. The realization of /∂/ by far mostly occurs in pseudowords containing a grammatical morpheme with stress on the second syllable.

To test the significance of these findings, a multivariate analysis of variance was conducted. Given that the frequencies of correct pronunciations varied across the six lists of words, the number of /∂/ and /ε/ realizations were first divided by the number of /e/ pronunciations per list. The relative numbers of /∂/ and /ε/ realiza-

TABLE 2
Proportions of Realization of /ə/ in First Syllable as a Function of Word Type and Word Stress

	Stress on First Syllable	*Stress on Second Syllable*
remer/remur	.02	.24
bemer/bemur	.12	.85
vemer/vemur	.02	.39

tions were then taken as the dependent variables, and the factors word type, $F(4, 12) = 14.9$, $p < .001$, and stress, $F(2, 5) = 1482.2$, $p < .001$, were both found to exert a significant effect. The interaction between word type and stress also proved significant, $F(4, 12) = 6.5$, $p < .01$. The type of vowel occurring in the second syllable did not influence the results.

Conclusions

The results of this experiment show the pronunciation of Dutch bisyllabic pseudowords containing *e* in first syllable to depend on word type and word stress. With respect to word type, the young readers clearly identified morphemes in pseudowords. The grapheme *e* was indeed pronounced predominantly as /ɛ/ in the pseudowords containing a content morpheme, as /ə/ in pseudowords containing a grammatical morpheme, and as /e/ in pseudowords containing no morpheme in this research. The identification of grammatical morphemes was found to be much more apparent than the identification of content morphemes. This result can be explained, however, by the fact that grammatical morphemes occur much more frequently in written language than content morphemes.

With respect to stress assignment, a clear interaction with word type was detected. In pseudowords starting with /ə/, stress was predominantly assigned to the second syllable. Stated differently, stress was assigned to the first syllable particularly when the second syllable contained the vowel *e*, which is in keeping with the general rules for the assignment of stress in Dutch bisyllabic words.

EXPERIMENT 2

The main goal of this experiment was to replicate and extend the major results of the first experiment by controlling for those aspects of the word lists that created some ambiguities with regard to the interpretation of the results. In the first experiment, the grammatical morpheme boundaries in the pseudowords clearly coincided with the syllable boundaries, yielding a necessary correspondence between morphemic and syllable boundaries. In the second experiment, new pseudowords were therefore constructed without such a correspondence. Pseudowords of the type CVCCVC were constructed allowing a syllabification in two ways: CV–CCVC versus CVC–CVC. The presence of an intervocalic consonant cluster thus took away the confounding in Experiment 1. It was predicted that the primacy effect of identification of grammatical morphemes in these newly constructed pseudowords would still be evident.

Method

Participants. The participants in this study were the same group of 33 children who participated in Experiment 1. The time between the two experiments was 6 months.

Stimuli and design. Two sets of 20 bisyllabic pseudowords containing the letter *e* in both syllables were constructed for this experiment (see Appendix). This time the pseudowords followed a CVCCVC pattern, the medial CC always being a legal syllable onset. One set included pseudowords containing the grammatical morphemes *be-* or *ge-* within the first syllable and no embedded content morpheme in the second syllable. An example is *beglem*. As can be seen, the grammatical morpheme *be-* does not coincide with the syllable boundary. The pattern can be syllabified as *be–glem* or as *beg–lem*. The other set included pseudowords with no embedded prefix or content morpheme whatsoever. An example is *keglem*. The bigram frequencies were compared for the two sets of pseudowords and found to be highly similar with no exceptional bigram sequences occurring within the sets. The various pseudowords were randomly printed on a card using the Arial font and a 12-point letter size.

Procedure. The participants were again tested individually in a separate room within the school. The experimenter explained the task and again checked to see that the child had understood the instructions. The children's pseudoword reading was audiorecorded. The participants were instructed to read the pseudowords into the microphone as if they were real Dutch words. One short break was included between practice and test. The total duration of the experimental session was approximately 15 min.

After administration of the task, the recorded pronunciations were analyzed to see how the child had interpreted the pseudoword patterns. Just as in Experiment 1, the percentage correct pronunciations was computed for each child. All three possible pronunciations of the letter *e* were considered correct. A pronunciation was considered incorrect when one or more graphemes were pronounced in any deviant manner. Once again, a criterion of 80% correct was taken as the cutoff point for inclusion of a child in the final analysis. Five of the children pronounced more than 20% of the pseudowords incorrectly and were therefore excluded from any further analysis. Finally, which pronunciation of the letter *e* the child produced and which syllable the child stressed were identified. A chi-square analysis was then used to analyze the data.

Results

Figure 2 shows the distribution of /∂/, /ɛ/, and /e/ pronunciations occurring for the two types of pseudowords. The /∂/ pronunciation can be seen to predominate in pseudowords containing a grammatical morpheme. In pseudowords with no embedded morpheme, the /ɛ/ pronunciation can be seen to occur most frequently.

Table 3 shows the distribution of stress assignment for the two categories of pseudowords. A clear tendency to stress the second syllable for pseudowords containing a grammatical morpheme and the first syllable for pseudowords containing no morpheme was observed.

A chi-square analysis showed the effects of word type, $\chi^2(2, N = 33) = 310.9, p < .001$, and stress assignment, $\chi^2(1, N = 33) = 144.9, p < .001$, to both be significant.

Conclusions

The results of this second experiment using pseudowords containing grammatical morphemes with boundaries that do *not* coincide to syllable boundaries replicate

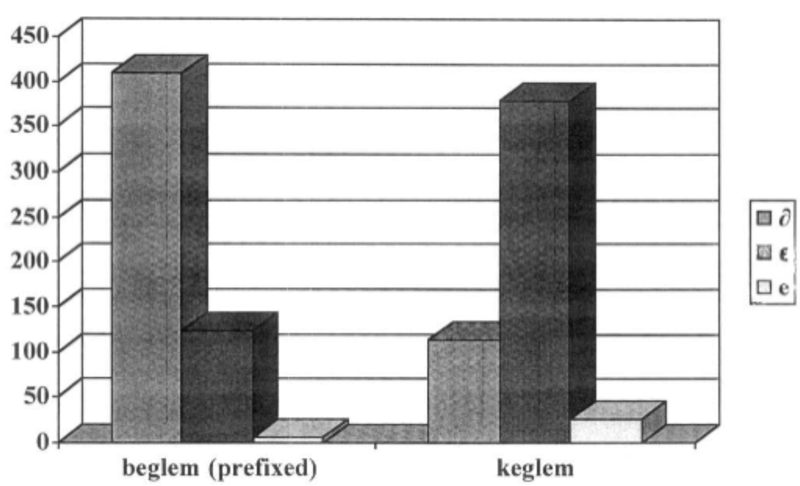

FIGURE 2 Distribution of /∂/, /ɛ/, or /e/ in the first syllable of bisyllabic Dutch nonwords, following a CVCCVC pattern.

TABLE 3
Proportions of Stress Assignment to First and Second Syllable of Dutch Bisyllabic Nonwords of the Type *Beglem* and *Keglem*

	Stress on First Syllable	*Stress on Second Syllable*
beglem	.24	.76
keglem	.61	.39

the results of the first experiment. Once again, a tendency to pronounce the vowel *e* when occurring in the first part of a pseudoword with a grammatical prefix as /∂/ and to pronounce it as /ε/ in all other pseudowords was observed. Stress tends to be assigned to the second syllable in pseudowords containing a grammatical morpheme and to the first syllable in pseudowords with no embedded morpheme. It can therefore be concluded that young readers are capable of identifying morphemes in pseudowords.

DISCUSSION

This study shows beginning readers of Dutch to clearly identify morphemes in bisyllabic pseudowords. The grapheme *e* presents a case of one-to-many mappings at the interface between Dutch orthography and phonology. Because the pronunciation of the same letter *e* differs in a prefix, in a content morpheme, or in a random letter string, the role of morphology as a disambiguating source could be demonstrated in that children use their knowledge about morphemes to determine the pronunciation of the grapheme. Evidence also suggests a frequency effect in that highly frequent grammatical morphemes are recognized much easier than content morphemes. It should be noted that the word-initial patterns of *be-* and *ge-* used in this study are not necessarily readable as prefixes, as pseudo-prefixes are even more common in Dutch than actual prefixes. In other words, it is not just a frequency effect that accounts for the present findings. The data show that beginning readers of Dutch not only apply grapheme-to-phoneme correspondence rules but also apply morphological rules. In other words, both phoneme and morpheme skills play a role in learning to read a language with such a “shallow” orthography as Dutch.

The identification of morphemes by the children studied here appears to be accompanied by the assignment of word stress. Given that word-initial affixes are never stressed in Dutch, the identification of a grammatical morpheme leads to a shift of stress from the first syllable. For words with the letter *e* in the second syllable, there is also a tendency for the identification of content morphemes to lead to the placement of greater stress on the first syllable. In other words, an intimate relationship between the morphological structures of words and their phonological structures is evidenced. The data from the second experiment show this relationship to even persist when morpheme boundaries do not necessarily coincide with syllable boundaries. It can thus be concluded that the phonetic material that appears in the syllabic slots of the phonetic plan originates from the phonemic properties of the constituent morphemes.

The data on children's pseudoword naming support alternative models of human cognitive processing. First, the finding that high-frequency subsymbolic units in pseudowords can be identified during a stage of learning to read fits with a parallel dual route model that includes both abstract grapheme-to-phoneme correspondence rules and lexical representations (cf. Coltheart, 1978; Coltheart, Curtis, Atkins, & Haller, 1993; Schreuder & Baayen, 1994, 1995). Independent lexical and rule-based procedures appear to operate in parallel to generate the pronunciation of not only words but also pseudowords. Alternatively, the same finding can be viewed as support for recent parallel-distributed processing models that explain the processing of both regular and irregular forms in terms of a single associative mechanism (cf. Plaut, McClelland, Seidenberg, & Patterson, 1996).

There are, of course, a number of limitations on this study. First, in the examination of pseudoword naming, we have limited ourselves to children's pronunciations. General naming latencies have not been taken into account. Second, we focused on the naming of morphemes in the first part of bisyllabic pseudowords. To generalize the present findings, the naming of other permutations of morphemes within various pseudoword patterns differing in length is called for. Third, our data are confined to children at the end of elementary school. To gain greater insight into the possible limits of cognitive processing during reading, the children's reading data should be compared to reading data from adults.

The study also has some important practical implications. The evidence of independent lexical and rule-based procedures makes clear that during the process of teaching children to read, attention should be paid to the two alternative—often complementary—processing routes. On one hand, children should be taught the relevant grapheme–phoneme correspondence rules with sufficient practice to automatize the rules in question. Computer-based flash card programs with words of various lengths appear to be particularly well suited for this purpose (see Torgesen, 2001). On the other hand, an attempt should be made by the teacher to enhance children's awareness of the constituent parts of longer words. Morphological skills become particularly relevant when polysyllabic and thus—in many cases—multimorphemic word patterns are addressed within the reading curriculum. And in previous studies, it has been shown that morphological awareness contributes significantly to the reading abilities of not only beginning readers (Carlisle, 1995, 2000; Carlisle & Nomanbhoy, 1993) but more advanced readers as well (Feldman, 1995; Leong, 2000; Nagy, Diakidoy, & Anderson, 1993).

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APPENDIX

TABLE A1
Items Used in Experiment 1

E in 2nd Syllable			*n-E in 2nd Syllable*		
Initial Word	*Prefix*	*Random*	*Initial Word*	*Prefix*	*Random*
remer	bemer	vemer	remur	bemur	vemur
hegem	begem	kegem	hegam	begam	kegam
legep	begep	fegep	legop	begop	fegop
veref	geref	neref	veruf	geruf	neruf
neteg	geteg	deteg	netag	getag	detag
zetef	betef	retef	zetuf	betuf	retuf
lefet	gefet	wefet	lefot	gefot	wefot
metep	getep	retep	metup	getup	retup
mepes	bepes	hepes	mepos	bepos	hepos
verep	berep	jerep	verup	berup	jerup
legep	gegep	megep	legip	gegip	megip
veret	beret	neret	verut	berut	gerut
velep	gelep	delep	velip	gelip	delip
netek	getek	detek	netuk	getuk	detuk
hemeg	bemeg	pemeg	hemog	bemog	pemog
remer	gemer	lemer	remar	gemar	lemar
nepef	bepef	vepef	nepof	bepof	vepof
webep	bebep	rebep	webip	bebip	rebip
lefek	gefek	mefek	lefak	gefak	mefak
veteg	beteg	keteg	vetog	betog	ketog

TABLE A2
Items Used in Experiment 2

Prefix	*Random*
beglem	keglem
gegrep	megrep
begrep	fegrep
begret	negret
getref	netref
getrep	letrep
gesteg	desteg
gertek	dertek
bestef	restef
bemteg	pemteg
gefret	wefret
germer	lermer
bemker	vemker
bepref	vepref
gebrep	retrep
bebrep	rebrep
bepres	hepres
geflek	meflek
betrep	jetrep
betreg	ketreg