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Difficulties with consonants in the spelling and segmentation of CCVCC pseudowords: Differences among Dutch first graders

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Abstract. The goal of the present study was to explore the errors made by Dutch first graders in spelling syllable-initial and syllable-final consonants clusters in CCVCC pseudowords, to look for error types that discriminate poorer spellers from better spellers, and to relate these error types to the errors made when segmenting the same words. Such a correspondence across tasks would point to problems with the phonemic conceptualization of the spoken word as a source of spelling difficulty. The most prominent spelling error among poor spellers was omission of the consonant immediately following the vowel. This error seemed to be reflected in segmentation by omission of that consonant, but even more by the consonant being left unsegmented from the preceding vowel. The spelling and segmentation errors that we observed in Dutch are similar to those previously observed in English. The finding that such errors are made with a disproportionate frequency by poor spellers is new and suggests a basic problem in developing a phonemic conceptualization of spoken words (and of postvocalic consonant clusters in particular) that is adequate for spelling.

Key words: Spelling, Segmentation, Consonants, School-age-children, Poor-spellers, Dutch

Introduction

Spelling is a complex skill that nevertheless in its essentials is mastered by most students within a short time. For other students, however, spelling is difficult at the start of literacy instruction and remains so for a long time. Knowledge of what makes words hard to spell will contribute to our insight into the nature of the spelling process in general and the nature of spelling problems in particular. The goal of the present paper is to further our insight by studying the spelling and segmentation of children who have early indications of spelling problems. We selected children at the lower end of the spelling score distribution and compared their spelling performance with that of more competent spellers with the same amount of spelling instruction. We focused on the manner in which spelling performance is influenced by specific features of the spoken word. If poor spellers generally perform worse than better spellers, we can conclude that poor spellers simply have more problems with what is difficult to spell than competent spellers, and that no specific problem underlies their low performance. If we find specific differences between the performances of problematic versus competent spellers for particular phonological or orthographic patterns, a deficit of a more special nature may be indicated.

Spelling is not only a complex skill but one whose character probably changes over the course of development. An adequate description of the poor speller will therefore need to specify various aspects of competence and performance. The present study, however, will be restricted in two respects. Based on a dual-route model of spelling production with a lexical, word-specific route and a phonological route (e.g., Barry 1994), we will concentrate on the phonological coding route (i.e., the skill of assembling letter sequences to represent the phonological structure of spoken words). For this purpose, only pseudowords, which do not require word-specific orthographic knowledge, will be used. We will study only children at the beginning stages of spelling acquisition in order to avoid facilitation of pseudoword spelling by the availability of prior word-specific knowledge. In particular, we will concentrate on their spelling of biconsonantal syllable-initial (or *prevocalic*) and syllable-final (or *postvocalic*) clusters in monosyllabic words.

For English, difficulties in the spelling of consonant clusters – and syllable-final clusters in particular – have been documented. Read (1975) observed frequent reduction of prevocalic *tr*- clusters and omission of leading nasals[1] in postvocalic clusters among precocious writers and first graders. Studying the spelling of school children and adults in literacy courses or speech therapy, Marcel (1980) observed the omission or misplacement of liquids in initial consonant clusters and the omission of nasals and liquids in syllable-final clusters. Concentrating on syllable-initial clusters, Bruck and Treiman (1990) found both dyslexics and normal children to have particular problems with the representation of a consonant immediately preceding a vowel. Treiman (1993) reported relatively high omission rates for the 'interior' consonants of syllable-initial and syllable-final clusters in first graders, with particularly high omission rates for nasals before voiceless obstruents in syllable-final clusters. Studying the spelling of consonant clusters in CVCCs by first graders. Treiman, Zukowski and Richmond-Welty (1995) observed the relatively frequent omission of sonorants (i.e., nasals and liquids) in the first postvocalic position, with a particularly high omission rate for nasals preceding voiceless obstruents.

Difficulties in spelling consonant clusters have also been reported for Dutch (see Booij (1995), for an introduction to Dutch phonology and orthography). In the Dutch spellings of precocious writers and first graders, van Rijnsoever (1979), like Treiman (1993), observed a tendency to omit the consonants immediately adjacent to the vowel. The omission rate was particularly high when leading nasals in postvocalic clusters and the following consonant were homorganic (i.e., had the same place of articulation). The latter finding suggests that kinesthesis plays a part in children's spelling and that the consonant cluster spelling problem may in part be caused by articulatory factors. Treiman (1993), however, concluded from her results that homorganity is not a determinant of consonant cluster spelling difficulty.

A study by van Bon and Duighuisen (1995) recently confirmed their earlier findings with first graders (Duighuisen & van Bon 1992) that syllable-final consonant clusters are more difficult to spell than syllable-initial consonant clusters for poor spellers. No differences were found for solitary consonants in prevocalic versus postvocalic position. No difference between solitary consonants and consonant clusters in prevocalic position was found, but postvocalic consonant clusters were more difficult to spell than solitary consonants in the same position. Van Bon and Duighuisen (1995) also found that the spelling problem with postvocalic consonant clusters was often reflected by errors in the segmentation of the same words. These errors frequently consisted of not segmenting the first postvocalic consonant from the preceding vowel (e.g., analyzing /stomp/ as /s-t-om-p/) and, less frequently, deleting the first postvocalic consonant (e.g., segmenting /stomp/ as /s-t-o-p/). This correspondence between spelling and segmentation errors resembles the correspondence found by Treiman et al. (1995, Experiment 2) for English.

Like English beginning spellers, Dutch beginning spellers appear to have a special problem with postvocalic consonant clusters. This is particularly the case when the first consonant in the postvocalic cluster is a sonorant and even more when the first consonant is a nasal. This means that a comparison of poor spellers with competent spellers should include an examination of prevocalic versus postvocalic consonant clusters and should also consider the phonological category of the consonants involved. In the present study, therefore, the handling of sonorants will be compared to that of obstruents and the handling of more specific categories of consonants and consonant clusters will also be explored. It should be noted that the general finding of a relatively high omission rate for postvocalic nasals before voiceless as opposed to voiced obstruents in studies involving English-speaking participants (Marcel 1980; Read 1975; Treiman 1993; Treiman et al. 1995) cannot be verified in Dutch. In Dutch /m/ and /n/ are the only voiced consonants that can end syllable-final consonant clusters although never after another nasal.

The dominant explanation for the observed difficulties in the spelling of consonant clusters has been in terms of spellers' ability to conceptualize the phonemic make-up of words. Specifically, the analysis of the speech sound configurations is inadequate for the application of phoneme-grapheme conversion rules. A specific explanation is formulated by Treiman (1993; Treiman et al. 1995) as the *different phonemic representation hypothesis*. According to this hypothesis, children attempt to symbolize their phonemic representation of a word in spelling it, although their phonemic representation does not always match conventional orthography. Children's initial conceptions of spoken words are "... close to the phonetic surface, influenced by the phonetic properties of words" (Treiman et al. 1995: 32). Increased reading experience either changes the phonemic representation to correspond to the orthographic representation or adds a new, orthographically adequate, level of representation. With regard to initial nasals and liquids in postvocalic clusters, Treiman (1993; Treiman et al. 1995) suggests that these are initially considered attributes of the preceding vowel because of their phonetic characteristics, and not separate phonemes. Supporting evidence reported by Treiman et al. (1995) is that children tended to count three instead of four tokens for nonsense CVCCs and tended to group the nasals and liquids with the preceding vowels (and obstruents with the following obstruents rather than with the preceding vowel) in their concomittant verbalizations.

If beginning spelling is indeed based on the inappropriate phonemic conceptualization of the word to be written, it should be possible to trace peculiarities in spelling to peculiarities in phonemic segmentation. When comparing poor spellers to more competent spellers, spelling errors on letters in specific positions should be paralleled by similar errors in segmentation.

Method

Subjects. Eighty-five first graders from three elementary schools participated. The data on two children were incomplete, and these children were thus eliminated from the analyses. At the time of the investigation (February, March), the average age of the remaining 83 children (44 boys, 39 girls) was 6 years, 9 months (standard deviation 4 months). At the time, they had received approximately six months of formal literacy instruction. The reading and spelling methods used in the schools were phonics oriented.

Materials. A list of 48 CCVCC pseudowords was developed using all possible biconsonantal clusters with the exclusion of the infrequent prevocalic /ps-/, /pn-/, /ts-/, /gn-/, /sf-/, and /wr-/ and postvocalic /-wt/, /-jt/, /-ws/, /-js/, and /-rw/. The frequent initial cluster /sχ/ (written as sch-) was also excluded because in all three schools the children were taught to recognize and write these sounds as unanalyzed wholes. Table 1 shows the remaining clusters categorized according to the phonological classification of the constituent phonemes. The selected clusters were arbitrarily combined to form 48 CC-CC frames, with the restriction that a given letter occurred only once in a given frame. All of the prevocalic clusters and some postvocalic cluster types were used twice in constructing the list. The middle positions in the frames were

Table 1. Consonant clusters used in constructing the CCVCC pseudowords

Prevocalic			Postvocalic		
Consonant type		Instances	Consonant type		Instances
C1	C2		C3	C4	
stop, voiced	glide	dw	stop, voiceless	stop, voiceless	pt,kt
stop, voiced	liquid	br,bl,dr	stop, voiceless	fricative, voiceless	ps,ts,ks
stop, voiceless	glide	tw,kw	ficative, voiceless	stop, voiceless	ft,sp,st,gt
stop, voiceless	liquid	pr,pl,tr,kr,kl	fricative, voiceless	fricative, voiceless	fs,gs
stop, voiceless	nasal	kn	nasal,	stop, voiceless	mp,mt,nt,ngt,nk
fricative, voiced	glide	zw	nasal,	fricative, voiceless	mf,ms,ns,ngs
fricative, voiced	liquid	vr,vl,gr,gl	liquid,	stop, voiceless	rp,rt,rk,lp,lt,lk
fricative, voiceless	stop, voiceless	sp,st	liquid,	fricative, voiceless	rf,rs,rg,lf,ls,lg
fricative, voiceless	nasal	sm,sn	liquid,	nasal	rm,rn,lm
fricative, voiceless	liquid	fr,fl,sl			

filled with the short vowels /a/, /e/, /i/, /o/, and /u/, which are the most easy to spell in Dutch. The vowels were selected at random but replaced if an existing word resulted or if an /e/ together with the following consonant would produce a letter name (e.g., /fl*e*sp/). The list of pseudowords can be found in the Appendix.

Task

In the *spelling task*, the children wrote the pseudowords to dictation. The second author pronounced each word twice. The participants were instructed to write the whole word anew if they thought they had made a mistake and not to make a partial correction. If they did not know how to write a particular letter, they were allowed to represent that letter with a dash. There were four practice items (see the Appendix). The 48 items were presented in a fixed random order. Testing was divided across two sessions scheduled on different days, and the spelling task was administered to an entire class at the same time.

The way in which each of the five phonemes in a word was represented was coded with one of six categories: correct, dash, omission, substitution, misplacement (at the same or to the other side of the vowel), or other. For all phonemes it could be unambiguously decided whether their graphemic representation was correct or not, because there is only one canonical way to represent them in writing (cf. Booij 1995), except for /χ/ in postvocalic positions, which can be represented with *g* and *ch*, both of which were counted correct. Morphological rules would also allow spelling /p/ and /t/ in postvocalic positions with *b* and *d*, respectively, but no child did so. In addition to these five codes (one for each phoneme), the word received codes to indicate whether one or more letters had been inserted at each of the six possible 'insertion positions' (including the places before the first and after the last consonants) in each word. For each child, the number of words spelled correctly was also calculated.

The *phonemic segmentation task* was administered in individual sessions, about one week after the spelling task. The children were asked to say (or 'chop') each word in its 'little parts'. The children were familiar with this task as part of their reading/spelling instruction. In order to avoid ambiguity in scoring responses containing an apparently unanalyzed sound cluster, the subjects were required to tap once on the table with a pencil for each 'little part' of the word. The sessions were tape-recorded for later analysis.

The scoring of the segmentation data paralleled that for the spelling data, with the addition of a 'nonsegmentation' category to indicate whether each phoneme was pronounced separately or together with one or more adjacent phonemes.

Results

Poor spellers were defined as those scoring in the lowest quartile (in terms of number correct) on the spelling test. By comparing poor spellers with subjects scoring in the middle two quartiles (normal spellers), and the latter with children in the upper quartile (good spellers), we hoped to find factors differentially affecting children with low spelling ability. The typical analysis of variance for this between-groups comparison used two contrasts: one comparing poor spellers to normal spellers, and another comparing normal spellers to good spellers. The effects of the various within-subjects factors were tested following the multivariate approach, i.e., by specifying contrasts between the measures representing scores on each level of these factors.

Table 2. Descriptive data for the three spelling groups (standard deviations in parentheses)

Spelling group	Poor spellers	Normal spellers	Good spellers
Age (in months)	83.73 (4.34)	83.63 (4.63)	84.03 (3.43)
Spelling score (max = 48)	12.24 (5.76)	26.63 (3.63)	35.75 (3.17)
Segmentation (max = 48)	29.52 (10.64)	36.14 (9.43)	43.63 (2.24)
N (boys/girls)	21 (14/7)	43 (25/18)	19 (5/14)

Significant multivariate effects were followed up by univariate F-tests. An alpha level of 0.05 was used for all statistical tests.

Table 2 shows the descriptive data for the three subject groups. As can be seen, the spelling and segmentation scores clearly differed across the groups [$F(2,80) = 164.27$; $p < 0.01$ and $F(2,80) = 13.04$, $p < 0.01$, respectively]. The groups did not significantly differ in age ($F < 1$). Relatively many girls were found among the good spellers and relatively few among the poor spellers [$\chi^2(2) = 7.46$; $p < 0.05$]. This finding is in accordance with the gender difference observed in children's spelling performance by others (e.g., Allred 1990; Lynn 1992; Smits, Mommers & Aarnoutse 1985; Vogel 1990).

Spelling

We will first briefly consider the spelling performance for the different phoneme positions and then concentrate on the consonant spelling error type, consonant position, and consonant class.

Figure 1 shows the number of correctly spelled graphemes for each of the five phoneme positions. The pattern for the poor spellers deviates from that for the normal and good spellers, who appear to differ only in the level, not the pattern, of their scores. The poor spellers generally made more errors in representing the phonemic structure of the word, with their low spelling performance most pronounced for C3, although that consonant position was also the most problematic for both other groups. Other relatively large differences between the poor and normal spellers concern the vowel (V) and the consonant that immediately precedes the vowel (C2).

Averaged across the five positions within a CCVCC, the children used a *dash* to indicate that they did not know how to write the sound in less than 1% of the phonemes. Although poor spellers tended to use dashes more often than normal spellers, an analysis of variance on the number of dashes with spelling group (3 levels) as a between-subjects factor and phoneme position (5 levels) as a within-subjects factor showed this difference to be

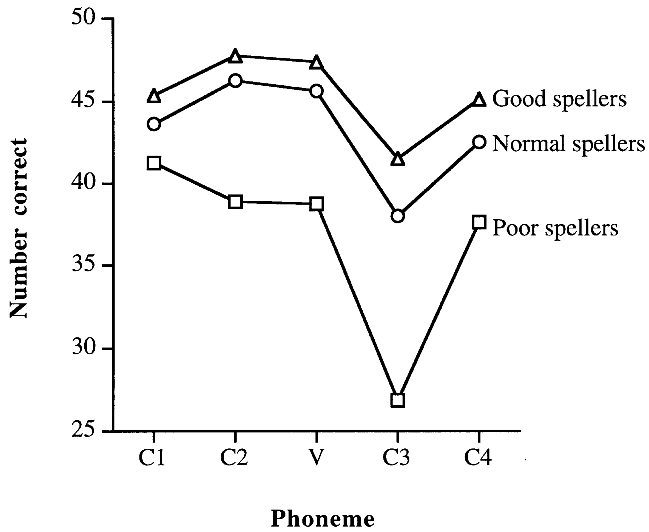

Figure 1. Number of correct spellings (max = 48) by phoneme position and spelling group.

only marginally significant [$F(5,76) = 2.18$; $p = 0.08$]. No other effects even approached significance.

Two main categories of spelling errors could be distinguished, insertions and misrepresentations. Of the six positions that can be occupied by *insertions*, only the position between the final consonants (C3 and C4) led to a substantial number of insertions. The difference between the means for the poor and normal spellers (3.10 versus 3.05 insertion between C3 and C4) was not significant ($F < 1$), but the means for the normal and good spellers (3.05 versus 1.47 insertions between C3 and C4) differed significantly [$F(1,80) = 7.84$; $p < 0.01$]. Thus, good spellers tend to make fewer insertion errors than other spellers. Postvocalic consonant clusters consisting of a liquid followed by a consonant that is not an /s/ or a /t/ are often pronounced with a schwa-like sound between the consonants in Dutch. Beginning spellers are inclined to represent this schwa in their spellings (for example, to write *knarp* as *knarup* or *knarip*). Most spelling methods teach rules to avoid this type of error. Good spellers appear to have learned this spelling convention better than poor or normal spellers.

Three main ways of *misrepresenting* consonants were distinguished – by omission, by substitution, and by misplacement. Figure 2 shows the average number of errors for the four consonant positions, the different types of misrepresentation, and the three spelling groups. As can be seen, the low performance of poor spellers is not simply caused by their making more errors of all types on all phonemes in a word or by greater difficulty with

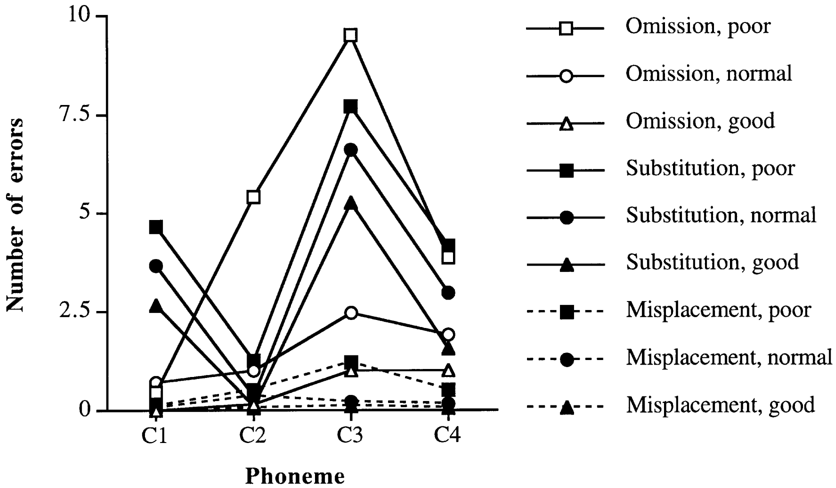

Figure 2. Number of spelling errors by consonant position, error type, and spelling group.

what makes CCVCCs difficult to spell for other children as well (substitution errors on C3s). The spelling errors of the poor spellers appear to be more specifically characterized by many omissions of C2 and especially C3.

An analysis of variance with number of errors as the dependent variable, error type (3 levels) and consonant position (4 levels) as within-subjects factors, and spelling group (3 levels) as a between-subjects factor produced a significant interaction among all of the factors [F(12,150) = 3.74; $p < 0.01$]; significant interactions between all pairs of factors [spelling group and error type: F(4,160) = 13.51, $p < 0.01$; spelling group and consonant position: F(6,158) = 6.15; $p > 0.01$; error type and consonant position: F(6,75) = 56.54; $p < 0.01$]; and significant main effects of all three factors [error type: F(2,79) = 317.42; $p < 0.01$]; consonant position: F(3,78) = 74.30; $p < 0.01$; spelling group: F(2,80) = 38.43; $p < 0.01$].

The contrasts between the different spelling groups showed the poor spellers to differ significantly from the normal spellers in the mean number of errors [F(1,80) = 49.73; $p < 0.01$], the type of errors [F(2,79) = 22.72; $p < 0.01$], the difficulty pattern of the consonant positions [F(3,78) = 9.50; $p < 0.01$], and the type of errors for the different consonant positions [F(6,75) = 5.59; $p < 0.01$]. The only significant difference between the normal and the good spellers was in the mean number of errors [F(1,80) = 7.31; $p < 0.01$]. Thus, the normal spellers differ from the good spellers only by making more errors, not by making errors of a different type or at other places in the word.

The number of *misplacements* was generally few: 0.25 averaged across the consonant positions and the different spelling groups, with a slightly elevated number of C3 misplacements for the poor spellers (mean 1.19). Poor spellers tended to swap C3 and C4 or to write C3 before the vowel, although the paucity of such errors makes their explanatory power low.

On average, the number of *substitutions* and *omissions* was larger than the number of misplacements, with substitutions exceeding omissions as in Treiman (1993). Whereas all three groups made most *substitutions* at the first postvocalic position (C3), fewest at the second prevocalic position (C2), and an intermediate number at the outermost positions (C1 and C4), the distribution of *omissions* across consonant positions showed equal pattern only for the normal and good spellers. Both of these groups made fewer omissions for both of the prevocalic consonants and more omissions for both of the postvocalic consonants. The omission error pattern of the poor spellers shows a striking deviation from that of both other groups. The number of omissions by the poor spellers involving C2 and C3 even surpasses the number of substitutions at those positions. For both C2 and C3, the difference between the omissions for the poor and normal spellers was significantly larger than that between the normal and the good spellers [C2: $F(1,80) = 4.133$; $p < 0.05$ and C3: $F(1,80) = 6.49$, $p < 0.05$].

Because the spelling errors of the poor spellers are concentrated at the C3 and to a lesser extend the C2 positions, the relation between particular consonant classes (*obstruents, sonorants*) and the two most frequent error types (omissions, substitutions) was investigated for these two consonant positions. The relevant data are presented in Figure 3. In these and related analyses, percentages are used in order to compensate for unequal maxima (e.g., of sonsorants and obstruents at C2 and C3). The percentages are always calculated across all responses to a certain phoneme category.

An analysis of variance with the percentage of *substitutions* as the dependent variable, spelling group (3) as a between-subject factor, consonant class (2) and consonant position (2) as within-subjects factors showed no interactions involving spelling groups. This finding supports the earlier suggestion that the groups do not differ in their patterns of substitution errors. Main effects were found for spelling group [$F(2,80) = 10.15$; $p < 0.01$; with both of the contrasts proving significant (poor/normal: $F(1,80) = 9.16$; $p < 0.01$ and normal/good: $F(1,80) = 4.87$; $p < 0.05$)] and consonant position [$F(1,80) = 143.88$; $p < 0.01$; with more substitutions at C3 than at C2]. Consonant class interacted significantly with consonant position [$F(1,80) = 7.43$; $p < 0.01$]: at C3 proportionally more sonorants than obstruents were represented with an incorrect grapheme while the reverse seemed to apply to the C2 substitutions.

The percentage of *omissions* for the good spellers was generally very low, with the exception of C3 sonorants. The normal spellers committed fewer omissions than the poor spellers, with only small differences between the

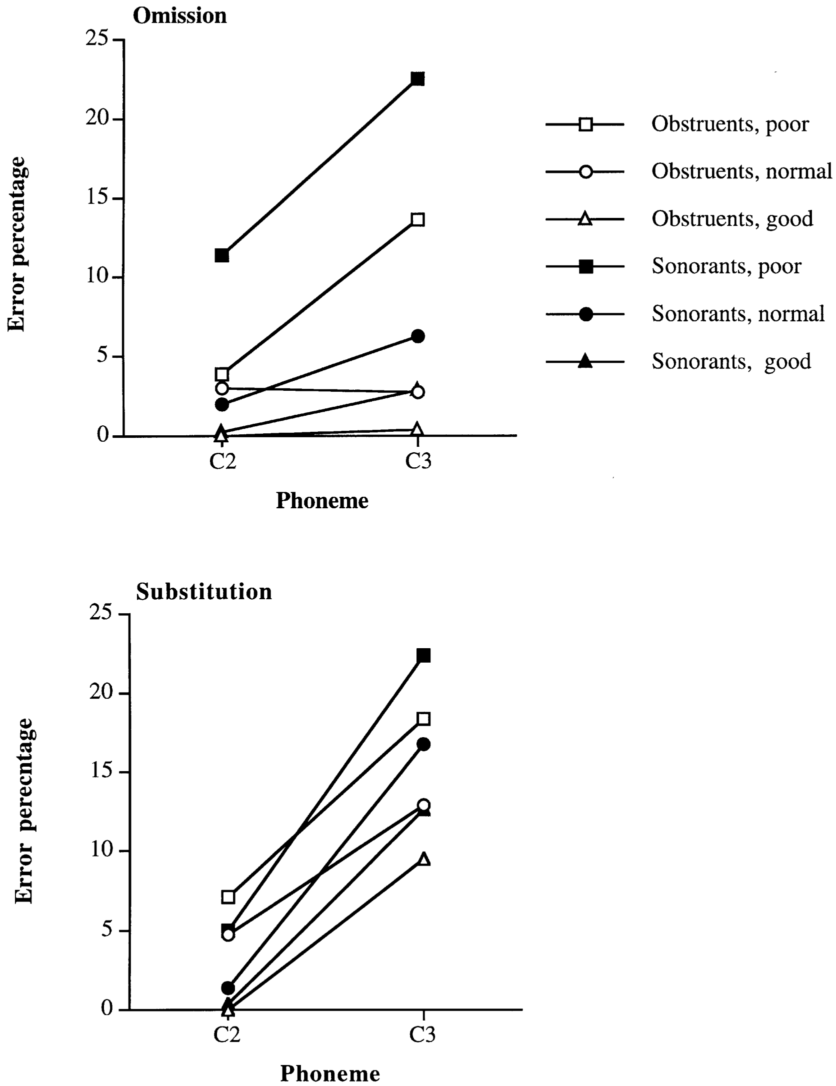

Figure 3. Spelling: Percentage omissions and substitutions by consonant class, consonant position (C2 and C3 only), and spelling group.

consonant classes and consonant positions (obstruents: 3%, sonorants: 4%; C2: 2%, C3: 4%). For the poor spellers, the consonant classes and consonant positions differed greatly with regard to the percentage of omissions (obstruents: 8%, sonorants: 17%; C2: 7%, C3: 18%). Using omission percentage as the dependent variable in an analysis of variance similar to that for substitutions, no significant second-order interaction involving all three factors was found. The first-order interactions involving the contrast between poor and normal spellers were significant, however [with consonant class: F(1,80) = 13.56; $p < 0.01$; with consonant position: F(1,80) = 14.21; $p < 0.01$]. The interaction of the normal versus good spellers contrast with both factors was not significant (both $F < 1$). Significant main effects were found for spelling group [F(2,80) = 19.70; $p < 0.01$ with the only significant contrast being between the poor and the normal spellers, F(1,80) = 28.39; $p < 0.01$], consonant class [F(1,80) = 17.50; $p < 0.01$; with more omissions of sonorants than of obstruents], and of consonant position [F(1,80) = 2.36; $p < 0.01$; with more omissions at C3 than at C2]. There was no significant interaction between consonant position and consonant class [F(1,80) = 2.36; $p = 0.13$], nor did the spelling groups differ in this interaction, as the insignificance of the second-order interaction indicates.

Although these results indicate a general problem with sonorants rather than a special problem with sonorants at C3, the literature for English suggests that nasals at C3 may be particularly prone to errors. This possibility was tested by comparing C3 *nasals* with C3 *liquids* in an analysis of variance with error percentage as the dependent variable, error type (omissions versus substitutions) as another within-subjects factor, and spelling group (3) as a between-subjects factor. C3 nasals indeed appeared to be more often incorrectly represented than C3 liquids [nasals: 33%, liquids: 20%; F(1,80) = 42.47; $p < 0.01$]. The difference – in contrast to what has been suggested in the literature for English – appears to be less the result of omissions [nasals: 7%, liquids: 12%; F(1,80) = 2.03; $p = 0.16$] than of substitutions [nasals: 25%, liquid: 7%; F(1,80) = 175.18; $p < 0.01$]. Most of the nasal substitutions consist of rendering the digraph *ng* with one letter (mostly *n*, occasionally *g*), and less frequently, *m* as *n*. Spelling group did not interact with C3 consonant class, which suggests that whatever makes nasals more difficult to spell than liquids does not add to the spelling difficulty of the poor spellers.

It was expected that C3s in *homorganic* clusters (n = 16) would be either more difficult than (van Rijnsoever 1979) or about as difficult as (Treiman 1993) C3s in inhomorganic clusters (n = 32). Surprisingly, homorganic C3s were more frequently represented correctly (82%) than inhomorganic C3s (71%) [F(1,80) = 43.47; $p < 0.01$]. This suggests that there are other more important determinants of C3 spelling difficulty than shared place of articulation, which also did not interact with spelling ability.

Comparison of spelling and segmentation

The mean number of correct on the segmentation task was 36.18 (sd 9.93) while the mean correct on the spelling task was 25.08 (sd 9.33) [$t(82) = 12.10$; $p < 0.01$]. This difference suggests that segmentation is easier than

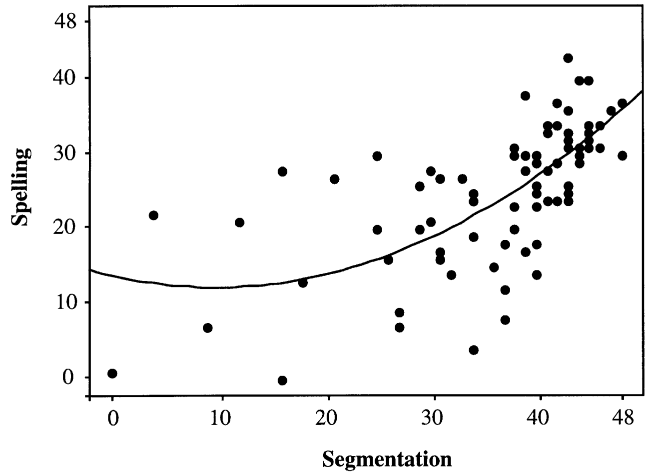

Figure 4. Scatterplot of the segmentation and spelling scores (max = 48).

spelling. Whereas three children segmented all words correctly, none of the children spelled all of the words correctly. Figure 4 presents a scatterplot of the spelling by segmentation data. The correlation between segmentation and spelling scores was 0.63, and such results can be expected if spelling is based upon segmentation, but involves some additional knowledge and skills (e.g., the application of phoneme-grapheme conversion rules).

A simple regression analysis with spelling score as the dependent variable and segmentation score as the predictor variable shows a nonsignificant intercept and a significant slope (0.59). Allowing for curvilinearity, however, results in a significant intercept (14.02), a nonsignificant slope, and a significant quadratic component (0.02). The latter result confirms the impression from Figure 4, namely that spelling was fairly easy for some children with low segmentation scores (for similar results, see van Bon & Duighuisen 1995).

Figure 5 shows the number of correct phonemes at each of the five positions in the segmentation task. Comparison to the spelling task (Figure 1) shows the pattern of the poor spellers in the segmentation task to less clearly differ from that of the other groups than in the spelling task.

Insertions made when segmenting will not be discussed because, as we have seen, insertions in spelling were not characteristic of the poor spellers. Figure 6 depicts the types of segmentation errors made by the three spelling groups at the four consonant positions. Misplacements are not represented and not discussed here because of their low frequency in spelling. Figure 6 draws our attention to the relatively large number of nonsegmentations by the poor spellers in particular. They are the most likely segmentation errors to explain the spelling error differences at C3.

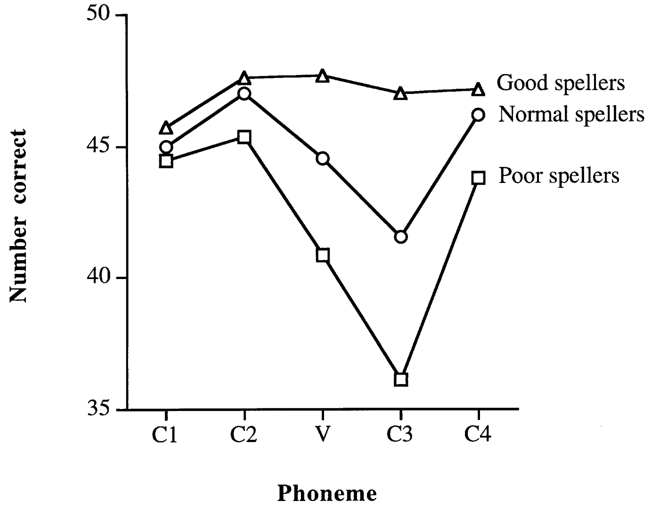

Figure 5. Number of correct segmentations (max = 48) by phoneme position and spelling group.

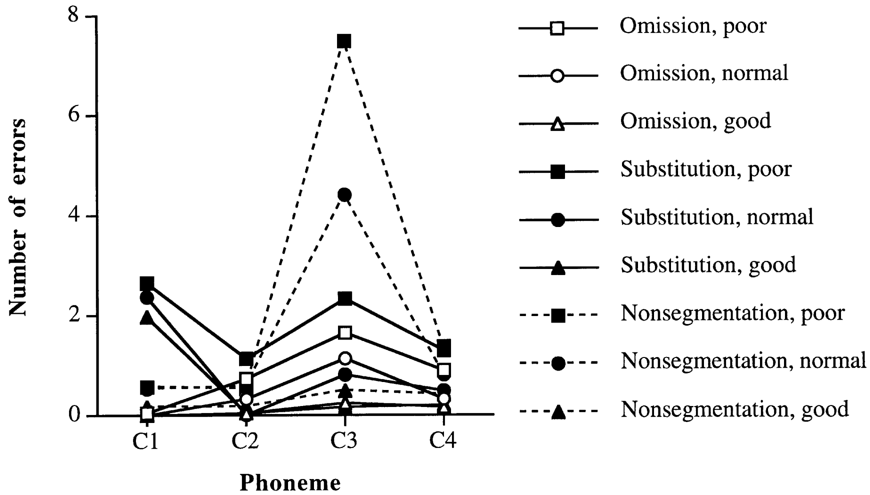

Figure 6. Number of segmentation errors by consonant position, error type, and spelling group.

In Figure 7, the data for the three remaining types of segmentation errors at the problematic spelling positions of C2 and C3 are depicted. Analyses of variance were performed with the percentage of errors of each type as the dependent variables, spelling group (3) as a between-subjects factor,

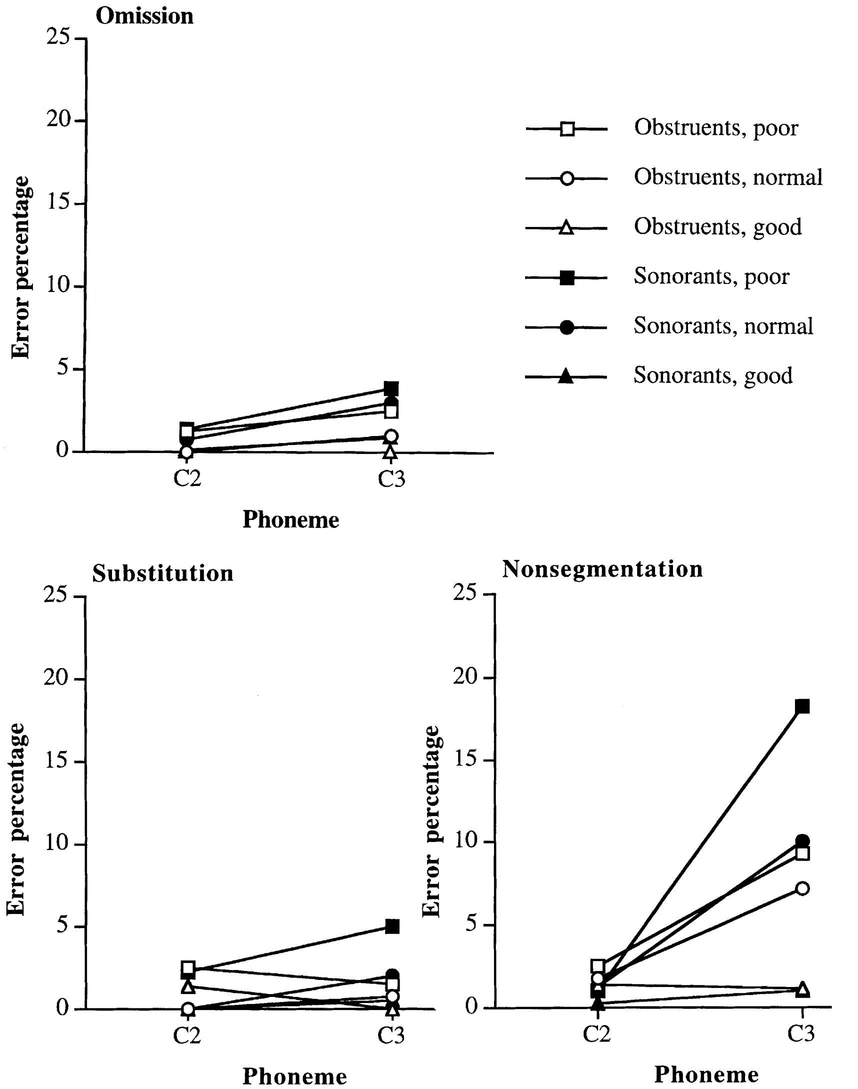

Figure 7. Segmentation: Percentage omissions, substitutions, and nonsegmentation by consonant class, consonant position (C2 and C3 only), and spelling group.

and consonant class (obstruent versus sonorant) and consonant position (C2 versus C3) as within-subjects factors.

The occurrence of *substitutions* in the segmentation data is low in both absolute terms and in comparison to their occurrence in spelling. Averaged across the four consonant positions, 8.5% of the consonants were substituted in spelling, against only 2% in segmentation. This difference between segmentation and spelling suggests that the basis of many spelling substitutions is not problems in identifying the phonemes in the spoken word, but uncertainty about the correct grapheme to represent a given phoneme. Nevertheless, the moderate correlations between the proportions of substitutions in segmentation and the proportions in spelling (C1: 0.35; C2: 0.34; C3: 0.33, C4: 0.48) indicate that at least some of the spelling substitutions may be caused by comparable segmentation errors.

Recall that the poor spellers did not distinguish themselves by making relatively many substitutions in spelling C2s and C3, nor by their pattern of substitution errors. In segmentation, however, the poor spellers made more substitutions than the normal spellers [$F(1,80) = 9.04$; $p < 0.01$], whereas no difference was found between the normal and the good spellers ($F < 1$). The poor/normal segmentation contrast also interacted with consonant position and consonant class [$F(1,80) = 4.67$; $p < 0.05$]. This three-way interaction is most likely caused by the relatively high frequency of C3 sonorant substitutions by the poor spellers, as seen in Figure 7. Surprisingly, however, the relatively high frequency of these segmentation errors is not reflected in the spelling errors of the poor spellers.

With regard to *omissions*, recall that omission of C2 and of C3 in particular was the most typical spelling error type for poor spellers. At both consonant positions, moreover, poor spellers omitted sonorants more often than obstruents. In segmentation, no comparable difference between the groups was found. Although the overall between-groups effect approached significance [$F(1,80) = 2.79$; $p = 0.07$], neither of the contrasts proved to be significant [poor/normal $F(1,80) = 2.15$; $p = 0.15$ and normal/good: $F(1,80) = 1.68$; $p = 0.20$]. Significant main effects of consonant position [$F(1,80) = 8.48$; $p < 0.01$; with more omissions of C3 than C2] and of consonant class [$F(1,80) = 3.65$; $p < 0.05$; with more sonorant than obstruent omissions] were found, but no interaction of the between-groups contrasts with consonant position or consonant class (all $F < 1$).

Across all subjects, a moderate correlation between the percentage of omissions in spelling and the percentage of omissions in segmentation was found (C2: 0.23; C3: 0.38), but omissions were much less frequent in segmentation (C2: 1%; C3: 2%) than in spelling (C2: 4%; C3: 8%). These spelling omissions, therefore, can only partly be explained from omissions in segmentation.

A segmentation error type that has no immediate counterpart in spelling is *nonsegmentation*. As Figure 6 shows, this was the most frequent type of segmentation error at C3 (9% of the C3 responses). Of the two types of C3 nonsegmentation found, the production of a VC3 whole was most common, 81% of the C3 nonsegmentations. VC3C4 groupings accounted for the remaining 19% of the C3 nonsegmentations.

An analysis of variance on the percentage of nonsegmentations revealed a significant interaction of the poor/normal contrast with consonant class (sonorants versus obstruents) and consonant position (C2 versus C3) [$F(1,80) = 7.24$; $p < 0.01$]. As Figure 7 shows, nonsegmentations were uncommon at C2. At C3, however, the poor spellers made twice as many nonsegmentation errors with sonorants (18% of occasions) as with obstruents (9%). The frequency of their obstruent nonsegmentations almost matched that of the normal spellers (7%) who left more phonemes unsegmented than the good spellers at C3 but did not seem to encounter more problems with sonorants than with obstruents. The almost equal frequency of C3 obstruent nonsegmentations made by poor and normal spellers suggests that C3 nonsegmentations as such are not characteristic of poor spellers. Rather, poor spellers produced many nonsegmentations of C3 sonorants in particular. The overall effect of group was significant [$F(2,80) = 3.45$; $p < 0.05$], but neither of the between-group contrasts proved significant [poor/normal: $F(1,80) = 1.50$; $p = 0.22$ and normal/good: $F(1,80) = 3.30$; $p = 0.07$]. A significant interaction of consonant class and position was found [$F(1,80) = 18.39$; $p < 0.01$] along with main effects of consonant class [$F(1,80) = 5.57$; $p < 0.05$; more nonsegmentations for sonsorants than for obstruents] and consonant position [$F(1,80) = 11.89$; $p < 0.01$; more nonsegmentation of C3 than of C2].

If the relatively high percentage of omission errors by the poor spellers at C3 in the spelling task is to be explained by the way in which they conceptualize the phonological make-up of the spoken word, their nonsegmentation of the consonants in that same position may provide us with some additional insight. The number of C3 nonsegmentations by the poor spellers (mean 7.48) approaches their number of C3 omissions in spelling (mean 9.52). Across all subjects, moreover, the number of C3 omissions in spelling indeed strongly correlates (0.64) with the number of C3 nonsegmentations and even more so than with the number of omissions in segmentation (0.38). A regression analysis with these two types of segmentation errors as predictors of C3 omissions in spelling shows a significant independent contribution for both types of error (β's: 0.60 (nonsegmentations), 0.26 (omissions); $R^2 = 0.48$). These results suggest that omissions of C3 in spelling can result from grouping this consonant with the preceding vowel.

A further analysis of C3 sonorant segmentation errors showed a significant difference between *nasals and liquids* [$F(1,80) = 4.99$; $p < 0.05$], but now in favor of nasals (14%) rather than liquids (18%), which contrast did not interact with spelling group (all $F < 1$). Most of these errors consisted of nonsegmentations, more for liquids (12% nonsegmentations) than for nasals (8%), which also interacted with spelling group [$F(2,80) = 3.18$; $p < 0.05$], but not with the between-group contrasts [poor/normal: $F(1,80) = 2.78$; $p = 0.10$

and normal/good: $F(1,80) = 1.60$; $p = 0.21$]. The relative excess of C3 nasal substitutions (25%) compared to C3 liquid substitutions (7%) in the spelling data was not reflected in the segmentation data: only 4% of the nasals were substituted with another phoneme and 1% of the liquids. This suggests that the difference between these consonant types in spelling difficulty is one of grapheme selection rather than phoneme identification. The difference in the frequency of substitutions for these two consonant types in the segmentation data was significant [$F(1,80) = 25.94$; $p < 0.01$], and, in contrast to the spelling data, interacted with spelling group [$F(2,80) = 4.12$; $p < 0.05$], but neither of the between-group contrasts did [poor/normal: $F(1,80) = 3.03$; $p = 0.09$ and normal/good: $F(1,80) = 3.59$; $p = 0.11$]. The frequency of omissions was also low for nasals (1%) and for liquids (4%).

C3s in *homorganic* clusters were not more difficult than in non-homorganic clusters (87% versus 86% correct segmentation). This suggests that the difference in favor of C3s in homorganic clusters in the spelling task can be attributed to problems with grapheme selection for some consonants in non-homorganic clusters. This contrast also did not interact with spelling group.

The difference between the poor and normal spellers in the frequency of their C2 omissions in spelling is not paralleled by a similar difference in segmentation (compare Figures 2 and 6). The number of omissions in spelling is only weakly correlated with the number of omissions in segmentation (0.23, $p < 0.05$), and there is no relation with the nonsegmentations involving C2 (-0.01). This shows that the omission of C2 graphemes does not stem from a lack of insight into the phonological make-up of the spoken word but from other sources. If such spelling was only a matter of choosing the corresponding grapheme, however, one would expect substitutions rather than omissions in spelling (recall that the children were also allowed to use a dash in case of uncertainty). The rather high correlation of C2 spelling omissions with C2 segmentation substitutions (0.59) suggests that uncertainty about the identity of the phoneme may be at the basis of these grapheme omissions. The question of why children omit C2s when spelling while substituting them when segmenting remains to be answered.

Discussion

The goal of the present study was to explore the errors made by Dutch first graders in spelling syllable-initial and syllable-final consonant clusters, to look for error types that discriminate poorer spellers from better spellers, and to relate these errors to errors made when segmenting the same words. Such correspondences across tasks would point to the phonemic conceptualization of the spoken word as a source of spelling errors.

A few specific types of spelling errors indeed distinguished the poor spellers in this study. The most prominent among these was the omission of the consonant immediately following the vowel (C3). This effort seems to be reflected by omission of that same consonant in segmentation but even more so by grouping that consonant with the preceding vowel (i.e., nonsegmentation).

The frequent omission of the first consonant in the spelling of final clusters is in agreement with the literature referred to in the introduction. New is our finding that poor spellers are particularly likely to make such errors. Although the more frequent use of dashes and the larger number of substitutions and misplacements may point to a general spelling weakness on the part of poor spellers, our data indicate a particular problem expressed by the frequent omission of the first grapheme in postvocalic clusters and probably, thus, a poor conceptualization of the phonemic make-up of the rime. The corresponding C3 omissions in the segmentation task suggest that this consonant is sometimes not noticed in the spoken word. The C3 omissions in the spelling task are even more likely to reflect the nonsegmentation of the vowel and the following consonant. Such nonsegmentations indicate that the spellers have noticed the consonant but for some reason only represent the vowel in their spelling. The co-occurence of these consonant omissions in spelling with grouping errors in segmentation has been reported before (Treiman et al. 1995; van Bon & Duighuisen 1995). Treiman (1993; Treiman et al. 1995) has suggested that the shortness of the consonantal segment in case of nasals and the absence of consonantal articulation in the case of liquids lead to them being not considered separate phonemes, but rather as mere 'colorings' of the preceding vowel. Items like /slant/ and /brilg/ will be constructed as consisting of three consonants (the two consonants in the initial cluster and the final consonant) and a vowel that is either nasalized or liquidized. If we assume that the specific nature of the vowel is noticed in such cases, we can also explain the occurrence of fragments like /an/ and /il/ in the segmentation responses. These fragments are attempts to represent the peculiar vowel sounds. They cannot be represented in spelling because the orthography lacks an appropriate symbol. Moreover, beginning spellers learn to ignore such allophonic variation in their spelling.

The phonetic effects implied by Treiman's different phonemic representation hypothesis were found in the present study. In spelling C2s and C3s, sonorants (mainly nasals and liquids) were more often omitted than obstruents; in segmentation, omissions and nonsegmentations involving sonorants were more frequent than those involving obstruents. The difficulties encountered by poor spellers in representing postvocalic consonant clusters may then be accounted for by phonemic representations that differ from those underlying standard orthography. The between-group differences in C3 omissions in spelling, nevertheless, cannot be fully explained by the phonemic representations of C3s. The excess of C3 sonorant nonsegmentations by the poor spellers, for example, has no counterpart in an excess of C3 sonorant omissions in spelling. Given the relatively small number of the errors involved, however, replication should be undertaken.

As in Treiman et al. (1995), C3 obstruent omissions also occurred, but less frequently (5% across all subjects) than sonorant omissions (10%) in the present study. The phonetic arguments that explain why nasals and liquids in the postvocalic positions are omitted (see above), however, do not apply to obstruents in that position. Treiman et al. (1995) suggest that, just as nasals and liquids form cohesive units with the preceding vowels, postvocalic obstruents form such units with subsequent obstruents. However, whereas nonsegmentations of VC3 involving obstruent C3s were observed in our data, no C3C4 nonsegmentation – either with obstruent or with sonorant C3s – were found. These findings suggest that the spelling of C3 obstruents is determined by the same factors as that of C3 sonorants but to a lesser degree. This does not principally undermine Treiman's different representation hypothesis but rather the suggestions about the phonetic factors that may be operative in the formation of the representations. The absence of C3C4 nonsegmentations is in contrast to Treiman et al.'s (1995) finding and points to a difference between Dutch and English phonology.

The literature on English shows a special spelling problem with C3 nasals. In the present study, C3 nasals were indeed spelled more incorrectly than C3 liquids. This difference, however, was found to lie in the number of substitutions rather than in the number of omissions. The nature of these substitutions and the lack of corresponding segmentation errors suggests that the problem is specific to spelling and may reside in grapheme selection rather than conceptualization of the word's phonology. The spelling difference between C3 nasals and liquids, however, was not uniquely characteristic of the poor spellers.

Our finding that homorganity of C3 with C4 does not determine spelling or segmentation difficulty is in keeping with Treiman's (1993) conclusions for English and does not corroborate van Rijnsoever's (1979) finding of a homorganity effect in Dutch children. Kinesthetic factors thus are unlikely to play a part in the consonant cluster spelling problem.

One problem with interpreting the present results in terms of a different phonemic conceptualization of the spoken word is that normal spellers also produced relatively many nonsegmentations but produced fewer spelling omissions than might be expected on the basis of such nonsegmentations. If their phonemic representations contain a colored vowel instead of a separate C3, then they should have committed an average of at least 4.37 C3 omissions (their mean number of C3 nonsegmentations) and not the observed 2.45 C3 omissions. One possible explanation is that the normal spellers indeed have the kind of different phonemic representation hypothesized by Treiman but have discovered that what they consider one unit (for instance, a nasalized vowel) is often represented by a vowel grapheme and a consonant grapheme. Their next step is to realize on the basis of the written representation of the spoken word that the word contains an additional consonant.

Although poor spellers often committed C3 omissions, they also produced relatively many C2 omissions, of sonorants and, to a lesser degree, of obstruents. We concluded from the pattern of correlations that these errors probably reflect uncertainty about the correct grapheme to represent a given C2 phoneme. If this suggestion is confirmed the theoretical problem arises of integrating two seemingly dissimilar spelling problems, those with C2s and those with C3s. Another between-group difference suggested by our data concerns the way in which poor spellers deal with vowels. A further study to define the nature of difference is called for.

Despite a few differences from the research with English-speaking children, a striking similarity appears to exist in the correspondence between spelling and segmentation in Dutch and English. This resemblance suggests that at least some of the phonetic, phonological, and orthographic factors that differentiate the two languages are *not* involved in the genesis of early spelling problems.

Having identified specific error types that are characteristic of poor spellers, two points can be raised about the current study's concept of poor spellers. First, our use of the term to indicate the lowest quartile of spelling performance differs from the way in which the term is commonly used, namely to indicate children who persistently and significantly lag behind their peers in spelling development. The children who participated in our study were at the beginning stages of literacy acquisition, and it is therefore not clear that their problems will persist. The error types identified in the present study and their psycholinguistic basis may thus be a stumbling block for only a short period of time, and most of our poor spellers may soon catch up to their peers. Further study is needed to study the development of children who after half a year of spelling education score in the lowest quartile. Longitudinal studies such as those by Mommers (1987) and Cataldo and Ellis (1988) show that differences in spelling and other literacy skills generally persist. Longitudinal studies are also needed to study the development of error patterns over time. Studies comparing spelling-error patterns for children at the same level of literacy but differing in age (e.g., Carpenter 1983; Moats 1983; Worthy & Invernizzi 1990) show no distinctive pattern for older, disabled subjects, which suggests that the typical segmentation and spelling error pattern observed for poor spellers in the current study may be similar to that for normal and good spellers at earlier stages of development.

The second point pertaining to our conceptualization of poor spellers is that they were identified on the basis of their phonological coding skill (i.e., their spelling of pseudowords). Dual-route theory, however, assumes the existence of an additional domain of orthographic competence, namely knowledge of word-specific spelling patterns. It is possible that some of our poor spellers would have performed at a normal or even good level if this lexical-orthographic knowledge had been called for. One of the questions not answered by the current study thus concerns the relation between the phonological spelling skills in our poor spellers and their word-specific orthographic knowledge.

The suggestion that the difficulties of poor spellers reflect the way in which these children conceptualize the spoken word has clear practical consequences. In adapting spelling education to the needs of children lagging behind their peer, efforts should be concentrated on insight into the nature of spoken words. In doing so, two strategies can be followed. One strategy is to draw attention to the acoustic or articulatory characteristics being disregarded by the speller by exaggerating them in speech (Olofsson & Lundberg 1983). Another strategy is suggested by Treiman et al.'s (1995) claim that reading may be an important factor in making phonological representations correspond to the orthography of written words (see also Ehri 1984). If so, using a written representation of the spoken word or a word scheme (Elkonin 1973) may encourage poor spellers with inadequate phonemic representations to search for the speech characteristics that are represented in the written word. Which of the two instruction strategies is the most effective is a matter for future research. The current results suggest that those children who tend to omit the first consonant of postvocalic clusters are most in need of effective instruction.

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Appendix

The pseudowords used in the experiment and their phonetic transcriptions (cf. Booij 1995).

Practice items			
wum (ʋʏm)	ran (rɑn)	glons (ɣlɔns)	vrust (vrʏst)
Test items			
blipt (blɪpt)	blukt (blʏkt)	brilg (brɪlg)	brimf (brɪmf)
dragt (drɑχt)	drips (drɪps)	dwums (dʋʏms)	dwunk (dʋŋʏk)
flisp (flɪsp)	flungt (flʏŋt)	froks (frɔks)	frongs (frɔŋs)
glofs (ɣlɔfs)	glurn (ɣlʏrn)	grift (ɣrɪft)	gronk (ɣlɔŋk)
klofs (klɔfs)	klurs (klʏrs)	knarp (knɑrp)	knirm (knɪrm)
kruls (krʏly)	kumps (krʏmp)	kwamt (kʋɑmt)	kwost (kʋɔst)
plangs (plɑŋs)	pluns (plʏns)	pralt (prɑlt)	prons (prɔns)
slant (slɑnt)	slurt (slʏrt)	smant (smɑnt)	smift (smɪrf)
snimt (snɪmt)	snulf (snʏlf)	spagt (spɑχt)	spimf (spɪmf)
stalm (stɑlm)	stalp (stɑlp)	trogs (trɔχs)	tromp (trɔmp)
twarg (tʋɑrχ)	twoms (tʋɔms)	vlangt (vlɑŋt)	vlikr (vlɪrk)
vrets (vrɛts)	vrons (vrɔns)	zwolk (zʋɔlk)	zwupt (sʋʏpt)

Note

1. Consonants will be classified as either *obstruents* ('real consonants') or *sonorants* ('vowel-like consonants'). Obstruents are divided into *stops*, produced by completely obstructing and then releasing the flow of air, and *fricatives*, produced by partially obstructing the stream of air so that a slightly hissing sound results. Sonorants are divided into nasals, liquids, and glides. *Nasals* are produced by obstructing the oral cavity with the air escaping through the nose. The articulation of *liquids* is characterized by relatively little obstruction of the flow of air. *Glides* resemble vowels in their manner of articulation but occur in positions usually restricted to consonants. See Table 1 for the consonants from each class used in the experiment.

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