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ON INTERPRETING THE ERROR PATTERN IN BEGINNING READING

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The error pattern in beginning reading was examined from two perspectives: the location of a misread consonant or vowel segment within the syllable and the phonetic relationship between a consonant or vowel and a misreading of it. The first analysis showed, as earlier work had led us to expect, that consonants in the final position in a syllable were more frequently misread than initial consonants. In contrast, the position of a vowel within the syllable had no effect on the frequency with which it was misread. With regard to the second analysis, consonant errors were found to bear a close phonetic relationship to their target sounds, while errors on vowels were essentially unrelated, phonetically, to the vowel as written. The striking differences, demonstrated by the results of both analyses, between the consonants and the vowels were attributed to the different linguistic functions of the two types of segments and to their different representations in English orthography. These findings underscore the importance of non-visual, language-related cognitive operations in reading acquisition.

By analyzing the errors that children make when they read, we can expect to learn something about the underlying difficulties of reading acquisition. However, analysis of beginners' errors can be enlightening only if the errors form patterns, and then only if we can make sense of the patterns in terms of what we know about those processes of language and perception on which the development of reading must depend. Of course, patterns do not reveal themselves automatically. Suitable strategies for examining the errors must be chosen by the investigator, and these naturally reflect one's views of the nature of the problem. That is to say, the choice of strategies for analysis of misreadings reflects our expectations and biases concerning what it is that makes learning to read difficult.

It seems patent to us that many children who lag behind in reading acquisition do not understand the nature of the link between the writing system and the language they already command in speech. Our research has therefore been directed to the problems the child encounters in mapping the letter signs of the written word to the linguistic segments of the spoken word. For this purpose, we have chosen to focus on the child's error pattern in reading isolated words rather than his reading of words in connected text. Our major reason for adopting this approach was a practical one: it is more feasible to assess a child's analytic knowledge of the writing system when the materials used are as free as they can be from the contextual cues supplied by ordinary meaningful discourse. Empirical support for the validity of this approach is provided by earlier studies (Shankweiler and Liberman, 1972) in which we found a high correlation between children's ability to decode isolated words and their ability to read meaningful, connected text with comprehension.

Given the word as the unit for investigation, our strategy was to examine the beginner's misreadings from two perspectives: the location within the word where errors most frequently occur, and the phonetic relationships between the word as written and the child's incorrect renditions.

Phonological Segmentation and Errors in Beginning Reading

The first perspective was suggested to us by the results of an earlier experiment (Shankweiler and Liberman, 1972). In that experiment, we obsesrved that the errors made by beginning readers did, in fact, show a pattern with respect to location within the word. Thus we noted, as others had (Daniels and Diack, 1956; Weber, 1970), that errors on final consonants far exceed those on initial consonants in a consonant-vowel-consonant (CVC) syllable. Additionally, we found that errors on medial vowels exceed errors on consonants in both the initial and final positions.

To account for this observed distribution of errors, we adopted a line of reasoning previously suggested by one of us (Liberman, 1971, 1973) in which it was argued that if the child is to take full advantage of an alphabetic writing system, he must be able to segment the *spoken* word into its component phonological units. That is to say, he first has to recognize that the continuous acoustic signal that constitutes the spoken word may be represented as an ordered string of discrete phonological segments. Second, the child must be able to identify explicitly the set of phonological segments that makes up a given word. Only by so doing can he acquire and use the orthographic rules that map these abstract units of sound onto their appropriate graphic representations. It is not enough that the child merely be able to discriminate words, such as *bag* and *bat,* which differ in one phoneme. Every normal child can do that long before he attains reading age. In order to learn to use an alphabet effectively, more is required than the perception of phonological differences. The child needs to know explicitly that, in the example given, the words each contain three segments and that they are alike in the first and second segments and differ in the third (cf. Gibson and Levin, 1975 and Rozin and Gleitman, in press, for extended discussions of this view).

Several recent investigations (Calfee, Chapman, and Venezky, 1972; Liberman, 1973; Liberman, Shankweiler, Fischer, and Carter, 1974; Rosner and Simon, 1970) of the phonological skills of young children have shown that many do indeed find the task of segmenting the spoken word a difficult one. In our study (Liberman *et al*., 1974) children in three age groups (nursery-preschool, kindergarten, and first grade) were asked to indicate, by means of a tapping game we showed them, the number of phonemes contained in each of a group of high-frequency words. Most of the youngest children were unable to perform the task, as were the majority of the kindergarteners. Even at the end of the first grade, 30% of the children failed. The first-grade children who failed in the segmentation task had considerably more difficulty later in reading acquisition than those who succeeded (Liberman, 1973).

In the light of these findings, it seemed reasonable to suppose that the task of phonological segmentation might also vary in difficulty with the position of a given segment in the syllable. That is, the initial sound in a syllable should be easiest to isolate for the purpose of relating sound to orthographic representation because it can be extracted without extensive analysis of the syllable's sound structure. Obversely, the final segment would be more difficult because just such an analysis would be required. The medial sound might be the most difficult to analyze because it is entirely embedded within the syllable. A report by Rosner and Simon (1970) seems to support these conjectures: when a child is asked to reproduce an auditorily presented word, but to leave out a specified consonant sound, he experiences the greatest difficulty with the medial consonant sound and the least difficulty with the initial sound.

One way to account for the error pattern observed in our earlier experiment, then, is to consider that it reflects the differential difficulty that the beginning reader experiences in segmenting sounds occurring in the initial, medial, and final positions in the syllable. Such an account would attribute the error difference we obtained between medial vowels, final consonants, and initial consonants to the relative *positions* within the syllable occupied by the different types of sounds and not to differences among the sound-types themselves.

Although the data of our previous experiment (Shankweiler and Liberman, 1972) are consistent with such an interpretation, controls were lacking that would enable us to rule out other possible interpretations. An adequate test of the hypothesis would require first that the set of consonants occurring in syllable-initial position be identical with the set that occurs in syllable-final position. Additionally, it would require that the vowel also occur in initial and final position, not only in the medial position as was the case in our earlier experiment. If, in a test designed to incorporate these controls, errors on initial, medial, and final segments again rank as before, then we can conclude with more assurance that the order of difficulty reflects a true position effect for both consonants and vowels.

Accordingly, for the present experiment, we developed two word lists designed to meet these requirements.[1] In List 1, the 19 consonant phonemes that can occur in both the initial and in the final positions of a word appeared twice in each position.[2] In List 2, the seven vowel phonemes that can occur in the initial, medial, and final segment positions in a monosyllable appeared three times in each position. The items comprising both the vowel and the consonant lists were monosyllable words, which insofar as possible were familiar to third-graders (Buckingham and Dolch, 1936). At the same time, we avoided words that typically are included as items for memorization in primary-grade reading texts.

The lists were presented in a single session.[3] The order of list presentation was balanced across subjects, and the order of words in each list was randomized. The test

[1] *Ideally, it would have been desirable to provide both the consonant and the vowel controls within one list. Contingencies relating to reading and vocabulary level made this impossible to achieve.*

[2] *Medial consonents were excluded from the test list, as they had been in the earlier experiment. Their inclusion would restrict us to a very small set of consonants unless we allowed disyllables. Disyllables were avoided because we did not wish to introduce problems of syllable segmentation into the reading task.*

[3] *A third list, used to study orthographic complexity, was presented at the same time. It will be described in a later paper.*

TABLE 1

Errors on initial and final consonants and on medial vowels (List 1) presented as proportions of opportunity for error (decimal points omitted).

Grade	*IC*	*FC*	*MV**
2	08	16	27
3	05	10	15
4	02	06	08

* Occurrences not controlled

words were printed with a black felt-tip pen on separate unlined 3 x 5-inch file cards. The cards were placed face down in front of the subject and were turned over one by one by the examiner. The subject was asked to read each word as it was presented and to give his best guess if he did not know the word. Responses were phonemically transcribed by the examiner and were recorded on magnetic tape for later checking.

The subjects were children of the second, third, and fourth grades, 20 from each grade, chosen alphabetically from the rosters of male and female students in a public elementary school in Andover, Connecticut. Testing was done in the late fall and early winter.

The Segment Position Effect in Consonant Errors

The distribution of phoneme frequencies in English is not the same in syllable-initial and in syllable-final segment positions. In order to control for possible effects of this difference, List 1 was constructed so that the same set of consonant phonemes appeared in each position. Despite this control, the error difference obtained in our earlier experiment was replicated. As can be seen in Table 1, final consonant (FC) errors continue to exceed initial consonant (IC) errors. The direction of the difference is the same at every grade level, and is consistent with the predicted rank ordering of difficulty of the initial and final segments in the syllable.

An analysis of variance performed on the data indicated that the effect of consonant position was highly significant, $F(1,57) = 44.80$, $p < 0.001$. As expected, there was also an increase in performance level with grade, $F(2,57) = 4.10$, $p < 0.025$. The grade-by-position interaction was not significant.

Although the identity of the phonemes that occurred in each segment position of the words was controlled in List 1, their orthographic representations were not controlled. Therefore, a further analysis was performed to ascertain that the larger FC error rates could not be ascribed to differences in the frequency or ease of apprehension of the different sets of orthographic representations that occur in the initial and final positions. For the purposes of this analysis, orthographic complexity was defined in two ways. First, it was defined in terms of the number of possible orthographic representations per phoneme. In this sense, a phoneme that can be spelled in many ways is more complex than one with few orthographic representations. Second, complexity was defined in terms of the number of letters in each orthographic representation. For example, "tch" would be more complex than "c". For the purposes of the following

TABLE 2

Errors on orthographically complex and simple sounds.† Errors presented as proportions of opportunity for error (decimal points omitted).

	Complex		Simple	
Grade	*IC*	*FC*	*IC*	*FC*
2	09	24	06	08
3	06	13	03	07
4	03	09	01	03

† Complex: /f,j,k,m,s,θ,ð,č,š,z/
Simple: /b,d,g,l,n,p,t,r,v/

TABLE 3

Errors on initial, medial and final vowels and on initial and final consonants (List 2) presented as proportions of opportunity for error (decimal points omitted).

Grade	*IV*	*MV*	*FV*	*IC**	*FC**
2	47	43	43	17	32
3	28	27	31	09	19
4	20	12	19	04	11

* Occurrences not controlled

analysis, both criteria were used—that is, a phoneme was considered orthographically complex if it could be spelled in more than one way, but it also was considered complex if its single orthographic representation consisted of more than one letter. Based on these criteria, the consonent phonemes were separated into "simple" and "complex" categories.

In Table 2, IC and FC errors in the simple and complex categories are presented as proportions of opportunities for error. If orthographic complexity were the sole basis for the FC/IC difference, removing the phonemes on which FCs and ICs differ with respect to orthographic complexity should equalize the error rates.

However, it may be seen from Table 2 that the error rates are not thereby equalized. It is true that errors in both positions in the syllable are higher when the orthography is complex than when it is simple. To be sure, the orthography is a source of error for the beginning reader. But orthographic complexity cannot account for the FC/IC difference, because that difference is present even in the "simple" category whose member phonemes are simple both in the syllable-initial and syllable-final position with respect to the indicated criteria.

Apparently then, neither phonemic distribution within the syllable nor orthographic complexity can account for the FC/IC difference in error rate. The difference, therefore, must be truly a position effect, that is, an effect of the location of a given phoneme in the syllable. Final-consonant segments are more difficult than IC segments because they are in the syllable-final position.

The Segment-Position Effect in Vowel Errors

It can be seen from Table 3, which displays the error scores for the vowel-controlled list of words, that the vowels do not show the marked position effect of the consonants.

The analysis of variance revealed only a marginally significant effect of segment position, $F(2,114) = 4.61$, $p < 0.025$. Again, there was an increase in performance level with grade, $F(2,114) = 11.08$, $p < 0.01$, and the interaction was nonsignificant.

Analyses performed separately on the error scores for each grade show that the position effect for vowels was statistically significant at one grade level, the fourth grade. This is in contrast to the position effect for consonants, which was significant in all three grades. Post-hoc means tests of the fourth-grade vowel data indicate that two significant differences accounted for the significant F values: errors on vowels in the initial position and in the initial and final positions combined both significantly *exceeded* errors on vowels in the medial position. Thus, if a segment-position effect for vowels can be said to exist at all, it must be attributed to the significantly *fewer* errors on medial than on initial and final vowels (and then only for the fourth-grade subjects).

The Rank Ordering of Consonant Errors and Vowel Errors

We can new re-examine the vowel>final-consonant>initial-consonant rank ordering of errors that we observed in our original experiment. It should first be noted that because both the consonants and vowels could not be controlled within a single list, the consonant-vowel error hierarchy cannot be directly examined within either List 1 or 2. However, as can be seen in Tables 1 and 3, if vowel errors are scored in the consonant-controlled list and consonant errors in the vowel-controlled list, the vowel> final-consonant>initial-consonant hierarchy of error frequency is replicated at every grade level within both lists. It is clear that whereas vowels in any position elicit more errors than consonants, the initial-final difference among the consonants is maintained.

On the consonant-controlled list of the present experiment, the difference in error rate between the final consonants and the initial consonants found earlier was replicated even after phonological and orthographic differences between the two categories had been removed. The discrepancy, then, may be attributed to some difference in difficulty between the initial and final segment positions of the consonants in the syllable and not to the particular consonant phonemes or the orthographic patterns that tend to occur in the two syllabic locations.

On the other hand, the preponderance of vowel over consonant errors that we obtained in our earlier experiment can no longer be attributed to the embedded position of the vowel within the syllable. The results obtained with List 2 indicate that vowels are approximately equal in difficulty across the three syllable locations. We may conclude, therefore, that the vowels in our earlier experiment were more difficult than the consonants for the beginning readers, not because of their embedded location within the syllable, but, rather, because of characteristics specific to vowels and not present in consonants.

In summary, we have looked to see where the errors are made in the syllable and have concluded that there is a position effect for the consonants. Syllable-final consonants give rise to twice as many errors as syllable-initial consonants. The position-related errors can therefore be viewed as an outcome of the difficulties of phonological segmentation. However, the frequency of vowel errors was not affected by the position of the vowel segment within the syllable. Therefore, we cannot regard the child's difficulties with vowels as a reflection of his inability to segment the syllable.

It may be argued (Liberman, 1973) that if the child's segmentation skills were improved, his difficulties with the vowels would not be a severe handicap to him in deciphering the text. This might be expected because the consonants carry the major information load in the word. If the child were able to assign correct sounds to the consonants in proper sequence, an incorrect rendition of the vowels would be corrected fairly easily in context.

The Nature of the Phonetic Errors in Beginning Reading

Having considered the location of the errors, we turn our attention now to an examination of their nature. We found both in this experiment and a previous one (Shankweiler and Liberman, 1972) that vowels generate more errors than consonants. It is appropriate to ask in what way the errors might be different in the two phonetic classes. Our purpose in the following analysis was to look for phonetic relationships between the misread segment and the target segment. Of course, in ordinary reading the lexical and broader linguistic context may affect the choice of the guessed-at word. We deliberately minimized the contribution of context, as we have said, in order to be able to assign a relatively unambiguous interpretation to the errors that occur.

Because the experiment required the children to read the words aloud, all of them presumably had to make a transformation from a visual to a phonetic representation. We may be sure then that the child is recoding the material phonetically as he reads and we can examine, segment by segment, the phonetic relationship between the child's misreading and the segment that would be produced in that position if the word were read as written. In order to make the examination, we have adapted techniques used by other investigators to examine errors of speech perception. There is much evidence from investigations of speech perception (see, for example, Miller and Nicely, 1955) that phoneme segments are themselves compounds of a small set of phonetic features and that errors in perceiving speech by ear can be understood on a feature basis. That is, a substituted phoneme, more often than not, is only a partial error, in the sense that it preserves features in common with the presented segment.

Recent data obtained by Eimas (in press) show that the pattern of consonant errors made by six- and seven-year-old children in recall of strings of visually presented nonsense syllables resembles extremely closely the pattern obtained with auditory presentation. Errors having more than one distinctive feature in common with the presented phoneme occurred significantly more frequently than errors sharing one or no features with the presented phoneme. These findings would lead us to expect that as the child reads, he recodes the input into a form that can be described in terms of a phonetic feature matrix.

If errors arise in the transformation from print to a phonetic code, then the pattern of errors due to misreading might be expected to resemble that due to mishearing. Thus, there is reason to expect that the frequency of misreading would vary directly with the number of features shared between the presented and the misread segments. Factors other than degree of phonetic contrast, however, are likely to be involved in the misreadings of vowels. Whereas the rules relating spelling to phonetic segment are relatively straightforward for consonants, they are quite complex for vowels. For this reason, we might expect to find not only that more errors occur on vowels than on consonants, but also that the nature of the substitutions may be different for the two phonetic classes.

Feature Substitution Errors Among Consonants

To determine whether the misreadings among consonants pattern non-randomly, we needed a way to quantify the phonetic distance between any two consonants. We also needed a way of comparing the observed frequency of errors at a given phonetic distance from a target phoneme with the frequencies that would be expected if the children were randomly assigning phonemes to letters.

For the purposes of this investigation, we defined phonetic distance in terms of the number of distinctive features shared by an error response and a target phoneme. Three features—voicing, place of articulation, and manner of articulation—describe the English consonants adequately, providing each with a unique feature description. For example, since /b/ and /p/ share two features, they are considered phonetically similar; /b/ and /s/, which share no features, are dissimilar. Each error response was classified in this manner, according to the number of features it shared with its respective target phoneme. The frequency of error responses in each of the phonetic-distance categories (zero, one, or two features shared) was tallied separately for children of each grade.

Frequencies expected by chance were calculated by constructing a 19 x 22 triangular matrix with the 19 target phonemes (that is, the 19 consonants that appeared in List 1) represented vertically and the complete set of the 22 consonants of English represented horizontally. Each cell of the triangular matrix thus uniquely represented a target phoneme paired with a possible error response. For the purpose of conducting a statistical test, we made the assumption that a child responding randomly would choose his responses only from among the set of English consonants, and that he would choose indiscriminately among members of that set. In each cell were listed the features shared by the appropriate target phoneme and error response. The number of cells with entries containing zero, one, or two features shared by the target consonant and each possible erroneous response were tallied separately. These were expressed as proportions of errors that would be expected to share zero, one, or two features with the target phoneme if the children were assigning phoneme categories to letters on a random basis. The total number of errors for each grade was multiplied by each proportion, thus providing an estimate of the number of errors expected to fall into each phonetic distance category under the assumption of randomness. These expected frequencies were statistically compared with the obtained frequencies using the χ-square analysis. Table 4 presents the obtained and expected frequencies and the value of χ-square by grade.

The finding that reading errors are distributed nonrandomly tells us only that the children are employing *some* strategy in their attempts to read. This, by itself, is hardly remarkable. The results shown in Table 4 permit us to draw a more specific conclusion, however. Our expectation that the child's errors would be governed by phonetic feature relationships appears to be strongly supported by consonant data. As can be

TABLE 4

Observed and expected frequencies of consonant errors sharing zero, one, or two features with the target sounds.

Grade	Number of shared features							
	0		1		2			
	observed	expected	observed	expected	observed	expected	Chi-square	p
2	11	44	43	65	81	28	132.5	< 0.001
3	8	25.1	22	37.2	47	16.8	72.2	< 0.001
4	3	12.4	13	19.6	26	10.5	32.2	< 0.001

seen in Table 4 the χ-square values for each grade are significant, with $p < 0.001$.

The proportion of consonant errors falling into the two-feature-shared category is remarkably stable across the grades: 60% of second-grade errors, 61% of third-grade errors, and 62% of fourth-grade errors share two features with their appropriate target phonemes. The results suggest, therefore, that phonetically motivated substitutions contribute substantially to the consonant-error pattern both at the very early stages of reading acquisition and beyond.

Feature Substitution Errors Among Vowels

Vowel errors were treated in much the same way as the consonant errors. A number of feature systems for vowels has been proposed, but none has won such strong empirical support as to give a clear basis for choice. The feature system we used was a modification of that proposed by Singh and Woods (1971). Their system distinguishes among 12 nondiphthongized American English vowels. Three of their features—tenseness, tongue advancement, and tongue height—distinguish among 11 of the vowels. A fourth feature, retroflexion, distinguishes only the vowel /ɝ/ from other vowels. Since /ɝ/ is an infrequent response in our data, we did not incorporate this feature in our analysis. In its place we added the feature, diphthongization, in order to distinguish the vowels /ᶦu/, /aᵘ/, /aᶦ/ and /ɔᶦ/ from their non-diphthongized counterparts /u/, /a/, and /ɔ/.

The vowel errors, like the consonant errors, were classified according to the number of features they shared with their respective target phonemes. The frequency of errors in each phonetic distance category (zero, one, two, or three features shared with the target) was again compared with the frequencies which would be expected if the child were randomly assigning phonemes to spellings.

The results of the vowel feature analysis, shown in Table 5, reveal a picture very different from the comparable analysis of consonant errors. The table gives grouped frequencies of errors on the vowel classified according to the number of features shared with the target vowel. Again, expected frequencies are calculated on the null assumption that the distribution of errors within these categories is random. Whereas for con-

TABLE 5

Observed and expected frequencies of vowel errors sharing zero or one feature, or sharing two or three features with the target sounds.

Grade	Number of shared features 0-1		2-3			
	observed	expected	observed	expected	Chi-square	p
2	285	304	262	243	2.67	> 0.10
3	180	191	170	158	1.54	> 0.20
4	110	118	105	96	1.38	> 0.20

sonants the effect of phonetic distance was significant across all grades, the vowel errors displayed in Table 5 reveal no consistent direction in the differences between observed and expected frequencies. Thus, for vowels, it appears that given the occurrence of an error, the assignment of phoneme to grapheme was random.

The contrasting results obtained for vowels and consonants are indeed striking. The opposition of these phonetic classes is revealed by both approaches to error analysis: the first, in which we investigated misreadings in relation to their location in the syllable, and the second, in which we consider the phonetic characteristics of the errors. From the latter analysis, we are led to conclude that the concept of degree of phonetic contrast, so successful in rationalizing the errors on consonants, does not enable us to understand the vowel errors. For these, other sources of difficulty must be sought.

At all events, these differences in error pattern between the consonants and vowels lend credence to the position taken by us and other investigators (Liberman, Shankweiler, Orlando, Harris, and Bell-Berti, 1971; Vellutino, Pruzak, Steger, and Meshoulam, 1973; Vellutino, Steger, and Kandel, 1972) that visual factors are not sufficient to account for the difficulties of the beginning reader. Surely problems in scanning, eye movements, and/or the apprehension of the optical form of letters cannot explain the differences in consonant and vowel error patterns that we have found. The set of letters that represents the consonants is not marked in any distinctive way from the set of letters that represents the vowels; the differences in error pattern therefore could not be related to a classification made on a visual basis. Consonants and vowels do, on the other hand, form distinctive categories in the language and have different functional roles in communication.

Considered from the standpoint of their contribution to the phonological message, consonants carry the heavier information load. Vowels, on the other hand, are the foundation on which the syllable is constructed, and as such are the carriers of prosodic features, It is the vowels that are more subject to phonetic variation across individuals and dialect groups, and more subject to phonetic drift over time. As we suggested in an earlier paper (Shankweiler and Liberman, 1972), the relatively greater variability of vowels than consonants may in part account for the different ways these segments are presented in the orthography. It may account for the fact that in English, at least, there tend to be many spellings for each vowel and more nearly one-to-one spelling-to-sound relationships for the consonants.

Summary and Conclusions

The errors children make in reading, before they have fully mastered the art, can teach us something about the special problems of learning to read. In an earlier study, we observed, as others have, that errors on the final consonant of a CVC syllable far exceed those on the initial consonant. Additionally, we found that errors on medial vowels exceed those on consonants in both initial and final position. The first purpose of the present study was to confirm these earlier findings and, by the use of various controls, to test their generality.

We found the same pattern of consonant errors as previously obtained, with those in final position being misread twice as often as those in initial position. As a result of the controls introduced in the present study, we can now conclude that the findings represent a true position effect. It cannot be attributed to a different phonological distribution of consonants in syllable-initial and in syllable-final position, nor can it be attributed to differences in the orthography associated with beginnings and ends of words. Having ruled out these interpretations of the position effect, we believe the greater difficulty of the final consonant is the result of the child's defective understanding of the phonological segmentation of his spoken language. We know from earlier work of our own and others that inability to indicate the phonemic segmentation of *heard* speech is characteristic of the prereading child. Given the difficulty in becoming explicitly aware that syllables may be analyzed into strings of phonological segments, it seemed reasonable to suppose that the task of phonological segmentation might vary in difficulty with the position of a given segment in the syllable. On this basis, the initial segment should be easiest to isolate because it can be extracted without analysis of the internal structure of the syllable.

In contrast to the findings on consonant misreadings, errors on vowels show no effect of position. When we placed the vowel in initial, medial, and final position in the syllable, the errors did not vary in any systematic fashion. We suppose, therefore, that vowel errors do not reflect primarily the child's difficulties in phonological segmentation, but rather the complexity and variability of the spelling-to-sound correspondences.

The assumption that consonant and vowel errors have different causes was supported by the results of a further analysis that took account not of the location of the errors, but of their nature. In that analysis, it was found that consonant errors were systematically related to the presented phoneme, differing from it most often in only one feature. Vowel errors, in contrast, were not systematically related to the phonetic features of the presented vowel; indeed, the feature distribution of the vowel errors was essentially random. Such differences in the distribution of errors on consonants and vowels in reading may reflect the different functions of those phonetic classes in speech. Perhaps the most general implication of these differences in error pattern between consonants and vowels is that they underscore the importance of non-visual cognitive processes in reading. These findings lend confirmation to our belief that visual factors contribute rather little to the difficulties of beginning reading—certainly less than factors relating to the language, such as awareness of phonological segmentation, phonetic recoding, and the structure of the orthography.

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