APPREHENDING SPELLING PATTERNS FOR VOWELS: A DEVELOPMENTAL STUDY*

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This study investigates the extent to which children and adults are responsive to orthographic regularities in their readings of nonsense syllables that conform to the phonology and spelling conventions of English words. College students and children of the second, third and fourth years of elementary school read a list of nonsense monosyllables in which most common vowel spellings were presented. Their vowel responses were analyzed according to three categories: incorrect assignment of sound to spelling and correct assignments by context-free and context-dependent criteria. At all levels of reading experience, the proportions of responses falling into the two latter categories far exceeded expectations based on chance responding. These results showed that the children were able to take advantage of orthographic regularities when asked to read unfamiliar words, and, moreover, with increasing age and reading experience they were able progressively to delimit the contexts in which the different regularities apply. The implication is that in learning to read, children do not merely add items to a sight vocabulary by rote recognition of unanalyzed word wholes. Instead, they acquire a practical knowledge of spelling patterns which can readily be applied to new instances.

INTRODUCTION

The errors children make in oral reading provide a window through which we may view the special problems of learning to read. One error pattern in particular merits further scrutiny because it is found so consistently in the misreadings of the beginning reader of English. We refer to the phenomenon (see Venezky, 1968; Weber, 1970) that misreadings of vowels occur with greater frequency than misreadings of consonants.

In two earlier investigations from our research group (Shankweiler and Liberman, 1972; Fowler, Liberman and Shankweiler, 1977), we reported that vowel misreadings occur about twice as frequently as consonant misreadings in children's oral reading of isolated words. In the latter paper we considered the possibility that the greater frequency of vowel errors might be an artifact of the syllable structure. Since all the test words used by Shankweiler and Liberman (1972) were monosyllables of the CVC type, the obtained result in that study could have been due entirely to the medial position of the vowel; that is, an embedded segment might be more difficult to apprehend than an initial or

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a final segment. That possibility was eliminated by the more recent investigation (Fowler *et al.*, 1977), which showed that vowels in initial, medial and final position are equally difficult for beginning readers, and that they generate more errors than consonants regardless of position.

Given this result, we next asked whether the error pattern in reading reflects the linguistic properties of consonants and vowels. Specifically, we might attribute the differential difficulty of vowels and consonants in reading to properties that distinguish them phonologically. We know from speech research that vowels are typically less clearly defined categorically than consonants in speech production and perception (Liberman, Cooper, Shankweiler and Studdert-Kennedy, 1967). Moreover, they are the more fluid and variable of the two classes of phonetic elements, being more subject to phonetic variation across individual and dialect groups. Finally, vowels and consonants have different functional roles in English phonology. For example, vowels are the foundation on which the syllable is constructed and as such are the carriers of prosodic features, while consonants carry the heavier information load.

In view of these major linguistic differences between consonants and vowels, we should expect the misreadings of these phonetic classes to differ not only in frequency but also in the nature of the error pattern. That is indeed what we found in a recent study (Fowler *et al.*, 1977). In that experiment, misreadings were tabulated according to the number of phonetic features shared between the phonological segment of the target word and that of the word as read. Consonant substitutions were found to bear a close phonetic relationship to the consonants of the target word. On the other hand, vowel misreadings were no more similar phonetically to their target segments than would be expected under the assumption of random assignments of sound to spellings.

A difference between the reading behavior with consonants and vowels was expected, but the particular outcome with vowels was puzzling. Why do the child's misreadings of vowels not pattern phonetically?

Three possibilities come to mind. One possibility is that the vowels do, in fact, pattern phonetically, but our analysis did not reveal the pattern because vowels are simply not readily amenable to a feature description. Provided that this is not the case (and we have no way of assessing this at present), a second possibility is that the children studied by Fowler *et al.* (1977) tended to adopt a holistic strategy for reading words. Thus, given an unfamiliar word, the child made a guess that was constrained by the identity of the consonants in the word, but was less constrained by the vowels. (Recall that consonants carry the heavier information load in a word.) Thus the children's readings of consonants were accurate or nearly so, while readings of the vowels tended to be random with respect to their target phonemes.

A third possibility is that the children attempted to "sound out" each unfamiliar word by transforming its several orthographic patterns into their phonetic correlates. In English, the spelling-to-sound relationships among vowels are substantially more complex than those among the consonants in the sense that many more vowel than consonant spellings may correspond to a given phoneme (see Dewey, 1970). This characteristic of the vowel orthography may be due in part to the lesser stability of vowels in speech production and perception, as we have suggested.

If children use this analytic strategy in reading by assigning phonological segments to the orthographic patterns of a word, we may expect their misreadings of vowels to bear a relationship to the target phonemes that can be rationalized on orthographic grounds. That is, a child's misreading of a particular vowel spelling should result in the substitution of a phoneme that is possible for that spelling in the context of other words even though it is not correct in the given word. For example, a child should misread *have* as [heiv] more frequently than as [hɛv], because the phoneme /ei/ typically corresponds to the vowel spelling *a-e*, while the phoneme /ɛ/ does not.

We do not wish to propose that children adopt either the holistic or the analytic strategy exclusively when they read an unfamiliar word. However, the focus of our research is on the analytic strategy and elsewhere we have discussed its powerful advantages (Liberman, Shankweiler, Liberman, Fowler and Fischer, 1977; see also Gibson and Levin, 1975). Previously we have assessed the child's ability to analyze the phonetic structure of a written word (Shankweiler and Liberman, 1972; Fowler Liberman and Shankweiler, 1977). Here we expand that line of research to consider the effect of the orthography on the child's reading behavior. Thus, the present experiment is designed to ask to what extent the children take the orthographic pattern into account as they attempt to read unfamiliar letter strings. Its broad purpose was to obtain evidence that bears on the question of whether with age and experience children learn the regularities of English orthography so that they can generalize to novel instances, or whether they more typically acquire a reading vocabulary in rote fashion.

Venezky (1974; Venezky and Johnson, 1973) has provided some evidence related to this question. He has examined the child's practical knowledge of a small number of spelling-to-sound regularities (in particular, the pronunciation of *c* and *g* before *e, i, y* and *a, o, u;* the silent-*e* rule). In general he has found a regular growth with reading experience in the child's ability to assign appropriate sounds to these spelling patterns when they appear in unfamiliar contexts.

Since our previous research has indicated that vowels *as a class* are difficult for the beginner, we adopt here a somewhat different focus from Venezky's on individual spelling patterns, and investigate a broad and representative sample of vowel spelling-to-sound correspondences.

EXPERIMENT

The experimental task involves a list of nonsense syllables to be read aloud. Most spellings of English vowels are represented, all with equal frequency insofar as possible. By requiring the child to read nonsense syllables instead of real words, we may obtain a measure of ability to recognize orthographic regularities that is uninflated by rote recognition of familiar words as unanalyzed wholes.

Method

Stimulus materials. The nonsense list was composed of monosyllables in which each

of 34 English vowel spellings occurred (where posible) in initial, medial and final syllable position. (The spellings are: *a, a-e, ai, au, aw, ay, e, e-e, ea, ee, ei, eigh, eu, ew, ey, i, i-e, ie, igh, o, o-e, oa, oe, oi, ou, ow, oy, u, u-e, ue, ui, uy, y-e, ye.*) There were 96 items in the list. To equalize, as far as possible, the difficulty of the consonantal context across the different vowel representations, the consonant set included only the stops (*b, d, g, p, t, k*). Examples of nonsense words in the list are: *ud, deg, tuy.* The words were printed in lower case on separate unlined 3 x 5 inch file cards. The order of words in the list was random, and every subject received the same random ordering.

Subjects. The subjects were second, third and fourth graders from an elementary school in Andover, Connecticut, and a group of 20 undergraduate students at the University of Connecticut. The names of the elementary school children were chosen alphabetically from the lists of male and female students of each grade. Ten boys and ten girls were tested at each grade level. Testing was done in late fall and early winter.

Procedure. The set of syllables was presented individually to the school children in a single 20-minute session in which (excluding the adult subjects) they also read two real-word lists described elsewhere (Fowler *et al.*, 1977). The order of list presentation was balanced across subjects. The adult subjects received only the nonsense list.

The index cards were placed face down in front of the subject and were turned over one by one. The subjects' task was to read each item as it was presented, giving their best guess if they were uncertain how to pronounce it. The children were informed in advance that the items were "pretend" words; the adults were told that the items were "nonsense" words.

The subjects' responses were transcribed by broad phonetic transcription, using the IPA system. An acoustic record was also made on magnetic tape.

Scoring procedure. Working from the phonetic transcriptions, we scored the responses in two ways. First we considered the vowel produced in response to each test item and asked whether it was a possible reading of the letters representing the vowel, according to the tables constructed by Dewey (1970). Since here we take account of the vowel alone without regard to its consonantal context, we call it *context-free* scoring. In the second scoring system we applied conventions[1] of English orthography to the whole syllable and asked whether the vowel as read by the subject was a possible reading of the vowel letters in the particular position in the syllable in which they occurred. Thus, this scoring is *context-dependent.*

To give an example: the response [teid] to the syllable *tade* is an orthographically possible response according to both context free and context-dependent scoring systems.

[1] *The context-dependent subset was difficult to establish. Dewey's (1970) tables are not appropriate for establishing the subset because they do not separately tabulate monosyllables and multisyllabic words. For this reason Hockett's (1963) tables were used here. These tables list all possible phonemic realizations of a spelling as a function of its location in a monosyllable. For the purposes of the present analysis, all sounds listed in Hockett as appropriate for a spelling in the initial, medial or final syllable positions were counted as appropriate responses for that context, provided they were judged to be not too rare.*

TABLE 1

Mean percentage of orthographically possible responses (and standard deviation) in the nonsense list*

Grade	Context-free	Context-dependent	Average difference
2	57.7 (8.4)	50.7 (11.5)	7.0
3	67.0 (12.0)	60.7 (13.1)	6.3
4	69.3 (12.5)	68.0 (11.7)	1.3
Adult	81.3 (6.3)	79.3 (5.9)	2.0

*see Footnote 2.

It is indeed an instance of a pattern that occurs in many English words, vowel-silent *e*, as in *fade* and *made*. However, the response [teid] to the syllable *tad* would not pass the context-dependent criterion, although it would in the context-free system. The response [tid] would fail by both criteria as a reading either of *tade* or *tad*.

Results

The results of the analysis are presented in Table 1, in which responses are expressed as proportions of opportunity to respond. The results are collapsed over position of the vowel within the syllable, because this variable did not affect performance. The "context-free" category refers to the whole set of responses correct by either scoring criterion; the "contextually-dependent" category refers to the subset of responses that were correct by the more stringent context-dependent scoring system.

The most notable result is the extent to which the proportions of correct readings of the vowels exceed the chance value[2] by either the context-free or the context-dependent criterion. Even among second-year pupils, the proportion of correct responses exceeds

[2] *Chance is approximately 22% for the context-free category and 11% for the context-dependent category. Chance for the context-free category was computed by summing the possible phonetic realizations for each spelling used in the nonsense-word list (from Dewey, 1970) and dividing by the number of spellings in the list. The outcome of this computation is the average number of possible phonetic realizations per spelling. That value, divided by 15, the number of vowel phonemes in English, gives the probability that a given phonetic response to a spelling if it is selected randomly, will be a possible response for that spelling. Chance for the context-dependent category was computed in the same way except that, as explained in the methods section, the criterion for inclusion of a sound as a possible phonetic realization was more stringent.*

chance by a factor of 2.6. Thus, even readers with just over a year of instruction in reading and writing are able to utilize the regular relationship between sound and spelling to decode new items.

The proportion of responses in the context-free and context-dependent categories was subjected to an analysis of variance with one between-groups factor, grade level, and one repeated measure, scoring method. The proportion of correct readings in both categories of scoring method increased with age and experience [$F(3,76) = 17.81, p < 0.001$].

The acquisition of orthographic rules is by no means complete in the oldest children we tested (fourth year in the elementary school); adults surpass them by a wide margin ($p = 0.02$ according to a Scheffé's test). Because the test items were nonsense syllables and not actual words, the increases cannot be attributed to an increase in the size of the vocabulary of familiar words that can be recognized holistically. Apparently readers continue to acquire orthographic rules or intuitions as reading skill improves.

The figures in the third column of Table 1 indicate that not only do children acquire new spelling patterns for vowels as their reading experience grows, but they show increasing sensitivity to the contexts in which each of the possible spellings applies (as in our earlier example, the silent-*e* marker). Again, even the youngest children (second year) show considerable discretion in their choices from among the possibilities; that is, their performance well exceeds chance by the more stringent context-dependent criterion as well as by the context-free criterion.

Turning to the fourth column of Table 1, we may note the average amount by which performance as assessed by the more lenient criterion exceeds performance by the more strict criterion, that is, the context-free/context-dependent difference. That difference decreases systematically between the second and fourth years as the context-dependent responses come to constitute an increasingly greater proportion of the context-free responses. A progressive increase in the proportion of context-dependent responses can be taken to mean that the reader is acquiring context-sensitive spelling-to-sound regularities as his experience increases, since there is no reason to expect that the proportion of context-dependent responses should change if the reading vocabulary expands merely by rote learning. In the present data, the decrease with reading experience in the difference between the context-free and context-dependent responses is marginally significant [$F(3,76) = 2.30, p = 0.08$]. However, as we will show now, the same pattern appears in an analysis of data on the reading of real words obtained in a previous experiment (Fowler, Liberman and Shankweiler, 1977).

The real-word data were collected from the same elementary-school children as the nonsense data. Briefly, the real word list included 63 monosyllables in which seven vowel phonemes, /i/, /ei/, /a/, /ai/, /au/, /ɔ/, and /ou/ appeared three times each in the initial, medial and final positions in the monosyllable. All were words selected to be familiar by sound to second-grade children. Additional information concerning the properties of the real word list is given in Fowler *et al.* (1977).

The analysis performed for the present purposes on the real-word data is analogous to that performed on the nonsense data. The results of the analysis are shown in Table 2. The higher overall performance level on the real-word lists as compared to the non-

TABLE 2

Mean percentage of orthographically possible responses (and standard deviation) in the real word list*

Grade	Context-free	Context-dependent	Average difference
2	73.7 (13.6)	63.3 (19.5)	10.4
3	84.3 (15.3)	78.0 (16.9)	6.3
4	90.0 (7.7)	86.3 (11.3)	3.7

*see Footnote 2.

sense list is consistent with previous findings (Liberman, Shankweiler, Orlando, Harris and Bell-Berti, 1971). Familiarity of the items of the real-word list would probably account for the difference. The results of the analysis are in good agreement with the findings on the nonsense words with regard to the point at issue. As in Table 1, the context-free/context-dependent difference decreases with the age and experience of the reader. In these data, the difference is significant [$F(2,57) = 8.85, p < 0.01$]. Thus we may be fairly confident that this decrease is reliable.

A final analysis was performed to assess the degree of relationship between a child's ability to read real words and his ability to apply spelling-to-sound rules. The analysis was intended to provide an indication, albeit indirect, of the contribution of spelling-to-sound decoding skills to skill in reading individual words.

For the purposes of this analysis, we correlated the percentages of context-free and context-dependent, orthographically possible responses to the nonsense words with a measure of each child's ability to read real words. The second measure was the number of words read correctly among the 63 words of the real-word list described earlier. Correlations were computed separately for each grade. The six correlations (three grades by two categories of orthographically possible responses) ranged between 0.77 and 0.91 and were all highly significant. Thus, between 59% and 82% of the variation among scores on the real word list is accounted for by individual differences at each grade level in ability to apply spelling-to-sound correspondences. There is no difference in the magnitude of the correlation across grades, nor any tendency for either the context-free or the context-dependent responses to correlate more highly with real-word reading skill.

DISCUSSION

In this experiment, we were concerned to assess the children's practical knowledge of the regular correspondences between sound and spelling in English orthography. Our results show that children know and use these regularities when they are asked to read unfamiliar words. Indeed the data indicate that readers with as little as one year of reading training[3] rely heavily on their knowledge of orthographic regularities to read unfamiliar words. However, this knowledge is limited in two ways. First, the children's responses are orthographically correct less than 60% of the time, indicating that they have not yet acquired the full repertoire of spelling patterns for each vowel spelling. Second, they are less able than the more skilled readers to use context to further restrict the range of possible alternatives. Their knowledge of spelling-to-sound regularities is less context-sensitive than that of more experienced readers. This limitation would be expected to contribute heavily to errors on vowels but much less on consonants that map in a more nearly one-to-one fashion.

Indeed, our reanalysis of the real-word data reported in Fowler *et al.* (1977) indicates that the responses on vowels, although they did not pattern phonetically in that experiment, can be characterized as moderately sophisticated guesses based on knowledge of orthographic regularities. That is, when a child made an error assigning a sound to a vowel spelling, he was likely to substitute a sound that is a possible sound for that spelling.

The next experimental question to ask, perhaps, concerns what it is that children learn as their practical knowledge of spelling-to-sound correspondences grows. The present experiment does not help to answer this question, but two possibilities come to mind. On the one hand, children may acquire a set of correspondence *rules* either tacitly or explicitly. Experience in reading, then, serves to add new rules, to add contextual detail to old rules, and to isolate exceptions to rules. Alternatively, a child's knowledge of spelling-to-sound correspondences may consist not of rules, but of a set of probabilities that particular sounds correspond to particular spellings. Thus a child may learn, for example, that *a-e* is pronounced [ei] two-thirds of the time, [æ] one-twentieth of the time, and so on.[4] With reading experience, these probabilities may come more nearly to approximate the true probabilities of the English orthography, and the contexts in which they apply may be defined increasingly narrowly.

The rule-governed strategy would be the more efficient of the two for reading unfamiliar words. Thus, if children consistenly pronounce *a-e* as [ei] in unfamiliar words because they "know" that silent *e* makes a vowel "say its name," they will guess correctly two-thirds of the time. But if they guess [ei] two-thirds of the time in accordance with

[3] *The approach to reading instruction was eclectic. One cannot, in the public schools locally, obtain children who have been exposed only to a phonetic approach, or only to a whole-word approach.*

[4] *The problem of describing the statistical aspects of the orthography can be approached either from the standpoint of the relative frequencies of types or of tokens.*

its relative frequency, they will tend to be correct just four-ninths [$(^2/_3)^2$] of the time. The better strategy then is to apply the general rule.

Nonetheless, it is not implausible that children may use something like the second strategy. The degree of uncertainty and thus the consistency with which a child assigns a sound to a spelling might reflect the frequency with which instances of that particular spelling-to-sound pattern are met in the child's lexicon. In that case, choices would be statistical in nature rather than rule-governed.

In principle, these alternatives may be distinguished by looking at the distribution of children's responses to a particular spelling pattern across many encounters with it when it is embedded in nonsense words. If their responses are invariant across encounters, then we may assume that they are applying a rule; if the responses are distributed according to the relative frequencies of the relevant spelling-to-sound correspondences, then we may assume that their choices are made on a statistical basis. In practice, the distinction may not be easy to make; first, because we do not know what rules the child is applying, if any, and thus we cannot be certain which nonsense words represent instances to which the rule applies, and second, because we do not have access to the child's history of encounters with the various spelling-to-sound correspondences. There is no table comparable to that of Dewey (1970) that tabulates the frequencies of these correspondences for school-aged children, and thus we cannot identify instances of statistical behavior with any certainty.

Whatever it may be that a child is picking up as he acquires orthographic structures, analyses of the present nonsense-syllable data and the previous real-word data reveal an orderly increase both in practical knowledge of spelling-to-sound correspondences and the contexts in which they apply. The first increase continued beyond the fourth grade, indicating that as reading skill develops, recognition of orthographic regularities is progressively strengthened. It is clear that in learning to read, children acquire an abstract system, not merely a growing accumulation of items recognized in rote fashion.

In regard to the second increase, in context sensitivity, the fact that there is any difference at all in the younger readers between the proportions of context-free and context-dependent responses in the present data is a reflection of the complexity of English orthography, and the reader's growing appreciation of it. In learning to read a language with a simpler orthography, such as Serbo-Croatian, in which the ideal of "one sound, one symbol" is more closely realized, the difference between context-free and context-dependent responses would have little practical meaning.

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