

Beyond zebra: Preschoolers' knowledge about letters

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ABSTRACT

Children in the United States and in other English-speaking countries often learn a good deal about letters before they begin formal reading instruction. We suggest that one important and previously unrecognized type of knowledge about letters is knowledge of the phonological structure of the letters' names. In two experiments, preschoolers with a mean age of 4;8 judged whether various syllables were letters. The children made significantly more false positive responses to syllables such as /fi/, which have a phonological structure shared by a number of letters, than to syllables such as /fɔ/ and /if/, which sound less like real letters. This was true even for children who could recite the alphabet without error. Learning the alphabet, we conclude, forms the basis for generalizations about the structure of letter names.

Across a number of studies, two abilities stand out as predictors of success in learning to read an alphabetic system. The first of these is phonemic awareness. Children who are sensitive to the phonemic structure of spoken words learn to read (and spell) more rapidly, on the average, than children who lack this sensitivity (e.g., Foorman, Francis, Novy, & Liberman, 1991; Wagner, 1988). A second predictor of reading success is knowledge of the alphabet. The more letters a young child can name, the more rapidly that child will learn to read (e.g., Blatchford, Burke, Farquhar, Plewis, & Tizard, 1987; Blatchford & Plewis, 1990; Bond & Dykstra, 1967). Indeed, in an influential study by Share, Jorm, Maclean, and Matthews (1984), phonemic awareness and letter-name knowledge, as assessed at the beginning of kindergarten, were the two best predictors of later reading achievement, whether measured at the end of kindergarten or at the end of first grade.

In the years since the Share et al. (1984) study, researchers have focused

their attention on children's sensitivity to the sound structure of language. A good deal of progress has been made in characterizing the nature of phonological awareness and in understanding how it relates to reading and spelling ability. The second major predictor of reading achievement – alphabet knowledge – has been somewhat neglected. Why is knowledge of the alphabet such a good predictor of reading success? What exactly is it that children learn when they learn to recite the alphabet, and how does this help them master the alphabetic writing system?

Part of the motivation for studying children's learning of the alphabet is that letter names play a central role in the early stages of literacy acquisition. Read (1975) described how some preschool children begin to spell before they have received any formal instruction, using the names of letters (often the letters in their own name) as a guide. For example, young children typically spell the /e/ of *bake* with *a*, the letter that has this name.¹ For the /ε/ of *bed*, which does not correspond to the name of a letter, children frequently use *a*. Spellings such as "bad" for *bed* reflect the phonetic similarity between /ε/ and /e/. These errors occur not only among precocious preschoolers, but also among first graders who are learning to read and write in a classroom situation (Treiman, 1993). Errors such as "cr" for *car* and "y" for initial /w/ provide further evidence that children use the names of letters in spelling (Treiman, 1994; Treiman, Tincoff, & Richmond-Welty, 1996; Treiman, Weatherston, & Berch, 1994). Given the role of letter names in early spelling, it becomes important to understand just what children are learning when they learn the letters of the alphabet.

Previous studies have shown that most middle-class children in the United States know a good deal about letters before they begin formal reading instruction. Over two-thirds of the 4-year-olds in Mason's (1980) study could, according to their parents, "very often" recite the alphabet without error by the time they entered a preschool program. These children knew that *a*, *b*, *c*, and so on were the names of letters, although they did not necessarily know the visual forms of these letters or the sounds the letters make. Worden and Boettcher (1990) tested children's knowledge of the alphabet directly rather than by relying on parental report. On average, the 3-year-olds in their study could recite a few letters of the alphabet. By 5 years of age, the children could recite almost all of the letters. The 5-year-olds could provide the names for most upper-case letters, but did not perform as well with lower-case letters. Their knowledge of the sounds of letters lagged behind their knowledge of the letter names.

Studies of children's alphabet knowledge have examined children's ability to recite the alphabet, give the names and sounds of letters, and print letters. However, there may be another aspect of alphabet knowledge that has not been previously recognized or assessed: that is, knowledge of the phonological structure of the names of letters. The names of English letters are not a random collection of phonological forms. Rather, the names have a number of similarities. All but one letter, *w*, have monosyllabic names, and 12 of the 26 names, including those of *b*, *c*, and *k*, are consonant + vowel syllables. The vowel is /i/ in 8 of these 12 cases. The next most popular structure is vowel + consonant (or consonant cluster), as in *f* and

x. Among the vowel + consonant letter names, the most common vowel (6 of 8 cases) is /e/. The remaining monosyllabic letter names are single vowels. As children learn to recite the alphabet, they may observe that the names of letters tend to vary within relatively narrow bounds. If such a sensitivity to the phonological structure of letter names develops, children may entertain the possibility that there exist more letters than the standard 26. For example, they may think that /fi/ is a letter because it begins with a consonant and ends with /i/, as do *b* (/bi/) and *c* (/si/).

The idea that children can “go beyond zebra” in their knowledge of the alphabet was first put forward by the well-known children’s author, Dr. Seuss. Young Conrad Cornelius o’Donald o’Dell, the protagonist of *On Beyond Zebra* (Seuss, 1955), knew the 26 letters of the alphabet from *a* to *z* and thought that he knew everything. One day, though, his friend revealed that the alphabet continues beyond *z*. “You’ll be sort of surprised what there is to be found,” the friend said, “once you go beyond *z* and start poking around.” “When you go beyond zebra,” Conrad’s friend exclaimed, “there’s no telling what wonderful things you might find yourself spelling!” By the end of the book, young Conrad agrees that, after all, “the old alphabet isn’t enough.” The additional letters in *On Beyond Zebra* include *yuzz*, *thnad*, and *fuddle*. These do not have the phonological structure of real English letter names and, in some cases (*thnad*), do not have even the phonological structure of real English words. Where our proposal differs from that of Dr. Seuss is in the view that, for young children, the letters “beyond zebra” are likely to be syllables such as /fi/ and /eb/, which share many of the properties of English letter names. Indeed, one of the reasons why *On Beyond Zebra* is so funny is that the new letters, such as *yuzz* and *thnad*, do not fit our expectations about what letters should be.

Preliminary anecdotal and experimental evidence suggests that some preschoolers learn about the phonological properties of letter names and use these properties to invent new letters. A bright 3½-year-old of our acquaintance said one day that *hat* has a /hi/ in it. When asked why, he said, “because it goes /hə/, /hə/, /hə/.” When questioned about the initial sounds of other words, this child said that *purple* starts with *p* (/pi/), that *mister* starts with *m* (/em/), and that *Fred* starts with /fri/. He also said that *yellow* starts with /ji/, and that *little* starts with /li/. The letters this boy made up had the structure of onset + /i/, which is common among English letter names. (An onset is a syllable-initial consonant or consonant cluster.)

In a previous experiment, we asked whether children ever make up letters (Treiman et al., 1996). In an initial letter task, children heard various spoken words and were asked to say their initial letters. The words included *feed*, *green*, *folk*, and *group*. We asked whether responses that consisted of the onset and vowel of the presented word were more common for words such as *feed* and *green*, where the resulting syllable is similar in structure to real English letter names (i.e., consonantal onset followed by /i/), than for words such as *folk* and *group*, where the resulting syllable is less similar in structure to real English letter names (i.e., consonantal onset followed by a vowel other than /i/). In a first experiment with 16 children, aged 5½ years,

an average of 9% of the responses to words like *feed* and *green* consisted of the onset and vowel of the stimulus, whereas the figure was 4% for words like *folk* and *group*. Although the difference was not statistically significant, one child produced a number of false letter names ending with /i/. For instance, she said that *feed* begins with /fi/, and that *green* begins with /gri/. But rather than say that *group* begins with /gru/, which would have revealed a general tendency to respond with the onset and vowel of any presented word, she said that it starts with /gri/. This girl also claimed that *loose* begins with /li/, and that *moon* begins with /mi/. However, in a second experiment with 26 children, aged 5 years, we observed very few responses that consisted of the initial consonant and vowel of the stimulus. This was true regardless of whether the word contained /i/ or some other vowel. In addition, Treiman et al. (1996) did not find any invented letter names in a task which asked children to report the final letters of words: for example, children never said that *web* ends with /eb/, even though /eb/ is similar in structure to the real letter name *s*.

The preliminary evidence reviewed here suggests that a small minority of preschoolers may learn about the phonological structure of letter names – or at least of onset + /i/ letter names – and may produce letters that have this structure. The rarity of this phenomenon in the study by Treiman et al. (1996) may reflect the fact that only a few children have both the ability to make generalizations about the structure of letter names and the confidence to volunteer them. However, the phenomenon may be more common among children younger than those tested by Treiman et al. By the age of 5 or 5½, children are typically quite familiar with the names of the conventional letters (Worden & Boettcher, 1990) and may no longer invent their own.

We designed the present experiments to tap knowledge of letters among children younger than those studied by Treiman et al. (1996). To do so, we developed a letter identification task. Rather than give children a spoken word and ask them to say its initial or final letter, as in the earlier study, we gave children a spoken syllable and asked them whether or not it was a letter. For example, children judged on one trial whether /fi/ was a letter and on another trial whether /fɔ/ was a letter. On other trials, children were questioned about real letters such as *f* and *b*. If children were sensitive to the phonological structure of English letter names, they should produce more erroneous “yes” responses to false letter-name syllables such as /fi/ than to control syllables such as /fɔ/. That is, the rate of false positive responses should be higher for false letter-name stimuli than for control stimuli. Experiment 1 also included false letter-name stimuli, such as /eb/, which have the /ɛ/ + consonant structure characteristic of some real English letter names. If children had learned about this structure, false positive responses should be more common for syllables such as /eb/ than for syllables such as /ab/. In addition to false letter-name stimuli such as /fi/ and /eb/, which begin and end with single consonants, Experiment 1 also included false letter-name stimuli such as /bri/ and /ɛpθ/, which begin and end with consonant clusters. If children conceptualized the structure of letter names as single consonant + /i/ and /ɛ/ + single consonant, they

should make false positive responses to stimuli such as /fi/ and /eb/, but not to stimuli such as /bri/ and /epθ/. However, if children conceptualized the structure of letter names as onset + /i/ and /ε/ + coda, they should make false positive responses to stimuli such as /bri/ and /epθ/, as well as to stimuli such as /fi/ and /eb/. (A coda is a syllable-final consonant or consonant cluster.)

EXPERIMENT 1

Method

Participants. The participants were 58 preschoolers with an average age of 4;7 (range 4;0–5;4). The children attended one of seven daycare centers and nursery schools located in the Detroit, Michigan, metropolitan area. Most of these schools served middle-class populations. Four of the children did not participate in the second session of the experiment; their results for the first session are included in the data. An additional child did not wish to complete the first session and so was not counted in the results.

Procedure. The children participated with an experimenter in two individual sessions, which took place in a quiet location at the child's school. The first session was devoted to the letter-name identification test. The experimenter began by asking if the child knew how to spell his or her first name. The child attempted to spell his or her name aloud, with the experimenter helping if necessary. The majority of children were able to say all the letters in their first names. Those who could not often knew at least the first letter. The experimenter then explained that "letters are what you spell words with." She gave the first letter of the child's name as an example of a letter. The experimenter said that "letters are also what's in the song, *a, b, c . . .*," singing the first three letters of the alphabet song. The child was asked to sing this song into a tape recorder (Marantz PMD221) if he or she knew it. A series of six practice trials followed in which the child was asked whether various stimuli were letters. The experimenter corrected any incorrect responses on the practice trials.

Next, the experimenter introduced a puppet who, she explained, was "not too good with letters. She doesn't always know what is a letter and what isn't." The experimenter explained that the puppet would "say" various items and the child should tell whether each one was or was not a letter. On each test trial, the experimenter pronounced the stimulus twice, and the child repeated it; any misrepetitions were corrected. The child then judged whether the stimulus was a letter. The experimenter provided general encouragement, but no specific feedback. The order of the test trials was randomly chosen for each child.

The second session included tests of the child's knowledge of the names and sounds of visually presented letters. For the letter-name test, two upper-case plastic letters were shown on each trial. The child was asked to

Table 1. *Sample stimuli for Experiment 1*

Stimulus type	Examples
Real letter name	
Ci	/bi/ (b), /zi/ (z)
εC	/ef/ (f), /en/ (n)
False letter name	
Ci	/fi/, /li/
Cci	/bri/, /pli/
εC	/eb/, /ep/
εCC	/epθ/, /esk/
Controls	
CV	/fɔ/, /lau/
CCV	/broi/, /plɔ/
VC	/ab/, /æp/
VCC	/æpθ/, /ask/

point to the one that had a specified name. For the letter-sound test, the same pairs of letters were presented; the child had to point to the one that made a specified sound. The order of letter-name and letter-sound tests was randomly chosen for each child. Within each test, the order of the stimulus pairs was randomized.

Stimuli. There were six practice stimuli for the letter-name identification test: three were letters and three were not. The real letters were the first, second, and third letters of the child's first name. The nonletters were /glup/, /zæf/, and /ufɪ/. These Dr. Seuss-like stimuli, although legal in English, sound quite different from real letter names.

The letter-name identification test contained 40 stimuli. Sample stimuli of each type are shown in Table 1; a complete list is provided in the Appendix. There were eight real letter names: four – *b*, *d*, *p*, and *z* – had the phonological structure consonant + /i/ or Ci in American English; four – *f*, *l*, *m*, and *n* – had /ε/ + consonant or εC structure. The remaining 32 stimuli were not the names of English letters: 16 were false letter names which were similar in phonological structure to real English letter names.

Of the false letter names, four were Ci syllables, made up of an initial consonant (one that does not occur in the name of a real English letter ending with /i/) followed by /i/: for example, /fi/ is a false Ci letter name. There were four Cci false letter names, such as /bri/, that had an initial consonant cluster and ended with /i/. In addition to the eight false letter names that began with consonants, there were eight false letter names that began with vowels: four had the phonological structure εC, as in /eb/, and four had the structure εCC, as in /epθ/. For the false letter names with εCC structure, the two final consonants were obstruents: specifically, stops and fricatives. We selected such stimuli because obstruent + obstruent final clusters appear to be cohesive units for children (Hindson & Byrne, 1997;

Treiman, Zukowski, & Richmond-Welty, 1995). Thus, VCC syllables with final obstruents are most naturally divided into a vowel plus a final cluster (or coda), just as CCV syllables are divided into an initial cluster (or onset) plus a vowel.

For each false letter-name stimulus there was a corresponding control stimulus. The control stimuli were formed from the false letter names by replacing the vowel of the false letter name with a vowel that never or rarely occurs in the names of real English letters. For example, the control stimulus for the false letter-name stimulus /fi/ was /fɔ/, as no English letter name ends with /ɔ/. This control stimulus was called a CV control. The CCV controls were similar to the CCi false letter names, except that they had final vowels that did not occur in English letter names. For instance, the control stimulus for the CCi false letter-name stimulus /bri/ was /broi/. In addition to the eight control stimuli beginning with consonants, there were eight control stimuli beginning with vowels. For example, the eC false letter name /ɛb/ had the VC control /ab/, and the eCC false letter name /ɛpθ/ had the VCC control /æpθ/.

The letter-name and letter-sound tests of the second session used the letters *b*, *d*, *p*, *z*, *f*, *l*, *m*, and *n*. These were the same letters as the real letter names in the letter-name identification task of the first session. There were 16 different pairs. Each of the eight letters was the correct answer on two trials.

Results

Table 2 shows the mean proportion of "yes" responses to the various types of stimuli on the letter-name identification task. The children did very well on the real letter names, accepting them as letters 87% of the time. Of interest is whether the children sometimes accepted syllables that were not letter names. In particular, were they more likely to make "yes" responses to false letter names, the phonological structure of which was similar to real letter names, than to control stimuli? To address this question, the data on false positive responses were subjected to an analysis of variance by subjects using the within-subject factors of letter name (false letter name vs. control), structure (consonant-initial syllable vs. vowel-initial syllable), and consonant type (singleton vs. cluster). The main effect of letter name was significant, $F(1, 57) = 4.00$, $p = .050$. The children made reliably more errors on the false letter-name stimuli than on the control stimuli (29% vs. 26%). There were also more false positive responses to stimuli that began with a vowel than to those that began with a consonant (29% vs. 26%), $F(1, 57) = 5.20$, $p = .026$. No other main effects or interactions were significant.

To confirm the results of the by-subjects analysis, an items analysis was carried out using letter name as a within-item factor and structure and consonant type as between-items factors. The main effect of letter name was again significant, $F(1, 12) = 7.61$, $p = .017$. The main effect of

Table 2. *Mean proportions of "yes" responses to various types of stimuli in Experiment 1 (standard deviations in parentheses)*

Stimulus type	Mean proportion of "yes" responses
Real letter name	
Ci (e.g., /bi/)	.87 (.21)
ɛC (e.g., /ɛf/)	.87 (.24)
False letter name	
Ci (e.g., /fi/)	.30 (.39)
CCi (e.g., /bri/)	.27 (.39)
ɛC (e.g., /ɛb/)	.30 (.40)
ɛCC (e.g., /ɛpθ/)	.31 (.41)
All false letter names	.29 (.37)
Controls	
CV (e.g., /fɔ/)	.25 (.37)
CCV (e.g., /broi/)	.24 (.37)
VC (e.g., /ab/)	.27 (.38)
VCC (e.g., /æpθ/)	.28 (.40)
All controls	.26 (.37)

structure just missed significance, $F(1, 12) = 4.39$, $p = .058$. No other effects in the items analysis were significant.

Although the difference in "yes" responses between false letter-name stimuli and control stimuli was statistically reliable, both by subjects and by items, the difference was quite small. In part, this was because 21 of the 58 children made no false positive responses, generally performing perfectly or almost perfectly on the letter identification task. Another four children showed a strong response bias, answering "yes" to all or all but one of the stimuli. When the data of these 25 children were removed from consideration, the proportion of false positive responses was 40% for the false letter names and 34% for the control stimuli. Further evidence that the difference between false letter names and controls is real comes from the results of the items analysis. Eleven of the 16 pairs of false letter-name and control stimuli showed a difference in the predicted direction, with more "yes" responses for the false letter names than for the controls. Only two pairs showed a difference in the opposite direction, and the remaining three pairs were tied.

To determine how the children's performance on the letter identification task related to their knowledge of the alphabet song, we scored performance on the song as either perfect (slurring of *l*, *m*, *n*, and *o* was not counted as an error) or imperfect. Of the 58 children, 24 were perfect on the alphabet song. When performance on the alphabet song was used as a between-subjects variable in the by-subjects analysis, it yielded a significant main effect, $F(1, 56) = 8.83$, $p = .004$. The mean percentage of false positive responses on the letter identification task was 12% for children

who could sing the alphabet song perfectly and 39% for children who could not. Alphabet performance did not interact with any other variables. In particular, there was no interaction between alphabet performance and the variable of false letter-name versus control stimuli. Thus, although children with better knowledge of the alphabet (as assessed by their performance on the alphabet song) produced fewer false positive responses than children with poorer knowledge of the alphabet, both groups showed a difference between the false letter-name and control stimuli.

The children did very well at matching visually presented letters with the names of the letters in the second session of the experiment, with a mean of 87% correct. The children had more difficulty matching visually presented letters with sounds, with a mean of 72% correct responses. The difference between letter names and letter sounds was highly reliable, $t(53) = 4.40$, $p < .001$. However, the children performed significantly above chance on both the name task, $t(53) = 12.05$, $p < .001$, and the sound task, $t(53) = 6.80$, $p < .002$.

Discussion

Like many preschoolers in the United States, the children in our study knew a good deal about letters. This was true even though they had not yet received formal instruction in reading. The majority of these preschoolers knew the letters in their name and could sing all or most of the alphabet song. They could also match many visually presented upper-case letters with their spoken names. The children were less knowledgeable about letter sounds than about letter names, as was found by Worden and Boettcher (1990). However, the children performed significantly above chance in matching consonant letters with their sounds on our two-choice task.

The primary goal of our study was to examine what the children knew about letter names. Had the children simply memorized that *a*, *b*, *c*, and so on were the names of letters, as was true for Conrad o'Dell at the beginning of Dr. Seuss's (1955) book? Alternatively, had the children acquired a more general knowledge about the phonological structure of English letter names? To address these questions, we asked children to distinguish between real letters and nonletters. We wanted to know whether children sometimes accepted nonletters that had the phonological structure of English letter names. For example, were children more likely to accept /fi/ than /fɔ/? Were they more likely to accept /eb/ than /ab/? We found that children made more false positive responses to syllables that were phonologically similar to letter names than to syllables that were less similar. "Yes" responses were more common to /fi/ and /bri/, which end with /i/, than to /fɔ/ and /broi/, which end with vowels that do not occur in the names of English letters. Similarly, children made more "yes" responses to /eb/ than to /ab/ and to /esk/ than to /ask/. The difference between false letter names and controls, although small, was significant both by subjects and by items. Even children who could recite the alphabet without error sometimes said that syllables such as /fi/ and /bri/ were the names of

letters. Although they did not include /fi/ or /bri/ in their recitation, they seemed to think that these syllables were potential letters.

Importantly, a difference between false letter-name stimuli and controls emerged both for syllables that began or ended with single consonants, as with the pairs /fi/-/fɔ/ and /ɛb/-/ɔb/, and for syllables that began or ended with clusters, as with /bri/-/broi/ and /ɛsk/-/ask/. These results suggest that the children conceptualized the structure of letter names such as *b* and *c* as onset + /i/ rather than consonant + /i/. Because /bri/ shares the onset + /i/ structure, they sometimes judged it to be a letter name. Likewise, children seemed to conceptualize the structure of names such as *f* and *s* as /ɛ/ + coda rather than /ɛ/ + single consonant. This conceptualization could be aided by knowledge of *x*, whose name has the structure /ɛ/ + coda.

There was a trend for false positive responses to be more common for syllables that began with vowels, such as /ɛb/ and /ɔb/, than for syllables that ended with vowels, such as /fi/ and /fɔ/. Perhaps because there are relatively few vowel-initial letters in English, the children were more likely to accept new vowel-initial syllables as possible letters. Because the trend did not reach significance by items, however, it should not be overinterpreted.

EXPERIMENT 2

The main finding of Experiment 1 was that preschoolers sometimes “go beyond zebra” in their knowledge of the alphabet. In addition to learning the conventional names of specific letters, they have acquired a more general knowledge about the phonological patterns of these names. What is the nature of this phonological knowledge? According to one interpretation, the *vowel hypothesis*, children have learned which vowels tend to occur in the names of English letters. For example, they know that /i/ is often found in letter names, whereas /ɔ/ is not. As a result, they are more likely to say that /fi/ is a letter than that /fɔ/ is a letter. The vowel hypothesis attributes a relatively minimal level of knowledge to children. According to a second hypothesis, the *structure hypothesis*, children have a more detailed knowledge of the phonological structure of letter names. They know that /i/ tends to occur at the ends of letter names that begin with a consonant, and that /ɛ/ tends to occur at the beginning of letter names that begin with a vowel. The results of Experiment 1 do not allow us to distinguish between the two hypotheses. All of the stimuli that contained /i/, for example, had this vowel at the end of a syllable that began with a consonant. We designed Experiment 2 to distinguish between the vowel hypothesis and the structure hypothesis. Given the small size of the effects in Experiment 1, we also wished to determine whether its basic results would replicate with another sample of preschool children.

The stimuli for Experiment 2 included four types of syllables that were not the names of English letters. Ci syllables, such as /gi/, included a vowel, /i/, that often occurs in real letter names. The vowel was in the

position in which it typically occurs in English letter names – at the end of a syllable beginning with a consonant. The iC syllables, such as /ig/, also contained /i/. However, the vowel was in an inappropriate position – at the beginning of a vowel + consonant syllable rather than at the end. The CV syllables, such as /ga/, were derived from the Ci syllables by changing the final /i/ to a vowel that does not typically occur in the names of English letters. Likewise, the VC syllables, such as /ag/, were derived from iC syllables by changing the vowel.

The vowel hypothesis and the structure hypothesis make different predictions about children's performance on the kinds of stimuli used in Experiment 2. According to the vowel hypothesis, children should be more likely to accept /gi/ and /ig/ as letters than to accept /ga/ and /ag/ as letters. There should be no difference in false positive responses between the two types of stimuli that contain /i/. This is because both the Ci and iC stimuli include a vowel that often occurs in letter names in English. The structure hypothesis makes a different prediction. According to this hypothesis, children should produce more false positive responses to Ci stimuli such as /gi/ than to iC stimuli such as /ig/. This is because only /gi/ has the phonological structure of onset + /i/, which is shared by many letter names of English. For syllables that do not contain /i/, however, false positive responses should be no more common to syllables beginning with a consonant (CV stimuli) than to syllables beginning with a vowel (VC stimuli).

Note that the current test of the vowel hypothesis and the structure hypothesis can be carried out with /i/ but not with /ε/. If we used syllables such as /be/ as stimuli, children might reject them not because they know that /ε/ does not occur at the ends of English consonant + vowel letter names, but because they know that /ε/ does not occur at the ends of English words. That is, words such as /be/ are illegal in English.

Method

Participants. The participants were 55 preschoolers with an average age of 4;9 (range 4;0–5;9). The children attended one of two nursery schools in suburban Detroit, Michigan. These schools served middle-class to upper middle-class populations. An additional child failed the practice items and so did not participate in the experiment.

Procedure. Each child participated in a single session, which was held in a quiet location at the child's school. The procedure was similar to that of Experiment 1. The experimenter began by asking if the child knew how to spell his or her first name. The child attempted to spell his or her name aloud, with the experimenter helping if necessary. The majority of children were able to say all of the letters in their first names. Those who could not often knew at least the first letter. The experimenter explained that "letters are what you spell words with" and used the first letter of the child's name as an example of a letter. The experimenter said that "letters are also what's

Table 3. *Sample stimuli for Experiment 2*

Stimulus type	Examples
Real letter name	/e/ (<i>a</i>), /ar/ (<i>r</i>)
Not real letter name	
Ci	/gi/, /fi/
iC	/ig/, /if/
CV	/ga/, /fau/
VC	/ag/, /auf/

in the song" and sang the complete alphabet song. A series of six practice trials followed, as in Experiment 1. The procedure differed from that of Experiment 1 in that the experiment was discontinued if a child achieved three or fewer correct responses on the practice trials. This change was instituted because the seven children who did this poorly on the practice trials of Experiment 1 tended to do poorly on the experiment itself, with some answering that all or almost all of the test syllables were letters.

The test trials were administered following the procedure of Experiment 1. The experimenter then asked the child if he or she remembered the song she sang earlier. The experimenter sang the first three letters of the alphabet song and asked the child to sing the complete song into a tape recorder.

Stimuli. The practice stimuli were the same as in Experiment 1. There were 38 test stimuli. Samples of the test stimuli are shown in Table 3, and a complete list appears in the Appendix. The test stimuli included the 14 real English letters, *a, e, i, o, u, h, j, k, m, q, r, w, s*, and *y*. These letters were chosen because they do not consist of a consonant followed by /i/. Thus, "yes" responses to false Ci letter names could not reflect a tendency to say "yes" to all stimuli in the experiment that ended with /i/. There were also 24 syllables that were not the names of English letters. Six of these, the Ci stimuli, consisted of a single consonant followed by /i/; examples are /gi/ and /fi/. Another six stimuli, the iC stimuli, consisted /i/ followed by a consonant. These stimuli, including /ig/ and /if/, were the mirror images of the Ci stimuli. There were also six CV stimuli. These consisted of an initial consonant followed by a vowel that rarely or never occurs in the names of English letters; examples are /ga/ and /fau/. The initial consonants of the CV stimuli were the same as those of the Ci stimuli. Finally, the six VC stimuli were the mirror images of the VC stimuli and included /ag/ and /auf/.

Results

Table 4 shows the mean proportion of "yes" responses to the various types of stimuli. The children did very well on real letter names, accepting them

Table 4. *Mean proportions of "yes" responses to various types of stimuli in Experiment 2 (standard deviations in parentheses)*

Stimulus type	Mean proportion of "yes" responses
Real letter name	.88 (.18)
Not real letter name	
Ci (e.g., /gi/)	.11 (.20)
iC (e.g., /ig/)	.07 (.14)
CV (e.g., /ga/)	.07 (.17)
VC (e.g., /ag/)	.10 (.18)

88% of the time. Of greatest interest were "yes" responses to stimuli that were not real letters. These data were analyzed in a by-subjects analysis using the within-subject factors of vowel (/i/ vs. other) and structure (consonant-initial syllables vs. vowel-initial syllables). Neither variable had a main effect, but the interaction was significant, $F(1, 54) = 5.56$, $p = .022$. As predicted by the structure hypothesis, children made significantly more false positive responses to Ci syllables such as /gi/ than to iC syllables such as /ig/, $t(54) = 2.09$, $p = .04$. This difference did not reflect a general tendency to accept consonant + vowel syllables more frequently than vowel + consonant syllables, for there was a nonsignificant trend in the opposite direction for vowel + consonant syllables, $t(54) = 1.42$, $p = .16$.

To verify the results of the subjects analysis, an items analysis was carried out. In this analysis, vowel was treated as a between-items factor and structure as a within-item factor. As in the by-subjects analysis, the only significant effect was the interaction between vowel and structure, $F(1, 10) = 6.15$, $p = .033$.

Of the 55 children, 24 made no false positive responses on the letter identification task, generally because their performance was perfect or close to perfect. When these children's data were removed from consideration, the percentages of "yes" responses rose to 20% for Ci syllables, 13% for iC syllables, 12% for CV syllables, and 18% for VC syllables. Unlike in Experiment 1, none of the children showed a response bias such that they answered "yes" to all or almost all of the stimuli. The children who could sing the alphabet song perfectly ($n = 32$) tended to do better in the letter identification task than those who made one or more errors ($n = 23$). The mean percentages of false positive responses were 6% for the former group and 13% for the latter group. However, the main effect of alphabet song knowledge was not significant in an analysis of false positive responses using the between-subjects factors of alphabet song knowledge and the within-subject factors of vowel and structure. Nor did alphabet knowledge interact with other variables. That is, the pattern of results was similar for

children who could recite the alphabet without error and children who could not.

Discussion

Experiment 2 was designed to shed light on precisely what children know about the phonological structure of letter names. We sought to distinguish between two possible interpretations of the findings in Experiment 1 – that children are more likely to judge syllables like /fi/ to be letters than to judge syllables like /ɔ/ to be letters. One possibility – the vowel hypothesis – is that children know which vowels tend to occur in English letter names. They know that /i/ occurs in many letter names, while /ɔ/, for example, does not. Another possibility – the structure hypothesis – is that children have a more fine-grained sensitivity to the phonological structure of letter names. They know that /i/ often occurs at the ends of letter names that begin with a consonant, but that it does not occur at the beginnings of vowel + consonant letter names. That is, children are sensitive to the phonological structure of letter names containing /i/, as well as to the fact that this vowel often occurs in the names of letters.

According to the vowel hypothesis, false positive responses should be equally common for syllables like /gi/ and syllables like /ig/. Because both these syllables contain /i/, children should be more likely to accept them as letters than to accept syllables such as /ga/ and /ag/. The vowel hypothesis thus predicts a main effect of vowel type (/i/ vs. other vowels). No such effect was found in Experiment 2; the results do not support the vowel hypothesis.

According to the structure hypothesis, false positive responses on the letter identification task should be more common for Ci syllables like /gi/ than for iC syllables like /ig/. Only the former have a phonological structure that is shared by many letter names of English. For syllables that contain a vowel that does not typically occur in the names of letters, however, we should find no more false positive responses to consonant + vowel syllables than to vowel + consonant syllables. The structure hypothesis thus predicts an interaction between vowel type (/i/ vs. other vowels) and structure (consonant-initial syllables vs. vowel-initial syllables). Such an interaction was found in Experiment 2, both in the analysis by subjects and the analysis by items. Children produced more “yes” responses to Ci syllables such as /gi/ than to iC syllables such as /ig/. This difference was limited to syllables containing /i/, as there were no more false positive responses to CV syllables such as /ga/ than to VC syllables such as /ag/. In fact, the nonsignificant trend for more false positive responses to syllables such as /ag/ than to syllables such as /ga/ is consistent with the trend observed in Experiment 1 for more false positive responses to vowel-initial syllables than to consonant-initial syllables.

In summary, the results of Experiment 2 support the structure hypothesis. Preschoolers implicitly know not only that /i/ frequently occurs in

English letter names, but also that this vowel tends to occur at the ends of consonant-initial syllables. That is, they are sensitive to the phonological structure of letter names in their language.

GENERAL DISCUSSION

Children in the United States and in other English-speaking countries often learn to recite the alphabet well before the beginning of formal schooling. Their knowledge of alphabet letters is a good predictor of future reading success (e.g., Blatchford et al., 1987; Blatchford & Plewis, 1990; Bond & Dykstra, 1967; Share et al., 1984). Does alphabet learning involve rote memorization without generalization, or do children pick up something about the phonological structure of letter names during the course of this learning? Our results suggest that at least some preschoolers acquire a sensitivity to the structure of letter names. In addition to learning the names and sounds of specific letters and how to print them, children gain a measure of phonological sensitivity during the course of alphabet learning. This is an aspect of alphabet learning that has not been previously recognized or assessed.

Evidence for our claims comes from a letter identification task in which children judged whether various syllables were letters. In our first experiment, children were significantly more likely to say that syllables such as /fi/ and /bri/ were letters than to say that syllables such as /fɔ/ and /broi/ were letters. The critical difference between the two types of syllables is that those in the first group end with a vowel (/i/) that often occurs at the ends of English letter names, whereas those in the second group do not. The children in Experiment 1 also seemed to know that /ɛ/ occurs at the beginning of some letter names: they made more "yes" responses to syllables that began with /ɛ/ (e.g., /ɛb/) than to syllables that began with other vowels (e.g., /ab/). In Experiment 2, we examined the case of /i/ in more detail. Do children know simply that /i/ is a common vowel in the letter names of English, or do they know that /i/ typically follows a consonant, as in *b*, *t*, and *z*? The results support the latter hypothesis; preschoolers were significantly more likely to judge that /gi/ was a letter than that /ig/ was a letter. In /gi/, of course, /i/ is in the position in which it typically occurs in the letter names of English; in /ig/ this is not the case. Together, the results of Experiments 1 and 2 suggest that preschoolers have some knowledge of the vowels that tend to occur in letter names and of the phonological structure of the names.

Although the preschoolers in our experiments showed some sensitivity to the phonological structure of letter names, the effects were small. In Experiment 1, the children produced 3% more false positive responses to false letter-name syllables such as /fi/ than to control syllables such as /fɔ/ – 6% when those children who made no false positive responses and those children who showed a strong response bias were removed from consideration. In Experiment 2, children produced 4% more false positive responses to syllables such as /gi/ than to syllables such as /ig/ – 7% when

those children who made no false positive responses were removed from consideration. These small effects suggest that children do not learn an all-or-none rule that onset + /i/ syllables are letter names. Instead, they become sensitive to the correlations that exist in English between phonological structure and the category of letter names and so show small differences between different types of syllables.

Children's sensitivity to structural regularities is not limited to the class of letter names. Children develop a similar sensitivity in the domain of print, noticing that certain letter sequences never occur in printed words, whereas others do. Treiman (1993) investigated children's knowledge of orthographic patterns by showing them pairs of nonwords such as *nuck* and *ckun* and asking them which looked more like a real word. Although both *nuck* and *ckun* are pronounceable, *ckun* begins with a letter group, *ck*, that never occurs at the beginnings of English words. Even kindergarteners performed significantly above the level expected by chance, and performance improved rapidly across the early elementary grades. Children also show a sensitivity to the phonological patterns in spoken words. For example, Messer (1967) devised pairs of syllables such as /frul/ and /mrul/. The first syllable is a possible word of English, whereas the second, by virtue of its non-English initial cluster, is not. When asked which syllable sounded more like a real word, preschoolers (mean age 3;7) picked the "possible" words significantly more often than the "impossible" words. Indeed, recent findings show that, by 9 months of age, infants prefer to listen to words that follow the predominant phonological and prosodic patterns of their language than to those that do not (Friederici & Wessels, 1993; Jusczyk, Cutler, & Redanz, 1993; Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993; Jusczyk, Luce, & Charles-Luce, 1994). Language learners also pick up the phonological patterns that characterize specific types of words in their language. For example, Russian-speaking preschoolers learn that nouns ending with stressed /a/ are typically feminine, those ending with stressed /o/ are typically neuter, and those ending with consonants are typically masculine (Popova, 1973). Given these impressive abilities (see Kelly, 1992, for additional examples), it is not surprising that English-speaking preschoolers can learn about the phonological patterns that characterize the set of letter names.

Our results help to explain why knowledge of the alphabet is such a good predictor of reading success (e.g., Blatchford et al., 1987; Blatchford & Plewis, 1990; Bond & Dykstra, 1967; Share et al., 1984). As they practice the alphabet, children not only learn the names and visual forms of specific letters, but also increase their phonological sensitivity, learning about the phonological patterns that characterize the letter names. Phonological sensitivity, in turn, benefits reading (e.g., Foorman et al., 1991; Wagner, 1988). Learning the names of letters and their phonological structure may also help children learn the sounds of letters. For example, the fact that the names of *b*, *c*, *d*, *g*, *p*, *t*, *v*, and *z* all rhyme in American English singles out the onset as relevant to their utility in the orthography. This may help children learn that *b* corresponds to /b/, that *c* can correspond to /s/, and

so on. Of course, the phonological sensitivity that develops during the course of alphabet learning is implicit. Preschoolers cannot explain how the names of *b*, *c*, and *d* are alike; they may be unable to segment a syllable such as /bi/ into /b/ and /i/. Nevertheless, the implicit phonological sensitivity that children gain during the course of alphabet learning may serve as a foundation for the explicit phonemic awareness that is critical for reading and spelling success.

CONCLUSIONS

Previous studies of alphabet learning have focused on children's knowledge of the names, sounds, and visual forms of letters (e.g., Worden & Boettcher, 1990). Our results suggest that there is another, previously unrecognized, aspect of alphabet learning – the development of an implicit sensitivity to the phonological structure of letter names. For example, children learn that many English letter names begin with a consonant onset and end with /i/. If the alphabet went beyond *z*, as Dr. Seuss (1955) suggested, children would expect to find letters named /fi/, /gi/, and /bri/; they would not expect to find letters like Dr. Seuss's *yuzz*, *thnad*, and *fuddle*. The implicit phonological sensitivity that develops during the course of alphabet learning may provide a base for the explicit phonemic awareness that is so important in mastering an alphabetic writing system.

APPENDIX

NONLETTER STIMULI FOR LETTER IDENTIFICATION TASK IN EXPERIMENTS 1 AND 2

Experiment 1

False letter-name stimuli

- Ci stimuli: /fi/, /li/, /ni/, /mi/
- CCi stimuli: /bri/, /pli/, /kli/, /gri/
- eC stimuli: /eb/, /ep/, /ez/, /ed/
- eCC stimuli: /epθ/, /esk/, /est/, /eft/

Control stimuli

- CV stimuli: /fɔ/, /lau/, /nɑ/, /moi/
- CCV stimuli: /broi/, /plɔ/, /klau/, /grɔ/
- VC stimuli: /ab/, /æp/, /ʌz/, /ɪd/
- VCC stimuli: /æpθ/, /ask/, /ʌst/, /ɪft/

Experiment 2

- Ci stimuli: /gi/, /fi/, /ni/, /tʃi/, /li/, /ʃi/
- iC stimuli: /ig/, /if/, /in/, /itʃ/, /il/, /ɪʃ/

CV stimuli: /ga/, /fau/, /no/, /tʃau/, /la/, /foi/
VC stimuli: /ag/, /auf/, /on/, /autʃ/, /al/, /oif/

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NOTE

1. Key to notation: /e/ as in bake; /ɛ/, bed; /i/, beet; /ə/, sofa; /j/ you; /u/, boot; /ɔ/, bought; /ɑ/, father; /θ/, thin; /æ/, bat; /ʃ/, shin; /oi/, boy; /au/, how; /ɪ/, bit; /ʌ/, but; /tʃ/, chin; /o/, boat.

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