Developmental Psychology
1997, Vol. 33, No. 5, 771–780

0012-1649/97/$3.00

Can Children and Adults Focus on Sound as Opposed to Spelling in a Phoneme Counting Task?

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Given the well-established link between phonemic awareness and literacy, it is important to better understand the foundations of phonemic awareness. The authors investigated the phoneme counting task, examining the degree to which children reading at a first-grade level and college students can focus on sound as opposed to spelling. In 2 experiments, both groups were found to be sensitive to some phonetic details that are not systematically represented in print. They had some ability to distinguish between monophthongs (as in *he*) and diphthongs (as in *how*), and they tended to count fewer "sounds" for syllables ending with the more sonorous (or vowel-like) consonant /r/ than for syllables ending with less sonorous consonants. However, print-related knowledge also affected both groups. Even children judged syllables that were the names of letters to contain fewer "sounds" than syllables that were not letter names.

Awareness of the sound structure of spoken language is an important foundation for mastery of an alphabetic writing system. According to many experts, causal links between phonological awareness and literacy run in both directions (Adams, 1990; Goswami & Bryant, 1990). On the one hand, phonological sensitivity facilitates learning to read. Children who enter school with at least a rudimentary level of phonological sensitivity, or who develop this sensitivity as a result of early instruction, tend to progress smoothly in learning to read and spell. Because these children are able to analyze spoken words into smaller units, they can appreciate how the letters in words' spellings map onto the sounds in the words' spoken forms. Children who lack a sensitivity to the sound structure of speech, on the other hand, have difficulty grasping the alphabetic principle. These children may become poor readers and spellers. There also appears to be a link from literacy to phonemic awareness. Learning to read and spell draws people's attention to the level of phonemes and increases the depth and sophistication of their linguistic awareness. In this view, individuals who are literate in an alphabetic writing system are phonemically aware. People who are alphabetically illiterate—whether they be young children who have not yet learned to read, older children who are experiencing serious difficulties in learning to read, or adults who have not had the opportunity to learn—have low levels of phonemic awareness.

The views outlined above are held widely in the field of reading research. However, questions have arisen in recent years about the empirical foundation for these assumptions. One question, which has been raised by several investigators (Moats, 1994; Scarborough, 1995; Scholes, 1993), is whether literate people are as phonemically aware as they have been thought to be. Literate individuals may use a spelling-based strategy on phonemic awareness tasks, leading to good performance on many test items but systematic errors on other items. In a phoneme counting task, for example, a spelling strategy will backfire when the number of letters in a word's spelling does not match the number of phonemes in its pronunciation. Consider the word *ox*, which contains three speech sounds but only two letters. When Moats tested experienced teachers of language, writing, or reading, she found that only one quarter of them could accurately determine the number of speech sounds in *ox*. Similarly, less than 40% of the participants in Moats's study knew that *straight* contains five speech sounds.

Another problem for the traditional view of phonological sensitivity and reading is that young children may not be as phonologically unaware as they are often thought to be. In fact, some children may be quite sensitive to certain phonetic details. Evidence for this claim comes from studies of children's invented spelling. For instance, young children sometimes spell the first sound of *drum* with *j* or *g* instead of the conventional *d* (Read, 1975; Treiman, 1985a, 1993). They do this because the pronunciation of /d/ changes when it precedes /r/, becoming similar to /ʤ/ (as in *Jim*). As another example, children may spell the second consonant of *sky* as *g* rather than *k*. Because this consonant lacks the aspiration or puff of air that is typical for initial /k/, it is indeed similar to /g/ (Treiman, 1985b, 1993). Such findings suggest that children's judgments about sounds are sometimes quite accurate from a phonetic point of view. Because children have not yet been influenced by print, their judgments may actually be more veridical than those of adults.

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This research was supported by National Science Foundation Grant SBR 94-08456. We thank Sarah Weatherston and Kira Rodriguez for their contributions. The participation of Our Lady Queen of Peace Elementary School, Warner Elementary School, Advent Child Care Center, Jack and Jill Child Care Center, and Beacon Elementary School is gratefully acknowledged.

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These findings show that it is important to gain a better understanding of the processes by which people perform phonological awareness tasks. Specifically, one must distinguish between two factors that may influence performance. The first factor is phonological—the properties of the sounds themselves. The second factor, and one that is sometimes overlooked, concerns the way in which the sounds are symbolized in print. The relative importance of these two factors may change with reading experience. For prereaders and children who are just beginning to read, phonological factors are expected to be more important than orthographic factors. Provided that children have an ability to focus on the sounds of language as distinct from the meanings, their judgments should be primarily influenced by the properties of the sounds. The way in which the sounds are symbolized in conventional orthography should have little or no effect for children. For literate adults, in contrast, print-related knowledge should have a large impact on performance. Thus, children may actually outperform adults on tasks that require a sensitivity to fine details of sound and for which orthography does not provide the right answer. We designed the present experiments to test these ideas by examining phonological sensitivity in beginning readers and college students.

The aspect of the English sound system that we examined in Experiment 1 was the distinction between two types of vowels—*diphthongs* and *monophthongs*. Diphthongs show an appreciable change in quality during the course of the vowel. Monophthongs do not show such a change. In Midwestern American English, the three most strongly diphthongized vowels are /au/ (as in *how*), /ai/ (as in *hi*), and /oi/ (as in *boy*). Each of these diphthongs begins with a relatively loud and steady portion, called the *steady-state portion*, and ends with a rapid movement toward another vowel, called the *offglide*. With /au/ and /ai/, the initial steady-state portion is a mid low vowel similar to the /ɑ/ of *father*. The offglide is in the direction of /u/ (as in *food*) for /au/ and in the direction of /i/ (as in *feed*) for /ai/. The diphthong /oi/ begins with a vowel similar to /o/ (as in *hoe*) and moves in the direction of /i/. The vowels /e/ (as in *hay*) and /o/ have some degree of diphthongization. There is a move in the direction of /i/ for /e/ and a move in the direction of /u/ for /o/. However, the diphthongization is not as marked for /e/ and /i/ as it is for /au/, /ai/, and /oi/. The remaining English vowels, including /ɛ/ (as in *head*) and /ɪ/ (as in *hid*), are monophthongs.

The distinction between diphthongs and monophthongs is not systematically reflected in the English spelling system. Some diphthongs are typically spelled with *digraphs* or two-letter spellings, as in *oy* and *oi* for /oi/ and *ow* and *ou* for /au/. The diphthong /ai/ is often spelled with *i* followed by a final *e*, as in *bite*. However, certain monophthongs are also commonly spelled with digraphs or with vowel letters followed by final *e*. For example, /u/ may be spelled as *oo*, as in *food*, or *u* plus final *e*, as in *flute*. Thus, there are no consistent orthographic clues as to whether a particular vowel is a monophthong or a diphthong.

Studies of children's invented spelling suggest that at least some young children are sensitive to the two-part nature of diphthongs. Read (1975), studying children who began to write on their own before receiving formal reading and spelling instruction, and Treiman (1993), studying first graders, found that children sometimes spelled /au/ as *ao* or *aoo*. In addition, children sometimes spelled /oi/ as *oe*. These spellings seem to be attempts to symbolize both parts of the diphthongs. Children who spell /au/ as *ao* may be using *a* to represent the mid low vowel at the beginning of /au/ and *o* to represent the offglide. Similarly, *ie* for /ai/ and *ae* for /e/ appear to be attempts to symbolize the diphthongization of these vowels.

The invented spellings just described were not all that common in the studies of Read (1975) and Treiman (1993). One possible explanation is that only some children are sensitive to the diphthongal nature of certain English vowels. A second possibility is that a number of young children already know something about the conventional spellings of the vowels. Some children may appreciate the diphthongal nature of /oi/ but may spell this vowel in the conventional manner (as *oy* or *oi*) rather than invent a spelling such as *oe*. Spelling tasks may thus be limited in what they can show us about children's sensitivity to sounds.

In the two experiments reported here, we assessed sensitivity to sounds more directly by using a counting task. This common measure of phonemic awareness was first popularized by Liberman, Shankweiler, Fischer, and Carter (1974). Our version of the sound counting task was designed to assess participants' appreciation of the phonetic properties of sounds and also the influence of orthographic factors. Participants heard a series of syllables and were asked to judge whether each syllable contained one "sound" or two "sounds." Each experiment consisted of two phases, a training phase and a test phase. During the training phase, participants heard syllables for which there were clear answers. For example, they learned that /ʊ/ (as in *hood*) contains one "sound" and that /æl/ (as in *pal*) contains two "sounds." The training phase was designed to orient participants to the task of counting sound segments as opposed to letters, syllables, or subsyllabic units. Those participants who succeeded in the training phase of the task went on to the test phase. They now heard syllables for which the answer was less clear. In Experiment 1, the test items included vowel monophthongs and vowel diphthongs. For example, would participants consider the test diphthong /oi/ to contain two "sounds" (like /æl/) or one "sound" (like /ʊ/)? In Experiment 2, the test items were designed to study children's and adults' appreciation of various distinctions involving consonants. Two groups participated in each experiment—children (with an average age around 6 years 6 months and an average reading level of beginning to mid first grade) and college students. In our analyses, we focused on those children and adults who learned a generalizable concept, asking what kind of concept they learned. Specifically, were children more influenced by the properties of the sounds themselves and were adults more influenced by alphabetic knowledge?

Experiment 1

Experiment 1 was designed to study children's and adults' ability to distinguish between monophthongs and diphthongs. During the training phase, participants learned that /ʊ/ (as in *hood*) and /ɔ/ (as in *fault*) contained one "sound" and that /æl/ (as in *pal*) and /ɪl/ (as in *pill*) contained two "sounds." During the test phase, participants heard new stimuli such as

/oi/ (as in *boy*) and /ʌ/ (as in *putt*). They were asked how many "sounds" these critical test stimuli contained. The items from the training phase were presented again in the test phase to make sure that participants remembered the correct responses. In addition, new two-phoneme syllables such as /ɑn/ (as in *Ron*), called *generalization items,* were presented during the test phase. The purpose of the generalization items was to determine whether participants had in fact acquired a distinction between one-phoneme and two-phoneme items during the training phase or whether they had learned by rote to respond "one" to certain training syllables and "two" to others.

For various reasons, we expected that some children would not succeed in the training phase of the sound counting task or would be unable to generalize to new items. Some children may not understand the task requirements or may be unable to focus on the sound properties of meaningless syllables. Our primary interest was in those children who did succeed. If children are more sensitive to phonetic detail than adults, these children should differentiate between diphthongs and monophthongs in a way that adults would not. Adults' responses in the sound counting task should be driven primarily by spelling. Thus, adults may judge a vowel that is commonly spelled with two letters to contain two units of sound, even when the vowel is a monophthong.

Method

Procedure. The experimenter explained that she would say various "made-up words," some of which contained one "sound" and others of which contained two "sounds." There were four stimuli in the training phase, two vowel monophthongs, and two VC (vowel–consonant) syllables. The training phase began with a demonstration trial. The experimenter pronounced each stimulus in turn, asked the participant to repeat the stimulus, and corrected the participant's pronunciation if necessary. The experimenter told the participant the correct response to each training stimulus. Following this demonstration trial was a series of training trials in which the same four stimuli were presented on tape. The participant judged whether each stimulus contained one or two "sounds." The participant was encouraged to guess if he or she was unsure. The experimenter praised right answers and corrected wrong answers. The test phase began when the participant reached a criterion of 2 successive correct training trials. If the participant did not meet this criterion by the end of 10 training trials, the experiment was stopped.

The test phase of the sound counting task included 40 taped test items, two presentations of each of 20 syllables. There were items from the training phase along with diphthongs, monophthongs, and VC syllables that had not been presented during the training phase. The participant judged whether each item contained one or two "sounds." The experimenter told the participant to guess if he or she was unsure. The experimenter offered general encouragement but did not say whether specific responses were correct or incorrect.

A spelling task made up the second part of the experiment. For children, the spelling task was given in a separate session between 1 and 3 days after the sound counting task. For adults, the spelling task followed the sound counting task in the same session. The experimenter explained that the participant would be asked to spell some "made-up words." The 28 syllables to be spelled—two repetitions of each of 14 syllables—were presented on tape. The participant was asked to spell each syllable by placing uppercase letters with magnetic backs on a metal board. The letters that were made available were *g, b, a,* 2 *e*s, *i,* 2 *o*s, *u, w,* and *y.* We used uppercase letters because young children are more familiar with them than with lowercase letters (Smythe, Stennett, Hardy, & Wilson, 1970–1971; Worden & Boettcher, 1990). The experimenter offered general encouragement but did not comment on the correctness of particular spellings. The children took the reading subtest of the Wide Range Achievement Test—Revised (WRAT–R; Jastak & Wilkinson, 1984) after finishing the spelling task.

With the few exceptions that have been noted, the instructions and procedures were the same for the children and for the adults. The experimenter told the adults that the tasks had been developed for use with young children.

Stimuli. The stimuli for the training phase of the sound counting task were /ʊ/, /ɔ/, /æl/ and /ɪl/. The first two syllables contained one phoneme, and the second two syllables contained two phonemes. We chose the vowels /ʊ/ and /ɔ/ because they are often spelled with digraphs, *oo* as in *hood* and *au* as in *fault.* The use of these vowels should encourage participants to make judgments on the basis of sound rather than spelling. The liquid consonant /l/ served as the second phoneme of the two-phoneme training items because /l/ forms a stronger unit with a preceding vowel than do most other consonants (Derwing & Nearey, 1991; Hindson & Byrne, 1997; Stemberger, 1983; Treiman, 1984, 1994; Treiman, Zukowski, & Richmond-Welty, 1995). A participant who succeeds in the training phase of the sound counting task has thus shown an ability to divide a cohesive sequence such as /ɪl/ into two parts. We can then ask whether the participant also segments a diphthong such as /au/ into two parts.

During the demonstration portion of the training phase, the experimenter presented the stimuli in the order /ʊl/, /æl/, /ɔ/, and /ɪl/. Following this were 10 tape-recorded training trials. On each trial, the four stimuli were presented in a random order with the constraint that the final stimulus of 1 trial was not the same as the first stimulus of the next trial. Each stimulus was repeated twice on each trial.

For the test phase of the sound counting task, two lists of 20 items each were prepared. Each list included one example of each of the four training stimuli and one example of each of the four generalization stimuli /ɑl/, /ʌl/, /æn/, and /ɑn/. Each list of stimuli for the sound counting test also included one example of each of the 12 critical items /au/, /oi/, /ai/, /e/, /o/, /u/, /ʌ/, /ɑ/, /i/, /ɪ/, /ɛ/, and /æl/. The order of the 20 items on each list was randomized with the constraint that 1 training item and 1 generalization item occur in each quarter of the list. The two lists were tape-recorded. The speaker on the tape said each stimulus twice before proceeding to the next stimulus. Each participant completed both test lists, responding twice to each stimulus.

For the spelling test, there were two lists of 14 CVC (consonant–vowel–consonant) syllables. All of the syllables began with /g/ and ended with /b/. Each list contained 1 syllable with each of the medial vowels /ʊ/, /ɔ/, /au/, /oi/, /ai/, /e/, /o/, /u/, /ʌ/, /ɑ/, /i/, /ɪ/, /ɛ/, and /ɪ/. The syllables were arranged in a random order with the constraint that at least 11 stimuli intervene between the presentation of a syllable on the first list and the presentation of that same syllable on the second list. The two lists were tape-recorded. The speaker on the tape pronounced each syllable twice. Each participant completed both lists, producing two spellings for each CVC syllable.

The speaker on the tapes was the same woman who served as the experimenter. She, like the participants, was from the Detroit area. The tapes were prepared in a sound-proof booth with a Marantz tape recorder (Model PMD221), which was also used to play the stimuli to the participants.

Participants. First-grade children were tested during November. Data from 12 first graders are included in the analyses to be reported. Seven other first graders began the experiment but did not reach criterion in the training phase of the sound counting task. Two additional first graders reached the criterion but performed poorly on the training and generalization items of the test phase of the sound counting task. These children may have mastered the training items as rote paired associates and so could not generalize the concept to new stimuli. (The criterion for poor performance was more than three errors on the 14 training and generalization items, not counting /ʌl/, that were included in the test phase of the sound counting task. The results for the generalization item /ʌl/ were not included for reasons discussed below.) The data of 1 additional first grader were not counted because this child performed at the fifth-grade level on the standardized reading test. Although this child's responses on the sound counting task were similar to those of the other children, her spellings were quite different. Twenty-four kindergartners were tested near the end of the school year (April through June) or the summer before they entered first grade. Only 4 of these children contributed data. Sixteen kindergartners did not reach criterion in the training phase of the sound counting task, and 4 others reached criterion but performed poorly on the training and generalization items of the test phase.

Preliminary analyses were carried out to compare the results of the 4 kindergartners who contributed data and the 12 first graders who did so. The two groups of children were similar in age, reading scores, and performance on the sound counting and spelling tasks. Thus, the results for all 16 children are pooled in the analyses to be reported. The mean age of these children was 6 years 4 months (range 5 years 9 months to 7 years 1 month). The children were on the borderline between a beginning first-grade and a mid first-grade reading level. All of the children were native speakers of English. They attended schools in the Detroit area that served middle-class populations.

Seventeen adults were tested. They were students at Wayne State University in Detroit and were native speakers of English. One adult's data were discarded because of a failure to reach criterion in the training phase of the sound counting task. We did not ask the adults whether they had had any training in phonetics or linguistics, but it is unlikely that more than 1 or 2 of them had done so. All in all, we had data from 16 children and 16 adults who were able to perform the task.

Table 1
Mean Number of "Sounds" Given in Test Phase of Sound Counting Task of Experiment 1

	Children		Adults		Pooled
Item type	*M*	*SD*	*M*	*SD*	*M*
Critical					
/au/	1.88	.22	1.88	.29	1.88
/oi/	1.75	.37	1.72	.36	1.73
/ai/	1.44	.48	1.06	.17	1.25
/e/	1.31	.40	1.03	.13	1.17
/o/	1.19	.31	1.13	.22	1.16
/u/	1.47	.29	1.28	.36	1.38
/ʌ/	1.22	.36	1.03	.13	1.13
/ɑ/	1.19	.36	1.06	.17	1.13
/i/	1.25	.37	1.00	.00	1.13
/ɪ/	1.16	.24	1.03	.13	1.09
/ɛ/	1.16	.35	1.13	.29	1.14
/æ/	1.22	.36	1.13	.29	1.17
Training phase					
/u/	1.25	.26	1.09	.27	1.17
/ɔ/	1.16	.30	1.22	.32	1.19
/æl/	2.00	.00	1.94	.17	1.97
/ɪl/	2.00	.00	2.00	.00	2.00
Generalization					
/ɑl/	1.88	.29	2.00	.00	1.94
/ʌl/	1.31	.40	1.16	.35	1.23
/æn/	1.94	.25	1.94	.17	1.94
/ɑn/	1.88	.22	1.91	.20	1.89

Results

Table 1 shows the responses in the test phase of the sound counting task in terms of the mean number of "sounds" that each stimulus was judged to contain. The results for the training items and generalization items were largely as anticipated. Specifically, the mean counts for the one-phoneme training items were close to 1, and the mean counts for the two-phoneme training items were close to 2. The mean counts for three of the four two-phoneme generalization items were also close to 2. The exception was the unexpectedly low counts to /ʌl/. Although this stimulus was pronounced as in the word *mull*, participants often seemed to interpret it as syllabic /l/ (as in *battle*). They often considered it to contain only one unit of sound.

Of most interest is participants' performance on the critical items, which were not presented during the training phase. Performance on the critical items was analyzed with the between-subjects factors of age (children vs. adults) and the within-subject factor of stimulus type (/au/ vs. /oi/ vs. /ai/ vs. /e/ vs. /o/ vs. /u/ vs. /ʌ/ vs. /ɑ/ vs. /i/ vs. /ɪ/ vs. /ɛ/ vs. /æ/). There was a main effect of age, $F(1, 30) = 6.14$, $p = .019$, which occurred because children tended to give higher counts than did adults. The overall mean was 1.35 for children as compared to 1.21 for adults. There was also a main effect of stimulus type, $F(11, 330) = 32.10$, $p < .001$. This finding shows that participants responded differently to the various vowels. These differences will be explored below. Importantly, the interaction between age and stimulus type was not significant. That is, the pattern of performance across the critical vowels was similar for beginning readers and literate adults.

Planned comparisons were performed following the analysis of variance (ANOVA) described above to evaluate the hypotheses of the experiment. We first compared the results for the three most strongly diphthongized vowels—/au/, /oi/, and /ai/—to those for the other critical vowels. The difference between these two categories of vowels was significant, $F(2, 30) = 76.20$, $p < .001$. Within the three most diphthongized vowels, /au/ and /oi/ were statistically indistinguishable. Children and adults were more likely to judge that the diphthongs /au/ and /oi/ contained two "sounds" than that they contained one "sound." However, participants gave significantly lower counts to the diphthong /ai/ than to the diphthongs /au/ and /oi/, $F(2, 30) = 24.42$, $p < .001$. This difference presumably reflects a fact about the English writing system—that /ai/ is the name of a letter (*i*), whereas /au/ and /oi/ are not the names of letters.

An analysis of performance on the remaining critical vowels—/e/, /o/, /u/, /ʌ/, /ɑ/, /i/, /ɪ/, /ɛ/, and /æ/—yielded a statistically significant effect of vowel type, $F(8, 240) = 4.27$, $p < .001$. This effect appeared to arise because participants gave higher counts to /u/ than to the other vowels, an unanticipated finding. When /u/ was eliminated from the analysis, no significant differences were found among the remaining vowels. In particular, participants responded similarly to the partially diphthongized vowels /e/ and /o/ and to the nondiphthongized vowels /ʌ/, /ɑ/, /i/, /ɪ/, /ɛ/, and /æ/.

Although the adults and the children showed similar patterns of performance in the test phase of the sound counting task, the adults reached this phase more quickly. The mean number of errors before reaching criterion in the training phase was 0.50 for adults as compared to 1.75 for children, $t(30) = 2.21$, $p =$

.018, one tailed. Also, the adults responded more consistently during the test phase of the task. Recall that each item was presented twice during the test phase. Adults gave the same response to the two presentations of an item 87.5% of the time as compared to 77.5% of the time for children, $t(30) = 2.26$, $p = .016$, one tailed.

Table 2 shows the mean number of letters that the participants used to represent the various vowels in the spelling phase of the experiment. In scoring these data, we assumed that all letters except for g and *b* were meant to represent the vowel phoneme of the /g/-vowel-/b/ syllable. The children generally used a single letter to spell each vowel. The adults tended to use two letters for those vowels that are commonly represented with digraphs or vowel plus final *e* and one letter for the other vowels. Statistical tests could not be carried out because there was no variability in responses for some of the vowels. However, a comparison of Tables 1 and 2 shows that participants' judgments about the number of sounds in various stimuli were not closely linked to their spellings. In particular, participants' judgment that /au/ and /oi/ contain two "sounds" does not reflect the use of two letters to spell these vowels. Children usually spelled /au/ and /oi/ with a single letter, as they spelled the other vowels. Nevertheless, they responded differently to /au/ and /oi/ than to the other vowels in the sound counting task. Adults often spelled /au/ and /oi/ with two letters, but they did the same for certain other vowels, such as /u/ and /i/, that they considered to contain one "sound."

Previous studies have found that children sometimes represent the two-part nature of /au/ and /oi/ in their spelling, writing /au/ as *ao* or *aoo* and /oi/ as *oe* (Read, 1975; Treiman, 1993). Such spellings were not common in the present study. One reason for this, as discussed above, is that these children tended to spell all vowels with a single letter. This outcome supports the view that children prefer to spell phonemes with single letters rather than with digraphs (Treiman, 1993). Moreover, the spellings of the children in this study seemed to be influenced by conventional orthography. Children generally spelled a vowel with the conventional adult spelling if that spelling was a single letter or with the first letter of the conventional spelling if that spelling was a digraph or a vowel followed by final *e*. These patterns are seen clearly in Table 2. For example, the children generally spelled /æ/ as *a*, as the adults did. The children often spelled /au/ as *o*, using the first letter of the standard *ou* or *ow*.

The children were less consistent spellers than were the adults. Across the two opportunities to spell each vowel, children produced the same spelling 56.3% of the time as compared to 77.4% for adults, $t(30) = 2.70$, $p = .006$, one tailed.

Table 2
Mean Number of Letters Used for Vowel in Spelling Test of Experiment 1 and Most Common Spelling of Vowel

	Children			Adults		
	Number of letters			Number of letters		
Vowel	*M*	*SD*	Most common spelling(s)	*M*	*SD*	Most common spelling(s)
/au/	1.09	.20	o, i	2.06	.31	ou, ow
/oi/	1.22	.41	o, oy, u	2.16	.30	oy, oi
/ai/	1.09	.20	i	1.94	.31	i & e
/e/	1.03	.13	a	1.91	.27	a & e
/o/	1.13	.34	o	1.97	.29	o & e
/u/	1.22	.36	o, u	1.94	.17	oo
/ʌ/	1.00	.00	u	1.13	.29	u
/ɑ/	1.00	.00	o	1.06	.25	o
/i/	1.22	.48	e	1.91	.27	ee
/ɪ/	1.03	.13	i	1.03	.13	i
/ɛ/	1.00	.00	e	1.00	.00	e
/æ/	1.00	.00	a	1.03	.13	a
/ʊ/	1.03	.13	u, o	1.66	.40	oo, u
/ɔ/	1.00	.00	o	1.53	.43	o, au

Note. Next most common spelling(s) is (are) also listed if most common spelling does not constitute the majority of spellings of the vowel. The symbol & means that the two letters used for the vowel are not adjacent.

Discussion

The results of Experiment 1 shed light on the factors that influence children's and adults' performance in one commonly used phonemic awareness task, a counting task. Our interest in this study was in those children and adults who were able to learn and perform the task. How did they do so? Did they focus on the phonetic properties of sounds, or did they rely on orthographic knowledge? We found that both adults and children reading at the first-grade level have some sensitivity to the phonetic level of language. They generally judged the diphthongs /au/ and /oi/ to contain two units of sound and monophthongs such as /i/, /o/, and /æ/ to contain one unit of sound. Both the college students and the children had some ability to distinguish between the sound properties of vowels and the way in which the vowels are represented in print. For example, although the college students normally spelled /i/ with two letters, they judged it to contain only one unit of sound. The college students used a digraph to spell /au/, as they did /i/, but they considered /au/ to contain two units of sound and /i/ to contain only one. The children also had some ability to distinguish between phonology and orthography. Although they tended to spell all vowel phonemes with a single letter, they counted two "sounds" for the diphthongs /au/ and /oi/ and one "sound" for monophthongs such as /i/, /o/, and /æ/.

Our results further show that neither adults nor children reading at the first-grade level can totally divorce sound and spelling. Participants tended to judge that all vowels that were the name of a letter—/e/ (*a*), /i/ (*e*), /ai/ (*i*), and /o/ (*o*)—contained a single "sound." This was true even when the vowel had a large degree of diphthongization, as with /ai/, or some degree of diphthongization, as with /e/ and /o/. These results suggest that one aspect of spelling—letter names—influences performance on phonemic awareness tasks from an early age.

At first glance, it is surprising that children who read only at the beginning to mid first-grade level appear to judge sounds partly on the basis of how they are spelled. Previous studies have shown that, although spelling influences performance on phonemic awareness tasks for normally achieving children in the second grade and above, the effects are weak or nonexistent for children below the second grade (Bruck, 1992; Ehri & Wilce, 1980, 1986; Landerl, Frith, & Wimmer, 1996; Perin, 1983; Tunmer & Nesdale, 1982). A consideration of the nature of the orthographic effects in this study and in the previous studies may help to explain the apparent discrepancy. In previous studies, orthographic effects on phonemic awareness have been diagnosed by, for example, the tendency to count four "sounds" for /ðɛb/ based on the knowledge that /ð/ (as in *them*) is spelled as *th*. In the present study, orthographic effects were diagnosed by the tendency to count one "sound" for /ai/ based on the knowledge that /ai/ is the name of the letter *i*. The conventional digraph spellings of phonemes such as /ð/ are not learned until first grade and are often not solidly in place even then (Treiman, 1993). In contrast, North American children learn the names of letters quite early, starting at around age 3 (Mason, 1980; Worden & Boettcher, 1990). As a result, children may use information about letter names in phonemic awareness tasks before they use information about digraphs.

Previous findings support the view that letter names strongly influence young children's ability to connect print and speech. For example, preschoolers can often say that *beech* starts with the letter *b* because the spoken word begins with the sequence /bi/ (Treiman, Tincoff, & Richmond-Welty, 1996). Kindergartners use the names of letters to learn and remember the letters' sounds, sometimes saying that *y* makes the sound /wə/ (where /ə/ is the unstressed, reduced vowel at the end of *sofa*) because /w/ is the first phoneme in this letter's spoken name (Treiman, Weatherston, & Berch, 1994). And first graders often spell phonemes or groups of phonemes that match the name of a letter with the corresponding letter, as in *bak* for *bake* and *cr* for *car* (Gentry, 1982; Treiman, 1993, 1994). The present finding that children reading at the first-grade level often judge /ai/ to contain one "sound" because it is the name of a letter further demonstrates the potency of letter names.

Our results suggest that letter-name knowledge continues to influence performance on phonemic awareness tasks into adulthood. Although the adults in this study could distinguish between diphthongs and monophthongs in some cases, for example counting two "sounds" for /oi/ and /au/ (which are commonly spelled with digraphs) and one "sound" for /i/ (which is also commonly spelled with a digraph), they could not distinguish between diphthongs and monophthongs when letter names were involved. Thus, they generally considered the diphthong /ai/ to contain one "sound" rather than two. These results support previous findings that adults' processing of speech is affected by their knowledge of spelling (Bruck, 1992; Donnenwerth-Nolan, Tanenhaus, & Seidenberg, 1981; Jakimik, Cole, & Rudnicky, 1985; Moats, 1994; Scholes, 1993; Seidenberg & Tanenhaus, 1979).

All in all, the present results do not support our original hypothesis that children's judgments about sounds differ from adults' in being less influenced by print and more influenced by phonetics. Instead, it appears that both children and adults are affected by both factors. Both groups have some ability to differentiate between vowel monophthongs and vowel diphthongs, but both groups are also affected by one aspect of spelling—knowledge of letter names.

Experiment 2

In Experiment 2, we continued to explore the degree to which children and adults can focus on sound as distinct from spelling in phonemic awareness tasks. The phonemic awareness task under investigation was again phoneme counting. Also as in Experiment 1, the aspect of spelling knowledge on which we focused was letter names. To verify the suggestion that participants in Experiment 1 gave low counts to /ai/ because it is the name of a letter, Experiment 2 included other syllables that were and were not the names of letters. We asked whether participants would count one "sound" for VC syllables that were the names of consonant letters, such as /ɑr/ (*r*) and /ɛl/ (*l*), and two "sounds" for VC syllables that were not the names of letters, such as /ir/ and /ol/.

The aspect of phonological knowledge examined in Experiment 2 was the distinction among consonants varying in *sonority*. The phonemes of English or of any other language may be classified in terms of their sonority or likeness to vowel sounds (Clements, 1990). Obstruent consonants such as /p/ and /b/ are the least sonorant type of phoneme. They are pronounced by completely obstructing the flow of air and then releasing the obstruction. Fricatives such as /ð/ are somewhat higher in sonority. Next in line are nasals such as /m/ and /n/, followed by the liquid /l/. In some of the versions of the sonority scale reviewed by Clements, /r/ is more sonorous than /l/; in other views, these two phonemes are comparable in sonority. Glides such as the offglide of /ai/ are higher on the sonority scale than liquids, with vowels being the most sonorous type of phoneme.

In Experiment 2, we asked whether children and adults distinguish between less sonorous and more sonorous consonants by counting fewer "sounds" for VC syllables with more sonorous final consonants. During the training phase of the experiment, participants were taught that the vowel-obstruent syllables /æb/ and /ɪb/ contained two "sounds" and that the monophthongs /ʊ/ and /ɔ/ contained one "sound." The test phase stimuli included VC syllables with final /r/, /l/, and /m/. Would participants consider a syllable ending in /r/ to contain fewer "sounds" than a syllable ending in /m/, in line with the fact that /r/ is more sonorous or more vowel-like than /m/?

Method

Procedure. The procedure for the sound counting task was the same as that of Experiment 1. No spelling task was given in this experiment.

Stimuli. The training phase of the sound counting task was like that of Experiment 1 except that the two-phoneme items /æl/ and /ɪl/ were replaced with /æb/ and /ɪb/, respectively.

For the test phase of the sound counting task, two taped lists of 21 items each were prepared. Each list included one example of each of the four training stimuli and one example of each of the six generalization stimuli /æð/, /ɑb/, /ɪð/, /æ/, /ɛ/, and /ɑ/. The first 3 generalization items were VC syllables. Their final consonants, like those of the two-phoneme training items, were obstruents. The second 3 generalization items, like the single-phoneme stimuli of the training phase, were vowel monophthongs. We included the generalization items to test whether participants had learned a distinction between one-phoneme and two-phoneme items during the training phase or whether they had memorized the responses to the 4 training items. Each list of stimuli for the sound counting test also included one example of each of the 11 critical items /ir/, /or/, /ɑr/, /æl/, /ɑl/, /ol/, /ɛl/, /ɪm/, /ɑm/, /om/, and /ɛm/. These syllables differ in the sonority of the final consonant (/r/, /l/, or /m/) and in whether they are the name of a letter (/ɑr/, /ɛl/, and /ɛm/). The order of the 21 items on each list was randomized with the constraint that 1 training item and 1 generalization item occur in each quarter of the list.

Participants. Data from 18 first graders are included in the analyses to be reported. Five additional first graders reached criterion in the training phase of the task but performed poorly on the training and generalization items of the test phase. The criterion for poor performance was more than four errors on the 20 training and generalization items in the test phase. The mean age of the 18 children who contributed data was 6 years 6 months (range 6 years 0 months to 7 years 3 months). Their score on the WRAT–R corresponded to a beginning first-grade reading level. All of the children were native speakers of English. They attended the same schools as the first graders in Experiment 1, but no child took part in both experiments. Testing occurred during November.

Eighteen adults from the same population as in Experiment 1 participated. All met the criterion in the training phase of the sound counting task, and all performed well on the training and generalization items that were included in the test phase.

Results

Table 3 shows the results in the test phase of the sound counting task. The participants generally gave the expected answers to the one- and two-phoneme items from the training phase and to the one- and two-phoneme generalization items. Of most interest are participants' responses to the critical items, which were VC syllables with final liquids or nasals. The data were analyzed with the between-subjects factor of age (children vs. adults) and the within-subject factor of stimulus type (/ir/ vs. /or/ vs. /ɑr/ vs. /æl/ vs. /ɑl/ vs. /ol/ vs. /ɛl/ vs. /ɪm/ vs. /ɑm/ vs. /om/ vs. /ɛm/). There was a significant effect of stimulus type, $F(10, 340) = 24.07$, $p < .001$. However, there was no main effect of age and no interaction between stimulus type and age. Because the adults and the children performed so similarly on the sound counting task, age was not used as a factor in further comparisons among the various types of stimuli.

Table 3
Mean Number of "Sounds" Given in Test Phase of Sound Counting Task of Experiment 2

Item type	Children *M*	Children *SD*	Adults *M*	Adults *SD*	Pooled *M*
Critical					
/ir/	1.69	.39	1.81	.39	1.75
/or/	1.69	.46	1.75	.39	1.72
/ɑr/	1.33	.42	1.22	.39	1.28
/æl/	1.86	.29	1.89	.27	1.88
/ɑl/	1.81	.35	1.81	.35	1.81
/ol/	1.36	.41	1.17	.30	1.26
/ɛl/	1.47	.40	1.33	.45	1.40
/ɪm/	1.78	.26	1.86	.34	1.82
/ɑm/	1.83	.30	1.94	.24	1.89
/om/	1.89	.27	1.97	.12	1.93
/ɛm/	1.39	.47	1.53	.47	1.46
Training phase					
/ʊ/	1.08	.19	1.00	.00	1.04
/ɔ/	1.28	.31	1.13	.34	1.21
/æb/	2.00	.00	2.00	.00	2.00
/ɪb/	1.97	.12	1.97	.12	1.97
Generalization					
/æð/	1.89	.27	1.97	.12	1.93
/ɑb/	1.94	.16	2.00	.00	1.97
/ɪð/	1.94	.16	1.92	.26	1.93
/æ/	1.17	.30	1.06	.16	1.11
/ɛ/	1.08	.19	1.00	.00	1.04
/ɑ/	1.11	.27	1.06	.16	1.08

Participants gave unexpectedly low counts to /ol/, with a mean of 1.26. On checking the tape, we found that the speaker did not pronounce the /l/ clearly in this syllable, leading participants to think that the syllable was /o/. This was verified by having 16 adults from the same population as the experimental participants listen to the tape and judge whether each syllable consisted of a vowel sound only or whether it had a consonant sound at the end. Most responses to /ol/ (72%) were that it contained a vowel sound only, whereas most responses to the other VC critical items (89%) were that they had a consonant sound at the end. Thus, the results for /ol/ were eliminated from the analyses that follow.

A planned comparison showed that the three critical syllables that were the name of a letter—/ɑr/, /ɛl/, and /ɛm/—yielded significantly lower counts than the critical syllables that were not the name of a letter, $t(35) = 8.27$, $p < .001$, one tailed. The difference was substantial, the mean counts being 1.38 for critical syllables that were letter names and 1.83 for those that were not. Moreover, the letter-name syllables differed significantly from one another. Planned comparisons showed no significant difference between /ɛl/ and /ɛm/, the names of *l* and *m*, but significantly lower counts to /ɑr/, the name of *r*, $t(35) = 2.36$, $p = .012$, one tailed. The average counts were 1.28 for /ɑr/ and 1.43 for /ɛl/ and /ɛm/. When participants heard a VC syllable that was the name of an English letter, especially *r*, they were more likely to judge that it contained one "sound" than that it contained two "sounds."

Among syllables that did not form the name of an English letter, the counts for those ending in /r/ were significantly lower than the counts for those ending in /l/ and /m/, $t(35) = 2.15$, $p = .020$, one tailed. Participants counted an average of 1.74 "sounds" for /ir/ and /or/, as compared to an average of 1.86 "sounds" for syllables ending in /l/ and /m/ that were not the name of a letter. The non-letter-name syllables ending in /l/ and those ending in /m/ were statistically indistinguishable from one another.

Although the adults and children showed similar patterns of performance in the test phase of the sound counting task, the adults made fewer errors before reaching criterion in the training phase. The mean number of errors was 0.22 for adults as compared to 1.89 for children, $t(34) = 2.85$, $p = .001$, one tailed. Also, the adults responded more consistently during the test phase. The adults gave the same response to the two presentations of an item 91.9% of the time as compared to 81.0% for the children, $t(34) = 3.74$, $p < .001$, one tailed.

Discussion

The results of Experiment 2 show that one aspect of spelling knowledge—knowledge of letter names—influences the sound counting performance of both first graders and adults. Neither children reading at the beginning first-grade level nor college students can completely divorce sound and spelling and think about the former independently of the latter. Thus, participants sometimes judged that two-phoneme syllables that matched the name of the letter *r*, *l*, or *m* contained a single "sound." Given similar syllables that were not the names of English letters, such as /ɑm/, participants more often judged the syllables to contain two "sounds." These results support the idea that the participants in Experiment 1 often considered /ai/ to be a single unit of sound because it is the name of a letter (*i*). The findings show that letter-name effects occur for both consonant and vowel letters and for both children reading at the first-grade level and college students.

Interestingly, the letter-name effects observed in Experiment 2 were stronger for *r* than for *l* and *m*. Both children and adults were more likely to judge that /ɑr/ was a single "sound" than that /ɛl/ and /ɛm/ were single "sounds." Compatibly, previous studies have found letter-name effects in children's spelling to be more pronounced for *r* than for other letters. For example, first graders are more likely to spell the nonword /zɑr/ as *zr* than the nonword /zɛm/ as *zm* (Treiman, 1994). The present findings support the view that /ɑr/ is a particularly cohesive sequence. The special phonological characteristics of this letter name affect children's performance in sound counting tasks as well as in spelling. Moreover, /ɑr/ is special for adults as well as children.

The sound counting performance of both children and adults was influenced by the phonetic properties of the stimuli as well as by whether the stimuli were the names of letters. For those VC syllables that were not the name of a letter, participants gave lower counts when the final consonant was /r/ than when it was /l/ or /m/. They seemed to consider vowel-/r/ syllables to be more similar to single vowels. These findings are consistent with data from speech errors and from other tasks showing that the bond between a vowel and a following consonant is stronger for more sonorous consonants than for less sonorous consonants (Derwing & Nearey, 1991; Hindson & Byrne, 1997; Laubstein, 1987; Stemberger, 1983; Treiman, 1984, 1994; Treiman et al., 1995). The present results show that sonority affects performance in tasks that require explicit counting of phonemes. Moreover, the findings support the idea that /r/ is more sonorous than /l/ or /m/. As suggested by Kahn (1976) and Laubstein (1987), /r/ may be best classified as a glide, higher in sonority than /l/ and more closely bound to a preceding vowel. Vowel-/r/ sequences, being difficult to pull apart, are more likely to be treated as units than as sequences of a vowel followed by another consonant.

General Discussion

Because phonological awareness is an important foundation of alphabetic literacy (see Adams, 1990; Goswami & Bryant, 1990), it is important to gain a better understanding of the tasks that are used to measure this awareness. The present study was directed toward this goal. Specifically, we studied the linguistic and orthographic factors that influence performance on one common phonological awareness task, phoneme counting. We selected children and adults who were able to perform the task and examined how they did so.

We began with the notion that at least two factors influence performance in phonological awareness tasks. The first factor is the nature of the properties of the sounds themselves, and the second factor is the way in which the sounds are represented in print. We hypothesized that the relative influence of these two factors would change with reading experience, such that beginning readers would be more affected by the first factor and literate adults would be more affected by the second factor. The results of two experiments did not confirm our hypothesis. Indeed, the most striking finding of our studies was a general lack of developmental differences. Provided that children could perform the task, they seemed to do so in much the same way as adults. This was true even though the children's average reading level—beginning to mid first grade—was much lower than that of the college students.

The children and the college students both showed some sensitivity to certain properties of speech that are not systematically represented in the English writing system. Thus, the participants in Experiment 1 distinguished between vowel monophthongs and certain vowel diphthongs. They considered the former to contain fewer "sounds" than the latter. The participants in Experiment 2 distinguished between consonants on the basis of sonority. They considered syllables with final /r/, a highly sonorous consonant, to contain fewer "sounds" than syllables with final /m/, a less sonorous consonant. Our results suggest that both beginning readers and college students have some awareness of the phonetic properties of speech sounds as distinct from how they are spelled.

Although both beginning readers and fluent readers can separate sound and spelling to some extent, neither can do so completely. Given a phoneme or sequence of phonemes that matches the name of a letter, such as /ai/ (*i*) or /ɑr/ (*r*), both children and adults sometimes judged it to contain one "sound." This was true even when the syllable contains two phonemes, as does /ɑr/. These letter-name effects were as strong in children reading at the beginning to mid first-grade level as in college students.

Previous studies have found developmental differences in the influence of spelling on speech processing, with spelling effects weaker for younger children than for older children and adults (Bruck, 1992; Tunmer & Nesdale, 1982; Zecker, 1991). For example, Bruck examined orthographic effects in phoneme counting and phoneme deletion tasks for first-grade children (reading at the second-grade level), second-grade children (reading at the third-grade level), and third-grade children (reading at the fifth-grade level) as well as for adults. The first graders did not make any orthographically influenced errors in the phoneme deletion task. For example, they never said that /ðos/ becomes /hos/ when the first sound is removed on the basis of knowing that /ð/ is spelled with *th*. The older children and adults often made such errors. Also, as compared with the older children and adults, the first graders made fewer "overshoot" errors in phoneme counting, such as counting four sounds for /lim/ on the basis of the fact that /i/ is frequently spelled as *ee*. Zecker also found developmental differences in a study of orthographic effects in rhyme monitoring. Normal readers aged 8 years 6 months and older were faster at judging that similarly spelled words like *bum* and *gum* rhyme than that dissimilarly spelled words like *thumb* and *gum* rhyme. Younger children showed less difference between the two types of pairs. Such findings suggest that orthographic effects require some time to take hold.

Unlike the researchers discussed above, we did not find a developmental increase in the influence of orthography on speech processing. Indeed, our study showed a striking lack of developmental differences, with effects of orthography as strong for children reading at the beginning to mid first-grade level as for college students. This is probably because we examined an aspect of orthographic knowledge—letter names—that is learned much earlier than digraphs (such as *th*) or silent letters (such as the *b* of *thumb*). The present findings, if replicable, show that it is important to distinguish between different kinds of orthographic effects. Although first graders' judgments of sounds may not be affected by more complex kinds of orthographic knowledge, simpler orthographic knowledge is influential. In fact, because North American children begin to learn the names of letters so early, even children younger and with less reading experience than those tested here may use this information in making judgments about sounds.

Returning to the views of phonological awareness and alphabetic literacy with which we began, we conclude that it would be wrong to characterize young children as more sensitive than adults to the phonetic details of speech and as uncorrupted by a knowledge of conventional spelling. We must acknowledge that young children know a good deal about at least one aspect of spelling, the names of letters, and that this knowledge influences their performance on phoneme counting tasks and probably other speech-related tasks as well. Our results support the idea that orthography, a visual representation of language, exerts an important effect on speech processing (see Ehri, 1984). Orthographic effects are not confined to skilled readers but emerge as soon as children begin to learn about the representational function of print.

In addition, it would be wrong to characterize literate adults as being insensitive to those properties of sounds that are not systematically represented in the writing system of their language. Our results confirm that adults sometimes use their knowledge of spelling when making judgments about sounds. However, our results also show that adults have some appreciation for properties of sounds that are not systematically reflected in print. These properties include the distinction between vowel monophthongs and vowel diphthongs and the distinction between more sonorous consonants and less sonorous consonants. When encouraged to focus on sound as distinct from spelling, as in the present experiments, phonetically untrained adults are not hopeless as phoneticians.

Our results have implications for two important practical issues. The first concerns dyslexia. Several researchers have reported that effects of spelling on speech processing are weaker for dyslexic children than for normal children (Bruck, 1992; Landerl et al., 1996; but see Rack, 1985). For instance, the dyslexics tested by Landerl et al. made fewer orthographic intrusion errors in phoneme counting tasks and phoneme deletion tasks than did younger normal children of a similar spelling level. On the basis of these findings, Landerl et al. suggested that "a weak link between phonological and orthographic representations might be a central problem in dyslexia" (p. 12). Our results suggest a need for caution in evaluating this claim. The orthographic errors studied by Landerl et al. required a knowledge of digraphs (e.g., *wh* for /w/) and silent letters (e.g., the *b* of *lamb*). It is possible that these relatively complex aspects of orthography influence phonemic awareness less in readers with dyslexia than in normal readers, perhaps because those with dyslexia have not yet mastered these features. Does the same hold true for simpler aspects of spelling such as letter names? We must study this question before drawing conclusions about the ability of readers with dyslexia to make connections between phonology and orthography.

A second issue that is addressed by our results concerns the preparation and training of elementary grade teachers. Those who would teach young children to read and write must have a good grasp of the structure of spoken language (e.g., Moats, 1994). For example, a teacher who is not aware of the way in which the pronunciation of /d/ changes before /r/ will not understand why a child might write *drum* with an initial *j*. As a result, the teacher may respond inappropriately to the error and may not design instruction in an optimal manner. The results of Moats's survey paint a gloomy picture of teachers' phonological awareness. However, it appears that the participants in her survey received little or no training before being asked to count the "sounds" in spoken words. Even a relatively small amount of training improves adults' performance (Scholes, 1993). Perhaps because we provided such training, our results present a more optimistic picture than those of Moats. Literate adults can and do show some sensitivity to features of sounds that are not represented in the English writing system. Although teachers need a higher level of sensitivity, our results show that there is something to build on in increasing their phonological awareness.

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Received May 28, 1996
Revision received February 6, 1997
Accepted February 6, 1997 ■