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Children's Phonological Awareness: Confusions between Phonemes that Differ Only in Voicing

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Given the role of phonemic awareness in learning to read and spell, it is important to examine the linguistic factors that influence children's performance on phonemic awareness tasks. We found that, contrary to some previous claims, children did not perform better with fricative consonants (e.g., /z/) than with stops (e.g., /d/) in a phoneme recognition task. However, preschoolers and kindergartners were more likely to mistakenly judge that a syllable began with a target phoneme when the initial phoneme of the syllable differed from the target only in voicing (e.g., /t/ for the target /d/) than when it differed in place of articulation (e.g., /b/–/d/) or in both place and voicing (e.g., /p/–/d/). These results shed light on the organization of children's phonological systems. They also have implications for the design and interpretation of phonemic awareness tasks. © 1998 Academic Press

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Phonemic awareness, or the ability to conceptualize spoken words as sequences of individual phonemes, is an important foundation of alphabetic literacy (for reviews see Adams, Treiman, & Pressley, 1998; Byrne, 1998). Children who are aware that the spoken word *dig* is composed of three smaller units, the first of which is the same as the first unit of *day,* are in a position to understand why *dig* is spelled with three letters, the first of which is the same as the first letter of *day*. Such children are able to grasp the alphabetic basis of the English writing system and to use this system productively in pronouncing and spelling words. For example, a child who can analyze a spoken word into phonemes and assign a letter to each phoneme can produce a reasonable spelling of *dome* (e.g., ''dom'') even if he or she has never seen this word in print. On the other hand, a child who cannot analyze spoken words into smaller units of sound may have trouble learning to read and spell. Such a child may be unable to produce plausible spellings of new words, for instance.

Given the role of phonemic awareness in learning to read and spell, it is important to understand the linguistic factors that affect children's performance on phonemic awareness tasks. Are some classes of phonemes easier for children to access and manipulate than others? Are children likely to confuse certain types of phonemes? Answers to such questions can help us understand the nature and development of phonemic awareness. Such research also has implications for education. For example, if certain types of phonemes are especially easy to access, then it would make sense to begin phonemic analysis instruction with these phonemes. An understanding of the linguistic factors that influence phonemic awareness can also aid in the design of phonemic awareness tests. Currently, there are a large number of tasks purporting to measure phonological awareness, and task comparisons are often impeded by differing levels of linguistic complexity among items (McBride-Chang, 1995; Stahl & Murray, 1994).

In the present study, we focused on the linguistic factors that affect children's performance on one particular phonemic awareness task, phoneme recognition. This task is designed to tap children's understanding of phoneme identity—the concept that *dig* and *day,* for instance, begin with the same sound. In the phoneme recognition task used here, preschool and kindergarten children are introduced to a puppet that likes all ''words'' that begin with a particular sound. For example, the puppet Dave likes ''words'' that begin with /d/. The child is presented with spoken syllables such as /dɑ/ and /po/ and is asked to judge whether the puppet likes each syllable. (See the Appendix for a key to the notation.) If the child is able to note the identity between the initial phoneme of /dɑ/ and the initial phoneme of *Dave,* he or she will respond correctly to this test syllable. If the child can judge that the first sound of /po/ is not /d/, he or she can produce a correct ''no'' response to this syllable. Children who have not grasped the concept of identity with respect to single initial consonants will perform poorly on the phoneme recognition task.

Our use of the phoneme recognition task was motivated by the suggestion that the concept tapped by this task, phoneme identity, is an important component of phonemic awareness. According to Byrne and Fielding-Barnsley (1990), phoneme identity is easier to teach than other aspects of phonemic awareness, is relatively stable once acquired, and provides a good foundation for discovery of the alphabetic principle. Byrne and Fielding-Barnsley recommended, based on their findings, that phoneme identity play a central role in phonemic awareness instruction. It is thus important to understand the factors that affect children's performance on tasks assessing this construct.

Several previous studies have examined the effects of linguistic variables on children's ability to recognize phonemes. One factor that appears to be influential is whether the target consonant is a single initial consonant or part of a cluster in the test stimulus. Treiman (1985, Exp. 2) used a phoneme recognition task like that described above with children averaging about $5\frac{1}{2}$ years old. Children were less likely to say that a syllable such as /spɑ/ began with the target /s/ than to say that a syllable such as /sɑ/ or /sɑp/ began with the target. The higher error rate on targets like /spɑ/ may reflect children's tendency to divide /spɑ/ into /sp/ (a consonant cluster onset) and /ɑ/ (a rime) rather than into /s/ plus /p/ plus /ɑ/. As a result, children sometimes judged that /spɑ/ did not begin with /s/. Similar difficulties with initial consonant clusters have been reported in other studies using the phoneme recognition task (Bruck & Treiman, 1990), as well as studies using different phonological awareness tasks (e.g., McBride-Chang, 1995; Stahl & Murray, 1994; Treiman & Weatherston, 1992). Given these findings, we used only single-consonant onsets in the test stimuli of the present experiments.

A review of the literature points to two other linguistic variables that may affect children's performance on tasks tapping the concept of phoneme identity but for which the evidence is less secure. The first of these is the phonological similarity between a negative item and the target. Suppose that the target phoneme in a phoneme recognition task is /s/ and that the test syllable is /zir/. Although /zir/ does not begin with /s/, the phoneme /z/ is quite similar to /s/. The two phonemes are alike in place of articulation (both are alveolar, or pronounced with the front of the tongue against the ridge in back of the upper teeth) and manner of articulation (both are fricatives, characterized by a small opening through which air escapes to produce a hissing sound). The phonemes /s/ and /z/ differ only in voicing. The phoneme /s/ is unvoiced, meaning that the vocal cords do not vibrate during its articulation. Its counterpart /z/ is voiced. Treiman (1985, Exp. 2) examined whether phonemes that differ from the target in few linguistic features are more difficult for children to reject than phonemes that differ from the target in many features. The correlation between number of shared features and number of errors on negative items, although in the predicted direction, was not statistically significant. However, post hoc analyses suggested that children made most errors when the initial phoneme of the negative item differed from the target in one specific linguistic feature, that of voicing. Treiman (1985, Exp. 3) found similar results

when she asked preschoolers (mean age 4 years, 8 months) and kindergartners (mean age $5\frac{1}{2}$) whether various pictured objects began with a specified letter. Here, too, post hoc analyses suggested that children made more errors based on voicing than on other linguistic features. For example, children sometimes mistakenly said that *bone* began with the letter *p*. This error may occur because the phonemes /p/ and /b/ are alike in all respects but voicing. The previous findings thus suggest that confusions between phonemes that differ only in voicing are more common than confusions between phonemes that differ in other ways. The present experiments were designed to provide firmer evidence on this point.

Another linguistic variable examined here was that of consonant type. Specifically, we compared children's phoneme recognition performance on stop consonants and fricatives. Stop consonants, such as /d/ and /b/, are pronounced by obstructing the flow of air through the mouth and then abruptly releasing the obstruction. With fricatives, as described earlier, the airstream is only partly blocked. Because of the way in which they are produced, fricatives can be pronounced in isolation. One can pronounce /s/ without a vowel, for example. Stop consonants cannot be held; /d/, for instance, must always be followed by a vowel. The fact that fricatives can be pronounced in isolation may make it easier for children to identify them as separate units. In addition, the acoustic representation of a stop consonant may vary to a large extent depending on the nature of the following phoneme. Because the /d/ of *dig* is not acoustically identical to the /d/ of *day*, children may have difficulty grasping the identity of the segments at the phonemic level. The acoustic representations of fricatives may be more constant from one context to another than those of stops (Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967). This, too, could make it easier for children to grasp the concept of phonemic identity for fricatives.

The results of Byrne and Fielding-Barnsley (1990) suggest that it is easier to teach children about phoneme identity with fricatives than with stops. In their Experiment 1, preschool children (average age $4\frac{1}{2}$) were more successful with the fricatives /s/ and /ʃ/ than with the stop consonant /t/. In Experiment 4, performance was significantly better with /s/ than with the stops /k/, /d/, and /g/. The difference between /s/ and /t/ was not significant in this latter experiment, although children tended to do better on /s/. Based on these results, Byrne and Fielding-Barnsley (p. 811) suggested that continuants (i.e., fricatives and other sounds that can be pronounced in isolation) ''offer an easier point of entry for identity training than do stops, and that stops may require special attention.''

Other studies offer mixed evidence regarding possible differences between stops and fricatives. Marsh and Mineo (1977) found that preschoolers (mean age 5 years, 0 months) were better at recognizing a consonant in a word if they were trained with continuant consonants (which include fricatives) than stop consonants. However, when Treiman and Baron (1981, Exp. 3) taught children to group syllables based on the identity of their initial phonemes,

training with fricatives was not more effective than training with stops. Other comparisons of stops and fricatives have tended to find a superiority for fricatives, at least at the beginnings of words (Content, Kolinsky, Morais, & Bertelson, 1986; McBride-Chang, 1995; Skjelfjord, 1976; Treiman & Baron, 1981, Exp. 1; Zhurova, 1963-64). However, differences in favor of fricatives are not always apparent (McBride-Chang, 1995; Treiman & Baron, 1981, Exp. 1; Treiman & Weatherston, 1992).

Although the previous findings on stop-fricative differences are not consistent, some researchers (e.g., Brady, 1997) have concluded that stops present special difficulties for phonemic awareness. Phonemic awareness training programs have been designed accordingly, with stops being avoided during the early stages of instruction (e.g., Lundberg, Frost, & Petersen, 1988). We revisited this issue in Experiment 3 in an attempt to determine whether fricatives really present an easier entry point into the concept of phoneme identity than do stops.

EXPERIMENT 1

In our first study, we examined children's errors in the phoneme recognition task. Specifically, are negative items that differ from the target only in voicing (e.g., items that begin with /t/ for the target /d/) harder to reject than negative items that differ from the target only in place of articulation (e.g., /b/ for /d/)? Are negative items that differ from the target in both voicing and place (e.g., /p/ for /d/) easier to reject than negative items that differ from the target in only one dimension? To address these questions, preschoolers and kindergartners participated in a phoneme recognition task with stop consonants as targets. Our primary interest was in children's performance on three types of negative items—those that differ from the target only in voicing, those that differ from the target only in place, and those that differ from the target in both.

The experiment began with a series of practice trials. This was followed by six sets of test trials, one for each of the targets /p/, /t/, /k/, /b/, /d/, and /g/. We included data only from children who performed reasonably well during the practice phase and the first series of test trials. Children who did not meet our criteria were dropped from the experiment. We adopted this procedure because our goal was to examine the effects of linguistic factors on the performance of children who had some ability to carry out the task.

Method

Procedure. For preschoolers, the experiment took place in two sessions, which were held an average of six days apart. The first session began with a practice phase. The experimenter introduced a puppet, choosing randomly from among Len, Sam, and Marge. The experimenter pronounced the puppet's favorite sound—/l/ for Len, /s/ for Sam, or /m/ for Marge. The experimenter stated that the puppet was happy whenever ''words'' started with this sound and sad whenever ''words'' did not begin with this sound. The order of the

six practice syllables was randomly chosen, following the constraint that the first practice syllable begin with the target. The experimenter pronounced the first practice syllable and the child repeated it. Here and throughout the procedure, if a child erred when attempting to repeat the consonant of a stimulus syllable the experimenter said the syllable again. The child repeated the syllable again, continuing until the child pronounced the consonant correctly or to a maximum of three repetitions. After the child had repeated the syllable, the experimenter pronounced its first sound and explained that this sound was the one that the puppet liked, making the puppet happy. A similar procedure was used for the first negative practice syllable to occur in the random sequence, except that the experimenter explained that the puppet was sad because it did not like the first sound of this syllable. For the other practice syllables, the experimenter pronounced the stimulus, the child repeated it, and the experimenter asked the child whether the puppet liked the syllable. The experimenter praised the child if he or she responded correctly and made the puppet react appropriately. If the child gave the wrong answer, the experimenter told the child the correct answer, explained the reason for that answer, and gave the child another chance to respond. For example, if the child said that Len liked the syllable /re/, the experimenter said, ''No, /re/ starts with /r/. Len only likes words that start with /l/.'' The experimenter again asked the child whether Len liked /re/. If the child made more than one error on the practice phase questions, the experiment was discontinued. If the child made a single error—for example, answering a question incorrectly but then providing the correct answer when asked again—the child proceeded to the test trials.

For the first series of test trials, the experimenter introduced a new puppet and told the child the puppet's favorite sound. Here and elsewhere, stop consonants were followed by /ə/ when pronounced. The experimenter said that the puppet was happy whenever a ''word'' started with the target sound and sad when it did not start with this sound. The experimenter pronounced each test syllable, and the child repeated it. The experimenter then asked the child whether the syllable started with the target phoneme. The child was encouraged to respond by holding the puppet and making it act happy or sad. The child could respond verbally if he or she did not wish to do this. The experimenter did not tell the child whether his or her responses to particular test trials were correct or incorrect. If, on the first series of test trials, the child did not achieve at least two correct on the three positive trials and at least four correct on the six negative trials, the experiment was discontinued on the grounds that the child seemed unable to perform the task. If the child met the criterion, two additional series of test trials were given during the first session.

The preschoolers' second session began with a series of practice trials. These were similar to the practice trials of the first session, except that a different puppet was used. Three series of test trials were then given. The order of the six test puppets was randomly chosen for each child. Within each

series of test trials, the order of the nine syllables was randomly determined for each child.

The procedure for the kindergartners was like that for the preschoolers except that the experiment was conducted in a single session. This session included one series of practice trials, with one third of the qualifying children receiving each practice puppet, and six test trials.

Stimuli. The targets for the practice trials were chosen from among /s/, /m/, and /l/. For each series of practice trials, there were two syllables that began with the target, two syllables that did not begin with the target but that began with a similar phoneme (which differed from the target in a feature other than voicing), and two syllables that began with a dissimilar phoneme.

The target phonemes for the test trials were /p/, /t/, /k/, /b/, /d/, and /g/. For each target, there were three positive stimuli, or syllables that began with the target, and six negative stimuli, or syllables that did not begin with the target. Of the negative stimuli, two began with a phoneme that differed from the target only in voicing, two began with a phoneme that differed from the target only in place of articulation, and two began with a phoneme that differed from the target in both voicing and place. For example, three stimuli for the target /d/ began with /d/, two began with /t/ (which differs from /d/ only in voicing), two began with /b/ (which differs from /d/ only in place), and two began with /p/ (which differs from /d/ in both voicing and place).

The Appendix provides a complete list of stimuli for the practice and test trials. All of the stimuli in this and the following experiments were CV (consonant-vowel) syllables. We used meaningless syllables whenever possible since children appear to perform better on phoneme recognition tasks with meaningless syllables than with meaningful words (McNeil & Stone, 1965). However, because many CV syllables are English words, some of the stimuli were necessarily meaningful.

Participants. Nineteen preschoolers (mean age 5 years, 1 month; range 4,8–5,6) met the criteria for participation in the experiment. Eleven were girls and 8 were boys. We set a minimum age of 4 years, 8 months based on pilot data showing that younger children were unlikely to meet the criteria. An additional 42 preschoolers who exceeded this minimum age did not meet the criteria, 24 because they made more than one error on the practice phase of the first session and 18 because they did not meet the criterion on the first series of test trials. One additional preschooler met the criteria and participated in the first session of the experiment but did not wish to continue. Her data were dropped.

There were 18 kindergartners (mean age 6 years, 1 month; range 5,8–6,9). Nine were girls and 9 were boys. Fifteen additional kindergartners did not meet the criteria for participation, 11 who made more than one error on the practice trials and 4 who did not meet the criterion on the first series of test trials. Data from one other child who met the criteria but did not wish to complete the experiment were also dropped. The kindergartners were tested during the last third of the school year or, in a few cases, shortly after the end of the school year.

All of the participants in this and the following experiments were native speakers of English. They attended child-care centers, preschools, and kindergartens in suburban Detroit that served primarily white, middle-class populations.

Results and Discussion

Table 1 shows the mean proportion of correct responses to the various types of stimuli. Of primary interest is children's performance on the three types of negative stimuli. Children performed relatively poorly on negative syllables whose first phoneme differed from the target phoneme only in voicing. They did better when the first phoneme differed from the target phoneme in place of articulation or in both place and voicing. An ANOVA using the within-subject factor of type of negative stimulus (voicing different vs place different vs voicing and place different) and the between-subjects factor of grade level (preschool vs kindergarten) confirmed the main effect of stimulus type ($F(2,70) = 15.06$, $p < .001$). There were no other significant effects. Planned comparisons showed that performance on the place-different trials was statistically indistinguishable from performance on the trials that differed in both voice and place. Average performance on these two types of trials significantly exceeded performance on the voicing-different trials ($p = .001$). The pattern of poorer performance on the voicing-different trials than on the other two types of negative trials held for each of the six phonemes at each of the two grade levels.

Just as the preschoolers and kindergartners did not show different levels of performance on the negative trials, so they did not differ reliably on the positive trials. The preschoolers' and kindergartners' similar level of performance probably reflects our fairly strict criteria for inclusion in the experiment. We only analyzed the data of children who showed some understanding of the task during the practice phase and who performed reasonably well on the first series of test trials. Fewer preschoolers than kindergartners met the criteria (32% vs 56%). However, those preschoolers who met the criteria performed similarly to kindergartners in the experiment itself.

To summarize, children who have some ability to perform the phoneme

TABLE 1
Proportion of Correct Responses in Experiment 1, Using Stop Consonants as Targets (Standard Deviations in Parentheses)

		Negative stimuli		
Grade	Positive stimuli	Voicing different	Place different	Voicing and place different
Preschool	.78 (.24)	.81 (.23)	.91 (.14)	.92 (.15)
Kindergarten	.74 (.22)	.84 (.22)	.94 (.09)	.98 (.05)

recognition task find it more difficult to reject negative items that differ from a stop consonant target only in voicing than to reject other kinds of negative items.

EXPERIMENT 2

The main goal of Experiment 2 was to extend the results of Experiment 1 to a different category of phonemes—fricatives. With fricatives, as with stops, do children have particular difficulty rejecting a syllable whose initial phoneme differs from the target only in voicing? To address this question, we used /f/, /v/, /s/, and /z/ as target phonemes. For example, with the target /f/ there were test syllables such as /vo/ (whose initial phoneme differs from /f/ only in voicing), /sɑ/ (whose initial phoneme differs from /f/ only in place), and /zai/ (whose initial phoneme differs from /f/ in both voicing and place). We expected to find the same pattern of results as in Experiment 1. Specifically, children should be more likely to falsely accept /vo/ as beginning with the target /f/ than to accept /sɑ/ or /zai/.

The procedure for Experiment 2 was similar to that for Experiment 1. However, we made certain modifications to the practice phase, described below, in an attempt to help children grasp the nature of the task.

Method

Procedure. The experiment was conducted in a single session for all children. This session included one series of practice trials using the puppet Len, whose favorite sound was /l/, and four series of test trials.

The practice phase included eight syllables, which were always presented in the same order. After introducing Len, the experimenter said the first practice syllable, /lɑ/, and the child repeated it. The experimenter stated that this syllable started with /l/, saying ''/l/, /lɑ/.'' The experimenter next asked the child whether /lɑ/ began with /l/. If the child responded correctly, the experimenter praised the child and made the puppet act happy, saying ''Len loves the /l/ sound.'' If the child responded incorrectly, the experimenter again said that /lɑ/ began with /l/ and had the child repeat ''/l/, /lɑ/.'' The experimenter again asked the child whether /lɑ/ began with /l/. If the child responded correctly this second time, the experimenter praised the child as described above and proceeded to the next item. If the child responded incorrectly on the second attempt, he or she was dropped from the experiment. For the second practice trial, /mɔ/, the experimenter pronounced the syllable, the child repeated it, and the experimenter said that /mɔ/ began with /m/. The experimenter then asked the child whether /mɔ/ began with /l/. If the child responded correctly, the experimenter praised the child and made the puppet act unhappy, saying ''Len is sad when words don't start with /l/.'' If the child gave the wrong answer, the experimenter again pronounced the first phoneme of /mɔ/ and had the child say ''/m/, /mɔ/.'' The experimenter explained that Len did not like the /m/ sound, only the /l/ sound. The experimenter again asked the child whether /mɔ/ began with /l/. If the child now

responded correctly, the experimenter praised the child and presented the next item. If the child responded incorrectly on the second attempt, the experiment was discontinued. The procedure for the remaining six practice trials was the same as for the first two trials except that the experimenter did not say the first phoneme of each syllable before asking the child whether it began with /l/. As before, children were given a second opportunity to respond to each item if they erred on their first attempt. If they responded incorrectly the second time, they were dropped from the study.

As compared to the procedure of Experiment 1, the procedure of Experiment 2 differs in several ways that may help children grasp the nature of the task. For one thing, a negative stimulus was always presented immediately after the first positive stimulus. This was not always the case in Experiment 1, where the order of the practice stimuli after the first positive stimulus was randomly chosen for each child. The presentation of a positive stimulus immediately followed by a negative stimulus may give children a better sense for items that do and do not begin with the target. Another change was that half of the practice trials required a ''yes'' answer and half required a ''no'' answer. In Experiment 1, where two-thirds of the practice stimuli were negative items, some children appeared to develop a bias to respond ''no.'' The number of practice syllables was larger in Experiment 2 (8) than in Experiment 1 (6), giving children more practice with the task. In addition, the child was asked whether each practice syllable began with /l/ instead of whether Len liked each syllable, as in Experiment 1. The change in wording was designed to reduce children's memory load; they did not have to remember that Len liked the /l/ sound. Moreover, the wording for the practice trials was now similar to that for the test trials, where the child was asked whether each syllable began with the target phoneme. The feedback for incorrect responses was also more extensive than in Experiment 1. For example, if a child said that /lɑ/ did not began with /l/ the experimenter explained the correct answer and had the child repeat both the syllable and its initial sound. This did not occur in Experiment 1, where the experimenter only explained the correct answer.

The procedure for the test trials in Experiment 2 was the same as in Experiment 1. The order of the four test phonemes was randomly chosen for each child. Within each series of test trials, the order of the nine syllables was randomly selected.

Stimuli. The target for the practice trials was /l/. There were four syllables that began with the target, two syllables that did not begin with the target but that began with the similar phoneme /r/, and two syllables that began with dissimilar phonemes. The practice stimuli are listed in their order of presentation in the Appendix.

The targets for the test trials were /f/, /s/, /v/, and /z/. For each target phoneme, there were three positive stimuli and six negative stimuli. Of the negative stimuli, two began with a phoneme that differed from the target only in voicing, two began with a phoneme that differed from the target only in

place of articulation, and two began with a phoneme that differed from the target in both voicing and place. The stimuli are listed in the Appendix.

Participants. Sixteen preschoolers (mean age 5 years, 2 months; range 4,8–5,11) participated. Nine were girls and 7 were boys. An additional 37 preschoolers failed to meet the criteria for participation, 27 because they did not meet the criterion on the practice trials and 10 because they did not meet the criterion on the first test trial.

Nineteen kindergartners (mean age 5 years, 5 months; range 5,0–5,10) contributed data. Nine were girls and 10 were boys. One additional kindergartner did not meet the criterion on the practice trials and so was disqualified. Another kindergartner did not wish to continue after completing the practice trials. The kindergartners were tested during the first third of the school year and were thus younger than the kindergartners tested in Experiment 1.

Results and Discussion

Table 2 shows the proportion of correct responses to the various types of syllables. The children made fewer correct ''no'' responses to syllables whose first phoneme differed from the target only in voicing than to syllables whose first phoneme differed from the target in place alone or in both place and voicing. An ANOVA using the factors of grade (preschool vs kindergarten) and type of negative stimulus (voicing different vs place different vs voicing and place different) confirmed the main effect of stimulus type ($F(2,66) = 15.87$, $p < .001$). There were no other significant effects. Planned comparisons showed that performance was statistically indistinguishable when the first phoneme of the test syllable differed from the target only in place and when it differed in both place and voicing. Average performance on these two types of trials was significantly better than performance on trials for which the first phoneme differed from the target in voicing ($p = .001$). This pattern held for each of the four target syllables for both preschoolers and kindergartners.

An additional ANOVA examining performance on positive items did not show an effect of grade. Those preschoolers who met the criteria for participation were not much younger than the kindergartners and did not perform significantly worse. However, the percentage of preschoolers who met the

TABLE 2
Proportion of Correct Responses in Experiment 2, Using Fricatives as Targets (Standard Deviations in Parentheses)

		Negative stimuli		
Grade	Positive stimuli	Voicing different	Place different	Voicing and place different
Preschool	.79 (.21)	.74 (.25)	.92 (.15)	.92 (.14)
Kindergarten	.77 (.18)	.75 (.24)	.93 (.13)	.92 (.20)

criteria was substantially lower than the percentage of kindergartners who did so, 30% as compared to 95%. This difference suggests that children who have had little if any formal training about letters and sounds (as is the case for most preschoolers in the United States) have lower levels of phonological awareness than children who are not much older but who have had such experience (as is the case for most kindergartners in the United States, who receive systematic instruction about letters and their sounds). Indeed, studies that have investigated this issue have found effects of schooling on phonemic awareness (e.g., Bentin, Hammer, & Cahan, 1991; Morrison, Smith, & Dow-Ehrensberger, 1995).

The changes in procedure from Experiment 1 to Experiment 2 did not appear to have made it easier for preschoolers to grasp the nature of the task. In Experiment 1, 32% of the preschoolers who began the study met the criteria for participation, as compared to 30% in Experiment 2. Apparently, many preschoolers find it hard to analyze a spoken syllable into its onset and its rime and to compare the onset of the stimulus syllable with a target. The changes that we made to the practice trials did not improve these children's performance, although more intensive training over an extended period of time is effective for many children (e.g., Bradley & Bryant, 1983). The procedural changes introduced in Experiment 2 did appear to have made the task easier for kindergartners. Although the kindergartners in Experiment 2 were younger and had less school experience than those in Experiment 1, 95% of those who began Experiment 2 met the criteria for participation, as compared to 56% for Experiment 1. Comparisons across experiments must be made with caution, for the children in Experiments 1 and 2 came from different schools. However, it appears that many kindergartners have some ability to recognize the identity of initial singleton consonants and can demonstrate this nascent ability under favorable conditions. From the present results, we cannot determine which of the several procedural changes made in Experiment 2 was most helpful.

EXPERIMENT 3

The main goal of Experiment 3 was to compare children's phoneme recognition performance for two types of consonants – stops and fricatives. As discussed in the introduction, some previous studies suggest that children perform better on tasks tapping the concept of phoneme identity with fricatives than with stops. In Experiment 3, each child received four series of test trials using stop consonant targets (/p/, /t/, /b/, /d/) and four series of test trials involving fricative targets (/f/, /s/, /v/, /z/). We asked whether children performed better on the fricatives than the stops. Only kindergartners were tested in this experiment.

Method

Procedure. The experiment was conducted in two sessions, which were held an average of five days apart. The first session began with a series of

practice trials. For half of the children these involved the puppet Gail, who liked /g/, and for the other half of the children these involved the puppet Sean, who liked /ʃ/. The order of the practice syllables was the same for all children. Two series of test trials involving stops and two series of test trials involving fricatives, randomly chosen, were given in the first session. The second session began with the other series of practice trials and included the remaining stop and fricative test trials. The order of the test trials in each session was randomly chosen, as was the order of the syllables within the test trials. The assignment of puppets to stop and fricative trials was balanced across children.

The procedure for the practice trials was similar to that of Experiment 2. The only change was that the experimenter told the child the first sound of each practice stimulus before asking the child whether the stimulus began with the target. Recall that in Experiment 2, the experimenter told the child the first sound of the first two practice stimuli but not of the remaining six practice stimuli. The procedure for the test trials was the same as in Experiments 1 and 2.

Stimuli. The targets for the practice trials were /g/ and /ʃ/. For each series of practice trials, there were four syllables that began with the target. There were also four negative syllables. These syllables were the same for the two series of practice trials and began with phonemes that were neither stops nor fricatives. The Appendix shows the stimuli for the practice trials in the order in which they were presented.

The target phonemes for the test trials were the stops /p/, /t/, /b/, and /d/ and the fricatives /f/, /s/, /v/, and /z/. For each target, there were three positive and six negative stimuli. Of the negative stimuli, two began with a phoneme that differed from the target only in voicing, two began with a phoneme that differed from the target only in place of articulation, and two began with a phoneme that differed from the target in both voicing and place. The stimuli are listed in the Appendix.

Participants. Twenty-six kindergartners (mean age 5 years, 10 months; range 5,4–6,8) met the criteria for participation. Fourteen were girls and 12 were boys. Two additional children failed to reach the criterion on the practice trials. The children were tested during the last third of the school year.

Results and Discussion

The results are shown in Table 3. An ANOVA on negative items using the factors of type of negative stimulus (voicing different vs place different vs voicing and place different) and target type (stop vs fricative) showed a main effect of negative stimulus type ($F(2,50) = 4.40$, $p = .017$), a main effect of target type ($F(1,25) = 4.50$, $p = .044$), and no interaction. The main effect of target type occurred because children performed better on negative items when the target was a stop (84% correct) than when it was a fricative (81% correct). This difference is in the opposite direction to that predicted by Byrne and Fielding-Barnsley (1990). The main effect of type of negative

TABLE 3
Proportion of Correct Responses in Experiment 3, Using Stops and Fricatives as Targets (Standard Deviations in Parentheses)

		Negative stimuli		
Target type	Positive stimuli	Voicing different	Place different	Voicing and place different
Stops	.78 (.26)	.79 (.24)	.88 (.20)	.87 (.25)
Fricatives	.74 (.26)	.77 (.24)	.86 (.21)	.81 (.28)

stimulus reflected the same pattern found in Experiments 1 and 2—poorer performance on negative items whose first phoneme differed from the target only in voicing than on the two other types of negative items ($p = .021$), which were statistically indistinguishable from one another.

On positive items, as on negative items, children tended to do better on stops than fricatives (78% vs 74%). However, the difference between the two types of targets was not significant for positive items ($F(1,25) = 1.11$, $p = .30$). Pooling over positive and negative items, the percentage of correct responses was 82% for stops and 79% for fricatives ($F(1,25) = 4.02$, $p = .056$).

The results of Experiment 3 replicate the findings of Experiments 1 and 2 that children find it harder to reject a phoneme that differs from the target only in voicing than a phoneme that differs from the target in place alone or in place plus voicing. However, the results of Experiment 3 do not support the suggestion that fricatives provide an easier point of entry into the concept of phonemic identity than do stops (Byrne & Fielding-Barnsley, 1990). Indeed, the trend in Experiment 3 was in the opposite direction—better performance on stops than fricatives.

The results of Experiment 3 suggest that kindergartners have an ability to compare word onsets that can be revealed under favorable conditions (e.g., with the training procedures of Experiments 2 and 3) but not under less favorable conditions (e.g., with the training procedure of Experiment 1). The percentage of kindergartners who reached the criteria was 93%, similar to that observed in Experiment 2 (95%) and much higher than that observed in Experiment 1 (56%). These differences show that careful attention to the details of task administration is necessary if children are to reveal the full extent of their abilities.

GENERAL DISCUSSION

In three experiments, we examined the linguistic factors that affect children's performance on the phoneme recognition task. This task taps the concept of phoneme identity—the concept that *day* and *dig*, say, share an initial segment. This concept is an key foundation of alphabetic literacy (e.g., Adams

et al., 1998; Byrne, 1998), and so it is important to understand the linguistic factors that affect its attainment.

Our results do not support the suggestion that fricatives provide an easier point of entry into the concept of phoneme identity than stops (Byrne & Fielding-Barnsley, 1990). Not only was there no significant superiority for fricatives over stops in Experiment 3, there was a trend in the reverse direction. One might argue that the initial attainment of phoneme identity is easier for fricatives than for stops, but that the difference disappears once children have achieved some understanding of the concept. However, the training study by Treiman and Baron (1981, Exp. 3) also failed to find a significant superiority for fricatives over stops.

Our clearest finding, which emerged in all three experiments, was that certain kinds of negative items are more difficult than others in the phoneme recognition task. Specifically, children have trouble rejecting items whose initial phonemes are identical to the target in all respects but voicing. Items whose initial phonemes are identical to the target in all respects but place of articulation are easier to reject. Thus, voicing appears to play a special role in children's phonological systems, with phonemes that are alike in all respects except voicing being close in phonological space and hence likely to be confused.

The suggestion that phonemes that differ only in voicing are particularly similar for children agrees with observations from studies of children's short-term memory errors, spelling, and reading. Eimas (1975) examined six-year-old children's short-term memory for CV syllables. He found that memory confusions tend to involve similar-sounding phonemes, especially phonemes that are alike in all respects but voicing. For example, children sometimes reported /gɑ/ in place of /kɑ/. Treiman (1993) examined first graders' spelling errors. She reported that misspellings of consonants often involved consonants that are alike in manner of articulation (e.g., both stops or both fricatives) and place of articulation but that differ in voicing. For example, children sometimes misspelled /g/ as *k* or *c* or /k/ as *g*. Young children who begin to write on their own (Read, 1975) and older children who have serious problems in spelling and reading (Kibel & Miles, 1994) make similar misspellings. Finally, voicing appears to play a special role in early reading. Five-year-old children can learn to pronounce a nonword like ''dbl'' as *table* more easily than they can learn to pronounce ''pbl'' as *table* (Rack, Hulme, Snowling, & Wightman, 1994). The critical difference between these two nonwords is that the phoneme symbolized by *d* differs from /t/ only in voicing, whereas the phoneme symbolized by *p* differs from /t/ in place. Children's better performance on pairs of the ''dbl''-*table* type suggests that voicing is less salient than place in their phonological systems.

That we find voicing errors in spelling and reading, as well as in purely oral tasks, supports the view that children's spelling and reading have an important phonological component (e.g., Adams *et al.*, 1998, Byrne, 1998). It would be difficult to explain misspellings such as ''gat'' for *cat* on the

view that spelling is a visual process involving the rote memorization of letter strings. The lower-case letters *g* and *c* do not look particularly similar. The most plausible explanation for misspellings such as ''gat'' for *cat* is that spelling is based on phonology. The phoneme symbolized by *g*, /g/, is similar in all but voicing to the first phoneme of *cat*, /k/, and so is highly confusable with it.

Our results can be interpreted in terms of theories in which phonemes are composed of elementary linguistic features. In the view of Chomsky and Halle (1968), all features are binary. For example, the feature of voicing may take on a positive or a negative value, with /g/ having the feature of [+voice] and /k/ having the feature of [−voice]. Chomsky and Halle used two binary features to represent the distinction between bilabials/labiodentals (/p/, /b/, /f/, /v/), alveolars (/t/, /d/, /s/, /z/), and velars (/k/, /g/). Alveolars have the feature [+coronal], with the other types of phonemes listed above being [−coronal]. Bilabials, labiodentals, and alveolars are [+anterior], with velars being [−anterior]. In this view, some of the place-different stimuli of Experiment 1 involved phonemes that differ in two distinctive features (e.g., /t/-/k/, which differ in the features of [coronal] and [anterior]). Other stimuli involved phonemes that differ in only one feature (e.g., /p/-/k/, which differ in the feature of [anterior]). In contrast, all of the place-different stimuli of Experiments 2 and 3 differed in just one feature (i.e., [coronal]). That children made fewer errors on the place-different stimuli than on the voicing-different stimuli even in Experiments 2 and 3 suggests that the feature of voicing is less salient than the feature of coronality in children's phonological systems. All features, in other words, are not alike.

More recently, the view that all features are not alike has been captured by linguistic theories that group features into sets. For example, features related to voicing and aspiration are classified as laryngeal features, whereas features relating to place of articulation and stop versus fricative are grouped under the oral cavity node (Clements & Hume, 1995). In this view, a consonant's place of articulation is described in terms of three one-valued features—[labial], [coronal], and [dorsal] (with the latter being used for velar consonants). For example, /t/ and /k/ differ in that /t/ has the value [coronal] and /k/ has the value [dorsal]. Interpreted within this framework, our results suggest that distinctions in oral cavity features are more salient for children than variations in laryngeal features. This hypothesis needs to be tested in future research.

In addition to their implications for the nature of children's phonological representations, our results have implications for education. As we have discussed, phonemic awareness plays an important role in learning to read and spell and early training in phonemic awareness has long-term benefits. Programs are therefore needed to teach phonemic awareness skills to children. Our results suggest that it may not be necessary to avoid stop consonants during the initial phases of phonemic awareness instruction, as Lundberg *et al.* (1988) attempted to do in designing their training program. However, it

may be important to keep voiced and voiceless consonants separate at first, as Lundberg and his colleagues also did. Knowing that children sometimes confuse consonants that are alike in all respects but voicing, extra time can be spent on this distinction.

Our findings about the way in which the linguistic properties of the items influence children's performance on phonemic awareness tasks have implications for the interpretation of such tasks. A large number of tests have been developed to measure phonemic awareness. These tests vary both in the cognitive demands of the tasks that children are asked to perform and in the linguistic structure of the items. Because of these differences, it can be difficult to compare performance within and across phonemic awareness tests. Our results, together with other recent findings (Stahl & Murray, 1994; Treiman & Weatherston, 1992), show that the linguistic structure of the items is a critical determinant of performance. Linguistic factors must be considered when developing and interpreting phonemic awareness tests.

APPENDIX

Stimuli for Experiment 1

Practice trials:
/l/ (Len): /li/, /lɑ/, /rai/, /re/, /fu/, /foi/
/s/ (Sam): /sɑ/, /soi/, /ʃe/, /ʃo/, /wu/, /wo/
/m/ (Marge): /moi/, /mau/, /nɑ/, /ne/, /zo/, /zi/
Test trials:
/p/ (Pat): /pɑ/, /poi/, /po/, /bu/, /bo/, /te/, /tau/, /doi/, /dɑ/
/t/ (Tom): /te/, /tau/, /to/, /doi/, /dɑ/, /ku/, /kai/, /gi/, /gɑ/
/k/ (Ken): /ku/, /kai/, /ko/, /gi/, /gɑ/, /po/, /poi/, /bu/, /bo/
/b/ (Barb): /bu/, /bo/, /be/, /po/, /poi/, /gi/, /gɑ/, /ku/, /kai/
/d/ (Dave): /doi/, /dɑ/, /dau/, /te/, /tau/, /bu/, /bo/, /po/, /poi/
/g/ (Gail): /gi/, /gɑ/, /goi/, /ku/, /kai/, /doi/, /dɑ/, /te/, /tau/

Stimuli for Experiment 2

Practice trials (in order of presentation):
/l/ (Len): /lɑ/, /mɔ/, /ru/, /lai/, /ʃe/, /loi/, /rau/, /lo/
Test trials:
/f/ (Fonz): /fe/, /fu/, /fo/, /vo/, /voi/, /sɑ/, /sau/, /zai/, /zɔ/
/s/ (Sam): /sɑ/, /sau/, /soi/, /zai/, /zɔ/, /fe/, /fu/, /vo/, /voi/
/v/ (Val): /vo/, /voi/, /vau/, /fe/, /fu/, /zai/, /zɔ/, /sɑ/, /sau/
/z/ (Zane): /zai/, /zɔ/, /zu/, /sɑ/, /sau/, /vo/, /voi/, /fe/, /fu/

Stimuli for Experiment 3

Practice trials (in order of presentation):
/g/ (Gail): /gau/, /mo/, /we/, /gu/, /ni/, /goi/, /ru/, /go/
/ʃ/ (Sean): /ʃau/, /mo/, /we/, /ʃu/, /ni/, /ʃoi/, /ru/, /ʃo/

Test trials:

/p/ (Pat): /po/, /poi/, /pau/, /bɑ/, /bo/, /te/, /tɔ/, /dɑ/, /de/
/t/ (Tom): /te/, /tɔ/, /tu/, /dɑ/, /de/, /po/, /poi/, /bɑ/, /boi/
/b/ (Barb): /bɑ/, /bo/, /boi/, /po/, /poi/, /dɑ/, /de/, /te/, /tɔ/
/d/ (Dave): /dɑ/, /de/, /dɔ/, /te/, /tɔ/, /bɑ/, /bo/, /po/, /poi/
/f/ (Fonz): /fɑ/, /fo/, /foi/, /vo/, /voi/, /sɑ/, /se/, /ze/, /zɔ/
/s/ (Sam): /sɑ/, /se/, /sɔ/, /ze/, /zɔ/, /fɑ/, /fo/, /vo/, /voi/
/v/ (Val): /vo/, /voi/, /vau/, /fɑ/, /fo/, /ze/, /zɔ/, /sɑ/, /se/
/z/ (Zane): /ze/, /zɔ/, /zu/, /sɑ/, /se/, /vo/, /voi/, /fɑ/, /fo/

Key to notation: /ɑ/ as in f*a*ther, /o/ bo*a*t, /i/ b*ee*t, /e/ b*ay*, /ə/ sof*a*, /ai/ b*uy*, /ɔ/ bo*ugh*t, /oi/ bo*y*, /u/ bo*o*t, /au/ bo*u*t, /ʃ/ *sh*op.

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