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Phonological deficiencies in children with reading disability: Evidence from an object-naming task*

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Abstract

Research indicates that children with reading disability have problems both in naming objects and in performing certain tasks that require phonological processing or phonological awareness. The present study explored the possibility that these problems are related: Poor readers may have object-naming deficits as a consequence of phonological deficiencies in establishing complete representations in long-term memory and in processing these representations. This hypothesis was supported in an initial experiment that required children to name pictured objects. The poor readers were less accurate than the good readers in labeling the objects. Their difficulty was particularly marked on objects with low frequency names and those with polysyllabic names, these being, presumably, more difficult to represent and to process accurately than frequent and short names. Moreover, the incorrect responses bore a phonetic resemblance to the correct object names. In a second experiment, the poor readers had difficulty making decisions based on the length of object names, even when it could be established that they knew the names. This suggests that they lack explicit awareness of the correspondence between the units of phonological representations and the units of speech. Since there is evidence that this awareness is important for learning to read well, the findings of this experiment and the first experiment support the hypothesis that the difficulties of poor readers reflect common stages in the processes that underlie reading and naming.

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Errors in naming objects are characteristic of children with reading disability (Denckla & Rudel, 1976; Jansky & de Hirsch, 1973; Mattis, French, & Rapin, 1975; Wolf, 1981). On tests of naming, it is usual for such children to name fewer of a set of pictured objects correctly than normal readers of the same age. In fact, the co-occurrence of naming and reading problems is found even among poor readers who score normally on intelligence tests and who have no obvious difficulties with spoken language. Although the occurrence of naming deficits in poor readers has been recognized for some time, the reasons they occur, and the relations they may have to reading problems, are matters that research has scarcely addressed. The present study provides new data that address these questions. The naming performance of reading-disabled children was investigated in the context of the children's other language-related problems on the expectation that an interpretable pattern of deficits could be elicited. The findings lead to a consideration of the possibility that phonological deficiencies might underlie both the children's naming deficits and their reading difficulties.

Some preliminary remarks on the naming act will indicate the rationale for the method of the present study. The starting point for naming is an object in the world and the endpoint is the production of a word that is the best label for a given object. A number of mental processes intervene. The first requirement is registration of the object in perception. Since the name of an object is not inherent in the object itself, a phonological representation of the name must then be located by a search of long-term memory. There is reason to believe (Labov, 1973; Miller, 1978) that the search may be influenced by stored semantic information, such as knowledge of the use for which the object is employed. Further, once the representation is located, it must be processed (i.e., given a phonetic interpretation) in order to articulate the object's name.

Thus, three broad classes of processes have been acknowledged in models of naming (Caramazza & Berndt, 1978; Goodglass, 1980; Wolf, 1981): perceptual, semantic, and phonological. A deficiency in any one of these could lead to failure in naming. A perceptual or a semantic deficiency could prevent an object from being recognized and identified. In contrast, deficiency in processing a phonological representation could prevent the individual from generating the accepted name even though the appropriate phonological representation had been located. Thus, naming deficits can occur in a number of ways. The occurrence of a naming error does not reveal its source without further analysis.

The aim of the present study was to confirm the existence of naming deficits in poor readers and to probe specifically for the phonologically-related deficiencies that may underlie them. This approach was adopted because a variety of evidence indicates that poor readers have weaknesses in the phonological domain. Their problems are evident in several laboratory tasks. Poor readers are less aware than good readers of the phonetic segments of spoken language (Liberman, Shankweiler, Fischer, & Carter, 1974) and less able to extract the phonetic information from speech stimuli degraded by noise (Brady, Shankweiler, & Mann, 1983). On short-term memory tasks, poor readers are less able than good readers to exploit phonetic properties in retention of the items and their serial order (Katz, Shankweiler, & Liberman, 1981; Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977; Mann, Liberman, & Shankweiler, 1980; Shankweiler, Liberman, Mark, Fowler, & Fischer, 1979). On long-term memory tasks, problems have also been found in poor readers' ability to learn new words (Nelson & Warrington, 1980). There are reasons, then, for suspecting that a deficiency in the phonological aspects of object naming could underlie the deficits of poor readers on naming tasks. Although this possibility has been raised in earlier discussions of reading disability (Denckla & Rudel, 1976; Wolf, 1979, 1981), it has never been investigated systematically.

In earlier research (Wolf, 1979), semantic similarities between errors in naming and the target items have often been noted (e.g., "hose" for "nozzle", or "Eskimo house" for "igloo"). Such so-called "semantic" errors can, of course, result from a misidentification of the object.[1] But, alternatively, semantic errors may be a consequence of the putative phonological deficiencies. These deficiencies could make it impossible for the child to use an existing phonological representation as the basis for correctly articulating the object name. In such cases, children may be compelled to substitute one or more words that are better represented or which can be more easily processed. It may sometimes happen that when a semantically-related word is substituted, it will also be related phonetically to the correct response (e.g., "seashell" for "seahorse"). This is found to be true of semantic errors that occasionally occur in normal spontaneous utterances (Fay & Cutler, 1977). It is easy to imagine a parallel in mistakes of naming. The influence of the "correct" phonological representation of the object name on the error may be revealed whenever a phonetic resemblance is present. Following this line of reasoning, the effect of phonological deficiencies can be assessed, at least in part, by comparing the phonetic similarity of the erroneous response to the target item. In contrast, attempting to classify the errors into categories, such as "phonetic" versus "semantic", would not be appropriate, since phonological deficiencies could conceivably result in errors of both types.

[1]One would also expect semantic errors to be made in instances where the correct word is not lexically represented at all. This points to the need to control for vocabulary differences in naming studies.

The hypothesis that the naming deficits of children who are poor readers are often due to phonological deficiencies can thus provide a principled account of naming errors. Moreover, this proposal has a major advantage over alternative accounts: it can rationalize the occurrence of naming deficits in conjunction with reading problems.[2] The same phonological deficiencies could lead to problems in both naming and reading, because each function depends critically on the efficient operation of certain phonological abilities. In reading, one can argue that the representations of words are accessed via the phonology that is reflected in the orthography of printed words (Liberman, Liberman, Mattingly, & Shankweiler, 1980). Once a phonological representation is accessed, the phonetic form of the word can then be derived. In naming an object, the way in which a phonological representation is accessed must be entirely different. Since the object itself does not inherently represent the phonology of the language, the representation is accessed by using perceptual and semantic information. But after accessing the representation, the child must use it as the basis for generating the phonetic code to be articulated, just as he would in reading. If the child's phonological representations are incomplete, or if his processing of the representations is inefficient, then deficits in both reading and naming would be expected to occur as a consequence. Thus, the co-occurrence of reading and naming disorders can be rationalized by proposing that both are based on the same phonological deficiencies.

Two experiments were conducted to examine the hypothesis that phonological deficiencies contribute to the object-naming deficits of poor readers. In the first experiment, children who varied in reading ability were required to name pictured objects in order to confirm the existence of naming deficits in the poor readers. Evidence that the failure to name objects correctly was due to phonological deficiencies was sought by analyzing the erroneous responses and by analyzing the characteristics of the object names that were produced incorrectly. In a second experiment, the same children were compared on their ability to make metalinguistic decisions based on the names of pictured objects. The children were tested on two metalinguistic tasks that differed in the kinds of phonological attributes that were relevant to successful execution. Each task required that the necessary phonological attributes be adequately represented and that the subject have conscious access to these attributes.

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[2]This is a matter of concern not only in the area of childhood reading disability, but also in the aphasias of adults, where reading problems are often accompanied by naming problems (Benson & Geschwind, 1969).

Experiment 1

The purpose of the first experiment was to confirm the existence of naming deficits in poor readers and to determine the basis of any deficits that might be found. Accordingly, children who differed in reading ability were asked to name line drawings of objects as quickly as possible. By stressing speed of response, it was expected that the children's naming ability would be taxed, thus eliciting errors. On those trials in which the correct name was not produced, further testing was done with the aim of assessing possible tacit knowledge of the name and of assessing familiarity with the pictured object. Then, a phonetic prompt to the correct response was provided, consisting of the initial consonant(s) and vowel of the target word. A post-test was conducted to determine whether the names of the objects were actually represented in the children's lexicons. On this test, the children were presented with sets of pictured objects, most of which had been presented earlier on the naming test. The task was to point to the objects as they were named by the experimenter. The recognition post-test was necessary in order to exclude the possibility that the poor readers could name fewer objects merely because they have smaller vocabularies than the better readers.

Evidence that the failure to name objects correctly can be attributed to phonological deficiencies was obtained in three ways. First, the degree of phonetic relationship between the erroneous response and the correct object name was analyzed. It was expected that phonological deficiencies would lead to errors that phonetically resemble the target names. This would be true of both the good and the poor readers, but, whereas the poor readers were expected to make many errors of this kind, the good readers were expected to err on the few object names that either are not fully represented or are not processed effectively. Second, the children were tested on their awareness of the length of the names of objects that were labeled incorrectly. It was expected that on this metalinguistic test all the children could provide evidence that certain gross phonological characteristics of most of the words, such as their length, were represented even though processing deficiencies may have prevented the production of the words. Third, the effect of word frequency and word length on object naming was examined. It was expected that objects with names that are low frequency words would tend to be labeled incorrectly since the names, having been encountered infrequently, would be incompletely represented. Objects with long names may also be difficult to label, since longer words require that more phonological information be represented and processed. Due to their general phonological deficiencies, it was expected that the poor readers would make disproportionately more errors than the good readers both on low frequency words and on long words.

Method

Subjects

The subjects were children selected from three third-grade classes in a suburban Connecticut public school. All those for whom parental permission was obtained were eligible for testing. Of the 45 children who were recruited, five were dropped because English was a recent second language for them. An additional child was dropped because of prolonged absence from school. The remaining 39 children were individually given the *Peabody Picture Vocabulary Test* (PPVT) (Dunn, 1959) and the reading, spelling, and arithmetic subtests of the *Wide Range Achievement Test* (WRAT) (Jastak & Jastak, 1965). An additional six children were then dropped from the study because their PPVT IQ was below 90. None of the remaining children had any noticeable articulatory problems.

On the basis of their scores on the reading subtest of the WRAT, the 33 children were divided by reading score into three nonoverlapping groups. The 10 children (5 females, 5 males) with a reading grade level of 3.9 or below (range: 2.5 to 3.9) were designated the "poor" readers. Although the WRAT indicated that some of these children were reading at grade level, all of them were achieving below local norms, and all of them lagged substantially behind their peers. The 12 children (4 females, 8 males) with a grade level of 4.1. to 5.1 were assigned to the "average" reader group. Finally, the remaining 11 children (8 females, 3 males) with a reading level above 5.1

Table 1. *Experiment 1: Mean scores of the children as a function of reading ability*

	Reading ability		
	Good	Average	Poor
n	11	12	10
WRAT grade level			
Reading	6.3	4.7	3.1
Spelling	5.5	4.5	3.0
Arithmetic	3.6	3.2	3.0
Age (yr;month)	8:8	8:9	8:8
PPVT			
IQ	117	107	106
Raw score	80	74	72

(range: 5.5. to 6.8) were designated the "good" readers. The mean age and test scores for each reading group are summarized in Table 1. From the table, it can be seen that the reading groups differed not only in reading level, $F(2,30) = 98.6$, $p < .001$, but also in spelling ability, $F(2,30) = 33.8$, $p < .001$. All three groups obtained grade-level scores in arithmetic. Differences between the groups, though small, were consistent enough to reach significance, $F(2,30) = 4.6$, $p < .02$. There were no significant differences in age, $F < 1$, or in IQ, $F(2,30) = 3.2$, $p > .05$.

In addition to its use in determining IQ, the PPVT was used to assess whether there were group differences in receptive vocabulary. For this comparison, the raw score (the absolute number of drawings that were recognized, unadjusted for age) of each child was examined. It was found that the groups were not equivalent on this measure, $F(2,30) = 4.8$, $p < .02$; there was a relationship between reading ability and the number of drawings recognized on the PPVT.

Materials

Forty pictured objects were selected from among the 85 line drawings of the *Boston Naming Test* (BNT) (Kaplan, Goodglass, & Weintraub, 1976). The BNT was standardized on a group of children ranging in age from 6 to 14. The test objects were ranked by the frequency with which naming errors occurred in the standardization group, thus giving a difficulty rank to each. The "correct name" for each object was determined by consensus of educated adults. The correlation between the ranked "difficulty" (i.e., incidence of naming errors) of the objects and the frequency of occurrence of object names[3] (Carroll, Davies, & Richman, 1971) was highly significant, $r(83) = -.35$, $p < .001$. The particular objects for this study were selected from across the entire range of the BNT. An attempt was made, within the constraints of the BNT, to include objects that are difficult to name but have short names, as well as objects with long names that are easy to name. Eighteen two-syllable names were represented, along with 12 with greater than two syllables and 10 consisting of one syllable. The items chosen are listed in Appendix A along with BNT difficulty rank, number of syllables, and frequency per million words (Carroll et al., 1971).

For the naming test, the 40 pictured objects were photographed and

[3]The frequency per million words for each name was calculated by summing the frequency of occurrence for the target word (e.g., whistle) and all syntactic variants of the name (e.g., whistles, whistled, whistling). The frequencies in the word count itself were determined by examining how often each lexical form occurred in elementary school and junior high school textbooks.

mounted on 2 × 2 in. slides. For the recognition test, the 40 objects were reduced in size to approximately 3 × 4 in. The 40 reduced drawings were then divided into eight groups of five, all close in difficulty rank. To each group was added another three reduced BNT object drawings which had difficulty ranks near those of the original five objects. This procedure resulted in 8 recognition sets, each consisting of 8 pictured objects of similar BNT difficulty rank. The eight members of each set were mounted in random order on a sheet of 8½ × 11 in. white paper.

Procedure

The children were tested individually in one 30-min session. For the naming test, the pictured objects were projected onto a plain white screen using a carousel slide projector. The children viewed the objects from a distance of about 52 in., with each object subtending a visual angle of approximately 5.5 degrees both vertically and horizontally. The onset of the visual display triggered the start of a clock, which was stopped by the child's vocal response, via a hand-held microphone and a voice-activated relay. The experimenter recorded all responses and the naming times of the correct responses. The entire naming test was recorded on audiotape.

At the beginning of the experiment, the child was instructed to name each object as quickly as possible. The objects were then presented sequentially in the order that they appear in the BNT, that is, according to their rank difficulty. If the child's first response was incorrect, the experimenter asked for another name for the object. If the second response was also incorrect, the experimenter tried to elicit a third attempt. If a child continued to respond inaccurately or gave no response at all, then his familiarity with the pictured object was assessed. To evaluate familiarity with an item, the experimenter asked the subject to describe the object's uses or where it had been seen before. The question was phrased in the way that was most appropriate for the particular object. If the child could demonstrate familiarity with an object, then he was tested for awareness of phonological properties of the name. To do this, the experimenter asked whether the object name was a short word like "cat", a medium-length word like "pencil", or a long word like a bicycle". Finally, a prompt was given consisting of the initial phonemes of the name, if the child had not already produced an incorrect response that included these phonemes. The prompt for "wreath", for example, was "/ri/".

The recognition test was conducted at the end of the test session. At that time, the child was shown each of the sets of recognition objects and was instructed to point to the object named by the experimenter. The experimenter then named in random order the eight objects of each set and recorded the subject's responses.

Results

Naming

An object was scored as correctly named if at any time its name was spontaneously given. Thus, the overall scoring did not reflect whether the name was produced on the first, second, or third try. Only a few objects were initially named correctly by a majority of the children. As a consequence, naming times on most of the objects were unavailable for most children and could not be subjected to statistical analysis. It was noted, however, that no tradeoff between speed of response and accuracy of response was evident; initial correct responses were generally given quickly. It was also noted that the stress on speed of response did not increase the likelihood that children would make errors that are phonetically related to the correct responses. Incorrect initial naming attempts bore as close a phonetic resemblance to the correct name as incorrect responses made on the second or third try when the stress on speed was relaxed.

Relationship between reading ability and object-naming ability. The number of objects correctly named without prompting ranged from as few as 10 of the 40 objects to as many as 30. The correlation between the number of objects a child named and his reading score proved to be significant, $r(31) = .46$, $p < .008$. Thus, there is a significant relationship between reading ability and object-naming ability.

The question arises, however, whether the poor readers named fewer objects than the good readers because they had smaller vocabularies including fewer of the object names. To examine this possibility, the results of the recognition and object familiarity testing (see later sections) were used to adjust each child's naming score. For the purpose of computing the adjusted score, pictured objects that were judged unfamiliar or were not recognized from their spoken names were eliminated from consideration on an individual basis. Moreover, the final five items (scroll, noose, tongs, sphinx, visor) were eliminated, because these were consistently found to be either unfamiliar or not recognizable by name. Of the remaining objects, the proportion correctly named ranged from .34 to .94. The relationship between the proportion of objects a child named and his reading score yielded a significant correlation, $r(31) = .48$, $p < .005$. This correlation is of about the same magnitude as the value obtained when the naming score was not adjusted for object familiarity or object-name familiarity. Thus, the variation in object-naming ability with reading level could not be explained as an artifact of differences in vocabulary size; it was also obtained when the analysis was limited to familiar objects that were immediately recognized when named by the experimenter.

The effect of difficulty rank and the length of object names on naming success. Other factors in addition to reading ability may have a relationship to naming success, namely, an object's difficulty rank and the length of its name. In examining these possibilities, only the objects that were both familiar and recognizable by name were considered for each child. Since it was necessary to eliminate the final five objects, and since objects with two-syllable names were overrepresented in the stimulus set, the data were reorganized into two difficulty levels, each containing short and long names, thus comprising four groups in all. The "easy" level consisted of the first 18 objects (from "toothbrush" to "harmonica" in Appendix A). The "hard" level was composed of the next 17 objects (from "igloo" to "pyramid"). Within each difficulty level, the objects were divided by the number of syllables in their names; objects with one- or two-syllable names were said to have "short" names, whereas objects with three- or four-syllable names were said to have "long" names. For each child, the percentage of objects correctly named in each of the four groups was calculated. The mean percentages for each group are shown in Figure 1 as a function of reading ability.

It is clear from inspection of the figure that naming performance varied with both reading ability and difficulty level. Furthermore, naming performance varied with reading ability to a much greater extent on the hard objects than on the easy objects. Word length appeared to have had less effect on naming than did difficulty level. For all the children, the objects with long names could be named about as well as those with short names. For the poor readers, however, there was a drop in performance on objects with long names, particularly in the hard group.

To test these observations, an analysis of variance was conducted with one between-groups factor (reading ability) and two within-groups factors (difficulty level and name length). The analysis revealed significant main effects of reading group, $F(2,30) = 7.0$, $p = .004$, and difficulty level, $F(1,30) = 300.6$, $p < .001$, and a significant interaction of the two, $F(2,30) = 5.1$, $p < .02$. Furthermore, the interaction of difficulty level and name length proved significant, $F(1,30) = 6.3$, $p < .02$.[4] The interaction of name length and reading group approached significance, $F(2,30) = 2.8$, $p < .08$.

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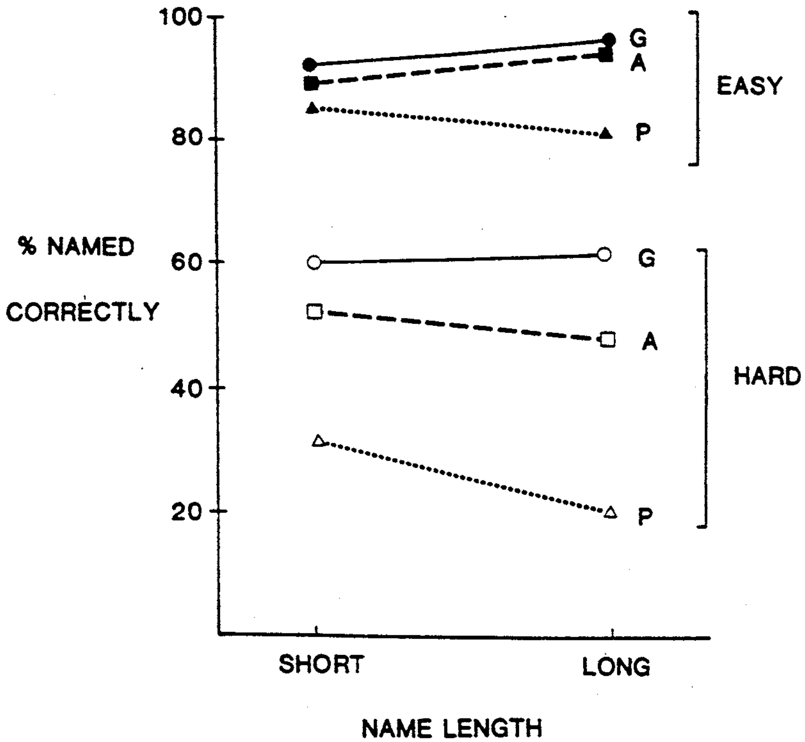
[4]It was desirable to test whether these findings can be taken to generalize to any set of objects. This was accomplished by considering the individual objects as a random effect in an analysis of variance (Clark, 1973). Since in every case but one the same effects were significant in this second analysis of variance as in the original analysis, we can be sure that the first results were not specific to any one set of objects. The analysis revealed significant main effects of reading group, difficulty level, and their interaction, respectively, $F(2,62) = 14.2$, $p < .001$, $F(1,31) = 54.7$, $p < .001$, $F(2,62) = 4.4$, $p < .02$. The interaction of difficulty level and name length was not significant in this analysis. The other results can be generalized.

Figure 1. *Experiment 1: Mean percentage of objects named correctly as a function of reading group (G = good, A = average, P = poor), difficulty level (Easy, Hard), and name length.*



To ascertain whether the interaction between reading ability and difficulty level might be explained as a function of absolute error scores, we can turn to a correlation measure, which is not affected by changes in scale or absolute magnitude (Baron & Treiman, 1980). Such an analysis can be meaningfully applied to the data, since reliability was comparable for the two difficulty levels. Split-half reliability adjusted by the Spearman-Brown correction was .83 for the easy objects and .86 for the hard objects. Proceeding with the analysis of the interaction, the correlation between the children's reading scores and mean performance on the difficult objects was found to be greater than that between reading scores and mean performance on the easy objects. The two correlations are, respectively, $r(31) = .50$, $p < .003$, and $r(31) = .26$, $p < .05$. (The relationship between performance on the two tasks is $r(31)$

$= .62$, $p < .001$.) Using a formula for comparing dependent correlations (Cohen & Cohen, 1975), the two significantly differed in a one-tailed test, $t(30) = 1.8$, $p < .05$. Thus, the interaction between reading ability and difficulty level cannot be attributed to a scaling problem.

The data were also analyzed with respect to the word frequency of the object names instead of the objects' BNT difficulty ranks. Although the difficulty ranks and the word frequencies significantly correlate, the relationship is not a perfect one. On the one hand, the difficulty ranks may, perhaps, better reflect the frequency of occurrence of the object names in spoken language than the word count frequencies, which were compiled from written material. On the other hand, it is likely that the difficulty ranks are contaminated by extraneous factors, such as the ease of articulation of the object names and the quality of the object drawings themselves. Thus, the analysis based on word frequency may be as meaningful as the previous one which used difficulty rank as a factor. This analysis revealed main effects of reading ability, $F(2,30) = 8.6$, $p = .002$, frequency, $F(1,30) = 147.5$, $p < .001$, and name length, $F(1,30) = 26.2$, $p < .001$. Moreover in this analysis, the interaction between reading ability and name length was significant, $F(2,30) = 8.0$, $p = .002$; the poor readers experienced increasing difficulty labeling objects with longer names.

Error analysis

Phonetic relationships between the errors and the target items. When an error in naming occurred, the frequency of the incorrect response word was greater than that of the target word 77% of the time. Moreover, many of the errors also bore an obvious phonetic relationship to the correct word. Examples are shown in Table 2 under the heading "Word errors". In these examples, the error often shares with the target word the same stress pattern, the same number of syllables, and several phonemes. Although nonword responses were infrequent, they usually bore a strong phonetic resemblance to the target words, as is apparent in the examples given in Table 2.

The effect of reading ability. It was important to quantify the degree of phonetic relationship between the errors and the correct names in order to make comparisons across reading groups. To do so, two separate analyses were done using the initial responses on those trials on which the objects were named incorrectly. The outcome of these analyses showed no significant differences between the groups. First, the agreement between the number of syllables in the incorrect response and the number of syllables in the target name was determined. Of the 170 responses, syllable agreement occurred for

Table 2. *Experiment 1: Examples of errors which bear a strong phonetic resemblance to the target names*

Target	Word errors	Nonword errors
volcano	tornado	/blou'keiʒən/
		/bal'keinou/
globe	bulb	/glouv/
		/gʌlb/
harmonica	thermometer	/hə'manəkɔrn/
		/man'kanə/
stethoscope	microscope	/'sIspəskoup/
	telescope	/'tεθəskoup/
rhinoceros		/'rainəsɔrəs/
		/rai'nasIs/
		/'rainəs/
		/də'ranəsɔrəs/
dominoes		/'danəmouz/
		/də'manəmouz/

48% (effect of reading group, $F < 1$). In the second analysis, it was found that 25% of the errors, on average, had the same initial phoneme as the target names. Again, even though the poor readers had produced significantly more errors than the better readers, there was no effect of reader group, $F(2,29) = 1.5$, $p = .23$.

Familiarity with pictured objects

An assessment was made of the children's familiarity with the objects that were named incorrectly, as described in Procedure. Of the 40 objects, only 2.7 were unfamiliar on average. There were no differences in object familiarity across reading groups, $F < 1$.

Tacit knowledge of names that were not produced

If an object was incorrectly named but was nevertheless familiar, the child was asked to choose a comparison word which matched the approximate length of the correct name, as described in Procedure. If, for example, the child had selected the word "cat", then his choice was a one-syllable word; if "pencil", a two-syllable word, and if "bicycle", then a three-syllable word. Agreement between the number of syllables in the target object names and the number contained in the children's choices was in this way determined. (Since a four-syllable comparison word was not available, four-syllable names were grouped with three-syllable names for this analysis.) It was found that agreement on the number of syllables tended to be low when the objects had one-syllable names. Apparently, there was a bias to choose the two-syllable item. Nevertheless, children correctly indicated the number of syllables for target items they could not produce on 63% of the trials. This percentage did not vary with reading group, $F < 1$. Thus, the children's tacit knowledge of names that were not produced was in that respect equivalent.

Effects of prompting

In cases of failure to name an object, the child was subsequently given a phonetic prompt if he had passed the test of object familiarity. The prompt led to a correct response 34% of the time, on average, and the reading groups did not differ on this measure, $F(2,30) = 1.4$. One may then assess how closely related phonetically the incorrect responses were to the target names. When a prompt was ineffective, the child often failed to respond at all. When prompting elicited a response it was often a nonword which bore a clear phonetic relationship to the target names. For example, in response to the prompt "/stɛ/" for "stethoscope", the following errors were produced: /'stɛfəkoup/, /'stɛləkoup/, /'stɛləskoup/, /'stɛpəskoup/, /'stɛsəfoun/, /'stɛlI/kə· . Again, it was desirable to quantify the phonetic relationship between the errors and the correct words in order to compare the reading groups. The incorrect responses always shared the initial phonemes with the target names because these were given as the prompt. It was determined that 66% of the cases also had the same number of syllables as the target words. Syllable agreement did not vary with reading ability.

Recognition of pictured objects from spoken names

Few errors were made in recognition of the pictured objects during the post-test when their names were spoken by the experimenter. Moreover, the percentage of correct recognitions varied only slightly with reading level; 86% of the objects were recognized by the poor readers, 88% by the average readers, and 90% by the good readers. These differences did not reach statistical significance in an analysis of variance, $F(2,30) = 2.8, p < .08$. In a more fine-grained analysis, however, the correlation between the children's reading scores and the number of objects recognized was significant, $r(31) = .46, p < .008$. Thus, these results are consistent with the variation in receptive vocabulary with reading level found earlier using the PPVT raw scores.

Discussion

The purpose of this experiment was to examine beginning readers' naming performance in order to confirm the presence of naming deficits in poor readers and to determine whether phonological deficiencies can account for the deficits. The results showed that there is indeed a relationship between reading ability and object naming in these children. The poor readers named significantly fewer objects than either the average or the good readers. Moreover, the difference remains when the children's naming scores were adjusted by eliminating objects that were unfamiliar or those whose names were unfamiliar. Therefore, we can be confident that the relationship between reading level and naming cannot be attributed to differences either in the children's familiarity with objects or in the relative size of their recognition vocabularies.

It is plausible that the better readers had previously been exposed to many of the object names in print. Possibly, having read the object names repeatedly, the good readers' representations of the names could have been more elaborate than those of the poor readers, thus allowing the good readers to name more objects correctly. It is possible, therefore. that reading experience resulted in an improvement in the ability of the better readers to name objects. In practice, the effect of reading experience on object-naming ability is impossible to estimate. On the one hand, the better readers knew more of the words on the PPVT than the poor readers. On the other hand, the "true" effect due to reading experience might well have been slight since the children had been reading for only a short time (about a year and a half) prior to their participation in this experiment.

It is now appropriate to consider whether the naming deficits of poor readers can reasonably be attributed at least in part to deficiencies in phonological processing. First, we should note that an interaction of difficulty level and reading group was obtained, which is in keeping with the findings of Denckla and Rudel (1976). We turn to consider the interpretation of this interaction. On one account, the poor readers may have had difficulty locating phonological representations. especially those of uncommon words, possibly due to inadequate perceptual or semantic interpretation of the objects themselves. On another account of the interaction, uncommon names, having been heard less frequently, may be represented incompletely or their representations may be processed ineffectively by all the children. The representation and processing of these names may be especially deficient in the poor readers who, because of their hypothesized phonological deficiencies, may require more experience to establish usable phonological representations (and to process these representations for output), accounting for their inferior performance on naming objects with uncommon names.

If phonological-deficiencies do underlie naming deficits, then other results would follow. An expected consequence of phonological deficiencies might be special difficulty naming objects with long names, since the longer the name the more phonological information that must be represented and processed. In this regard, the interaction between name length and reading group is of interest. It approached significance when it was analyzed in conjunction with difficulty level, as assessed by the BNT ranks, and it attained significance when frequency in print of the object names was used as a factor instead of BNT rank. An increase in error rate on longer names cannot readily be accounted for by a general perceptual or semantic deficiency leading to difficulty locating phonological representations. Such a problem should be insensitive to the length of the objects' names. Furthermore, the poor readers' difficulty with long names cannot be accounted for by supposing that they have an articulatory problem that hinders their production of long names. The poor readers were able to label correctly about half the objects that had long names, and their erroneous responses were sometimes long words. In view of its importance in explaining the naming deficits of poor readers, the relationship between name length and reading ability merits further investigation.

The results of the error analysis indicated that the incorrect responses of all the children, irrespective of their reading level, were equivalent in degree of phonetic relationship (as judged by the initial phoneme and word length) to the correct object names. Moreover, all the children, by producing incorrect responses that were phonetically related to the correct names, demonstrated that they could locate the correct phonological representations and that some of the phonological information was brought to bear in articulating their responses. When errors in naming occurred, we may suppose that the representations were not sufficiently detailed or not effectively processed. The results of the error analyses reveal no problems peculiar to the poor readers, but their higher error rate is consistent with the many sources of data that implicate phonological immaturity and deficient processing in this group.

Further evidence that implicates phonological deficiencies resulted from tests of the children's awareness of object names that were not correctly produced. Awareness of the length of the object names was above chance and did not vary with reading level. This is consistent with the results of Wolf (1979), who employed a similar procedure. This result should be interpreted cautiously, however, since the children usually did not offer a response on every trial of this task. If the children had been required to respond on every trial in which they failed to name the object correctly, they might have registered a lower level of accuracy and performances might have varied with reading ability. Nonetheless, the present findings are compatible with the idea that all the children could locate the appropriate phonological representations and that word length was specified in the representations. However, it might be supposed that full segmental information was not represented completely enough to enable the children to carry out the processing necessary to produce the name.

Finally, there were no differences across reading groups in sensitivity to phonetic prompts. The likely effects of prompting are complex. It is possible that the prompt, by providing speech cues, aided all the children in finding the correct phonological representation. On the other hand, it may be that the prompt provided confirmatory evidence that the children had found the correct representation. Following that, they may have been less reluctant to use the specified information. In either case, the high incidence of nonword responses after prompting indicates that many of the phonological representations contained partially deficient segmental information, although word length was relatively well represented.

Qualitative differences between the groups did not emerge from the error analysis or in the response to various probes for tacit knowledge of the properties of misnamed items. Apparently, when the good and the average readers failed to name pictures, their failures were similarly determined. The reading groups differed, however, in how often they were able to use their representations of names to produce the standard labels for the stimulus objects. Thus, the results of this experiment provide support for the hypothesis that the poor readers had difficulties naming objects because of underlying deficiencies in representing phonological information and in generating responses from the phonological representations.

Experiment 2

In Experiment 1, the evidence for phonological deficiencies was provided by using an object-naming task. Object naming, like speaking spontaneously, requires that phonological representations be used to guide the overt production of the target word. Use of phonological representations in this way is obviously a well-practiced routine, and humans are specially equipped biologically to carry it out (Lenneberg, 1967). The use of phonological representations in other ways, however, may require different linguistic abilities than those necessary for speaking. More specifically, making metalinguistic decisions based on the characteristics of words requires an explicit awareness of the phonological composition of those words, an awareness that is not necessary for normal speaking, but may be necessary for effectively learning to read language that is written by an alphabet (Liberman et al., 1977).

Moreover, if the metalinguistic decisions are to be made on the names of objects, then the ability of subjects to use phonological representations that are stored in long-term memory can be assessed. The present experiment explores the possibility that poor readers would prove deficient at using phonological representations to perform metalinguistic decisions even on words whose representations are completely specified in long-term memory.

The requirement that metalinguistic decisions be based on stored phonological representations may make for greater difficulty than the same decisions based on words presented auditorily. In fact, it is possible that certain metalinguistic tasks could be done easily by poor readers on spoken words, but only with great difficulty when they are required to generate the necessary phonological information without the acoustic cues provided by speech. Judging the length of a pair of words and deciding whether two words rhyme are metalinguistic tasks which are within the capability of young children when words are presented auditorily. In this connection, it has been found tht 90% of the children in a first-grade class could indicate correctly the number of syllables in words presented auditorily (Liberman et al., 1974). The number of syllables in a word is, of course, a good measure of its relative length. Thus, the information necessary to judge the length of a spoken word is available to children before they reach school age. Moreover, rhyme is a phonological relationship that is easy for young children to identify in spoken words (Lenel & Cantor, 1981). Thus, the two questions being asked in themselves are not likely to be beyond the abilities of the subjects.

Even though young children are able to make rhyme decisions and length decisions on spoken words, the same decisions may be difficult when they have to be based on representations that must be accessed through some other medium than that of speech, as, for example, the medium of pictures. Decisions based on object names require that the necessary phonological characteristics of the names be adequately represented in long-term memory. Experiment 1 suggested that poor readers may be deficient at representing the full segmental structure of words, although they may be able to represent adequately their gross characteristics, including approximate length. Since rhyme decisions based on object names apparently require that the full segmental structure be represented, it would come as no surprise if poor readers were deficient in making these decisions. In contrast, poor readers would not necessarily be deficient in making decisions based on word length provided that they could become explicitly aware of this attribute. The issue of the children's awareness of the length of object names not produced was examined incompletely in Experiment 1 and did not produce a clearcut result.

Thus, two difficulties would lead to deficient performance on certain metalinguistic tasks: a difficulty in representing the pertinent attributes of words and a lack of awareness of those attributes, which must become explicitly known in order to carry out the tasks. To examine whether the second possibility is indeed a genuine problem, we must first ascertain that the necessary information about a word is represented completely. Proof that a word is well-represented phonologically is demonstrated by the ability to generate the word acceptably. Accordingly, in this experiment the children were asked to perform metalinguistic tasks requiring access to the names of objects. It was later investigated to what extent the names were represented completely by testing for the ability to name the objects aloud. Following that, consideration was restricted to those item presentations for which it could thus be shown that the names were adequately represented. If the performance of poor readers was shown to be inferior to that of good readers even on these presentations, then evidence will have been adduced that poor readers lack explicit awareness of certain phonological properties of words they know.

Method

Subjects

The subjects were the children who participated in Experiment 1. Two children (a boy reading at a 5.5 grade level and a girl with a 6.8 reading level) were dropped from the study due to prolonged absence from school. Despite the loss of these two subjects, the test scores of the present group of good readers were close to those of the group described earlier (see Table 1).

Materials

For the rhyme condition, 15 pairs of line drawings of objects with rhyming names and 15 pairs with nonrhyming names were prepared. The names in each pair were monosyllabic words matched in frequency of occurrence[5] (Carroll et al., 1971). In addition, the mean frequency of each rhyming pair of names approximated the mean frequency of one of the nonrhyming pairs. (The names of the objects are listed in the left side of Appendix B. The first pair in each column was used for practice.)

For the length condition, 15 pairs of line drawings of objects with monosyllabic names were prepared. As a control, an additional 15 pairs of pictured

[5]As in Experiment 1, the frequencies (per million words) were for the name itself and all syntactic variants of the name.

objects with names of different length were also prepared. For the latter, one object in each pair had a monosyllabic name and the second object had a polysyllabic name, usually comprising three syllables. As in the rhyme condition, the names of the two objects in each pair were matched in frequency of occurrence. Further, the mean frequencies of the same-length pairs were matched to those of the different-length pairs. Moreover, each pair in the length condition was matched in frequency to a pair in the rhyme condition. (The names of the objects used in the length condition are listed in Appendix B. Again, the first pair in each column was used for practice.)

The two pictured objects designated for each test trial were separated by a vertical line, photographed, and mounted on 2 × 2 in. slides. For the different-length series, the object with the long name appeared on the left on half the slides and on the right for the other slides. The order of the slides in the rhyme condition was random with the constraint that no more than three successive trials be either rhyme or nonrhyme trials. The same ordering was used for the slides in the length condition.

Procedure

The children were tested individually on both the rhyme and length conditions in a single 30-min session. The order of conditions was counterbalanced so that half the children in each reading group received the rhyme condition first and the length condition second. The order of conditions was reversed for the remaining children.

In each condition, the pictured objects were projected onto a plain white screen using a carousel slide projector. The onset of the visual display triggered the start of a clock, which was stopped when the child pressed one of two telegraph keys. The children viewed the pictured objects from a distance of approximately 52 in., and each object subtended a visual angle of approximately 4.4 degrees both vertically and horizontally.

For the rhyme condition, the experimenter first ascertained that the child could distinguish spoken rhyming words and nonrhyming words. The experimenter spoke pairs of words and asked the child if they rhymed. Following that, the child was instructed that he would see two pictured objects simultaneously on the screen and that he was to indicate quickly whether the objects had rhyming names. Each subject responded by pressing either the key labeled "YES" or the key labeled "NO". As a reminder of the task, a card marked "Rhyme?" was placed between the keys. The child's responses on the two practice trials were reviewed to ensure that the task was understood.

For the length condition, it was first ascertained that the child could distinguish spoken monosyllabic and polysyllabic words by indicating whether words spoken by the experimenter were "long" or "short". Then pairs of words were given and the child had to indicate whether or not both words were short. Following this pretest, the subjects were asked to make length judgments on pairs of pictured items. The task was to indicate as quickly as possible whether the names of two pictured objects presented simultaneously were both short (i.e., monosyllabic). The child again responded by pressing one of two keys, one labeled "YES" and the other "NO". As a reminder of the task, a card marked "Both short?" was placed between the keys. As in the rhyme condition, two practice trials preceded the test trials and the subject's responses were reviewed.

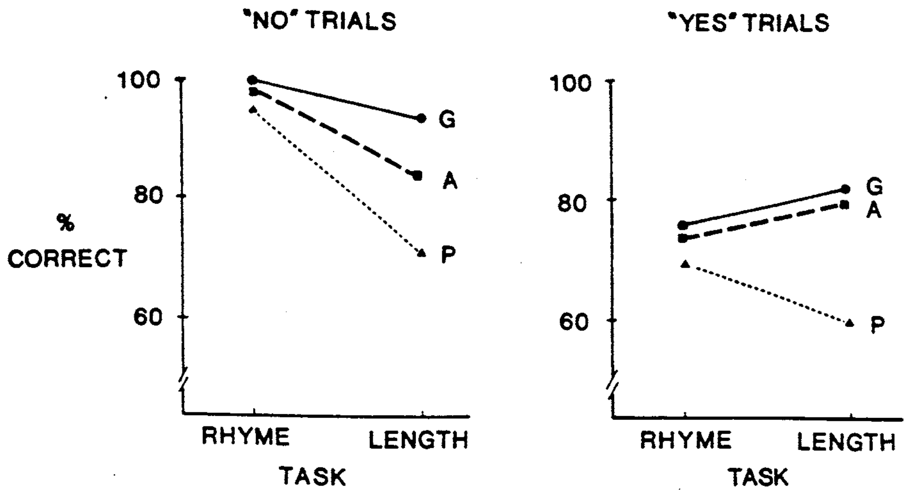
Following the testing on both conditions, the children were again shown each test slide. This time they were asked to name the objects aloud.

Results

For each task, the mean percentage of correct responses and the mean response times on correct trials were calculated. These calculations were made separately for the trials on which the correct answer was "no" (the so-called "no" trials) and for the trials on which the correct answer was "yes" (the "yes" trials). Because of the error rate, it was not practical to subject the response times to statistical analysis. The mean percentages of correct responses are shown in Figure 2 as a function of reading ability and task. When one examines the data from the "no" trials alone (left graph), it can be seen that overall performance on the rhyme task was very accurate; indeed, all the children performed near the ceiling level. In contrast, on the length task, performance varied markedly with reading ability. An analysis of variance with one between-groups factor (reading ability) and one within-groups factor (task) was conducted. In accordance with the above observations, main effects of reading group, $F(2,28) = 15.0$, $p < .001$, and task, $F(1,28) = 53.5$, $p < .001$, were obtained. Moreover, there was a significant interaction between reading ability and task, $F(2,28) = 7.6$, $p = .003$.

The mean percentages of correct responses on the "yes" trials are also displayed in Figure 2 (right graph). Compared with the corresponding percentages on the "no" trials, these values were generally lower. Neither the length task nor the rhyme task is near the ceiling level. It is apparent from the table that overall accuracy varied as a function of reading ability; the poor readers were correct on 64% of the trials, the average readers on 77%, and the good readers on 79%. Performance on the two tasks was comparable in overall accuracy with 74% correct on each, but varied with reading ability, particularly on the length task.

Figure 2. *Experiment 2: Mean percent correct as a function of reading ability (G = good, A = average, P = poor) and task.*



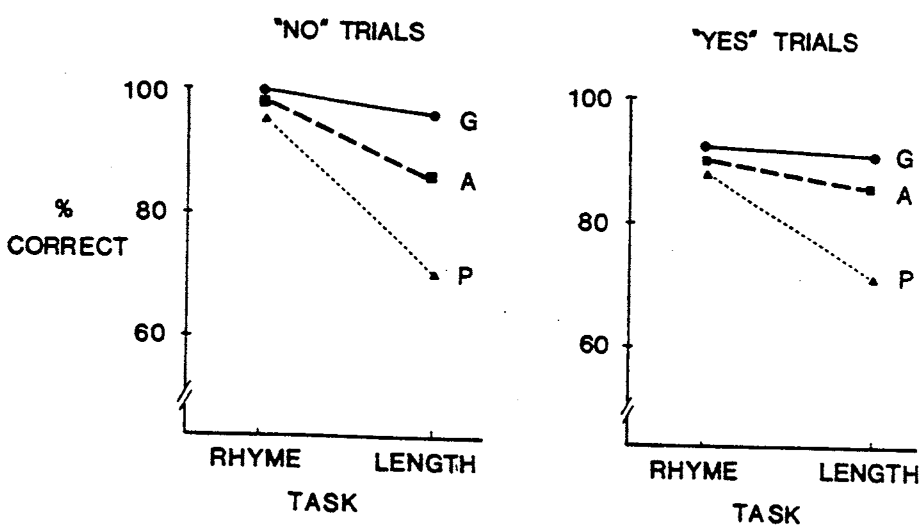
To evaluate these differences statistically, an analysis of variance analogous to that for the "no" trials was conducted. The analysis revealed a main effect of reading ability, $F(1,28) = 7.3$, $p = .003$. The interaction between reading group and task also proved significant, $F(2.28) = 6.3$, $p = .006$. The poor readers again had special difficulty on the length task even though all the object names on the "yes" trials were monosyllabic words.

Two possibilities come to mind as explanations of the inferior performance of the poor readers on the length task. Obviously, if their representation of word length information were inadequate, then the poor readers would fail to make correct length decisions. Even with adequate representations, however, difficulties could arise if the poor readers were unable readily to become aware of the word length specified by the representations. To investigate this one must first have ensured that any given subject's representation of word length is accurate. To that end, each child's task performance was assessed using only those trials on which both pictured objects had been later named correctly. For items that meet this criterion, the object names must have been represented entirely. Thus, if the poor readers prove to have difficulty making length decisions on these object names, their failure must indicate a lack of awareness of the length of the object names specified by these representations.

Considering only those trials on which the objects could be named, the mean percentages of correct decisions are shown in Figure 3. On both the "yes" and the "no" trials, it can be seen that performance was very accurate for all children on the rhyme task, but that it varied with reading ability on the length task. The effects of reading ability and task and their interaction were computed and are given in that order: for the "yes" trials, $F(2,28) = 3.9$, $p = .032$, $F(1,28) = 18.6$, $p = .001$, and $F(2,28) = 7.1$, $p = .004$; for the "no" trials, $F(2,28) = 17.5$, $p < .001$, $F(1,28) = 51.0$, $p < .001$, and $F(2,28) = 10.0$, $p < .001$. Possibly, the interaction effects in these analyses were inflated, since rhyme performance approached ceiling levels. Nevertheless, it is clear that performance on the length task effectively distinguished the reading groups. Analyses of variance with one factor (reading ability) computed on only the length task data were highly significant; for the "yes" trials, $F(2,28) = 8.5$, $p < .002$; for the "no" trials, $F(2,28) = 14.6$, $p < .001$.

Thus it is found that even when the children demonstrated that they could name both objects on the length task, the poor readers nonetheless failed more often than the good readers to make accurate decisions. Therefore, one may suppose that the poor readers found it particularly difficult to make explicit the word length information specified in a phonological representation.

Figure 3. *Experiment 2: Mean percent correct as a function of reading ability (G = good, A = average, P = poor) and task when the objects were nameable.*



Discussion

The purpose of this experiment was to explore the possibility that poor readers are deficient in using their phonological representations to guide performance on two metalinguistic tasks: a rhyme task, which required them to decide whether two objects have rhyming names, and a length task, which required them to decide whether two objects both have short names. The results indicated that the relationship between performance on the rhyme task and reading ability was small. There was, in contrast, a strong relationship between performance on the length task and reading ability. Considering only those trials on which objects were successfully named, performance on the length task improved for all the subjects, but the poor readers' performance remained significantly inferior to that of the better readers. Therefore, it can be said that the poor readers have a genuine difficulty in making length decisions even on words that are fully represented in long-term memory.

The results of Experiment 2 raise several issues. To begin with, examining only the trials on which both objects could be named, we see that complete representation of the object names provided a firm basis for making accurate rhyme decisions for all the children. The high level of performance indicates as well that, by the third grade, rhyme is a very salient characteristic of words. Children, of course, are acquainted with the existence of rhyming words, since these occur often in children's verse and song. The children's ability to make rhyme decisions on object names that vary in completeness of representation can be examined by considering all the trials (not just those that presented objects that could be named correctly). On the "no" trials of the rhyme task, all the children performed at high levels of accuracy, whereas on the "yes" trials, performance was at lower levels. This finding supports the view that rather complete representation is necessary for subjects to recognize that object names rhyme, but that incomplete representation provides an adequate basis for deciding that they do not. Apparently, incomplete representation of object names existed even for the good readers sufficiently to lower response accuracy on the "yes" trials.

Although the poor readers performed as well on the rhyme task as the better readers, they were unable to become explicitly aware of the length of words that were represented in memory. This finding is ostensibly discrepant from the result of an awareness test that was conducted in Experiment 1. In that experiment, when an object was familiar but could not be named, the child was asked to decide whether the object name was a short word like "cat", a medium-length word like "pencil", or a long word like "bicycle". It was found that reading groups were not differentiated on this task. This result, however, must not be overinterpreted, since the children often failed to respond on these occasions. Caution in interpreting the earlier finding is reinforced by the results of the present experiment.

Additionally, it may be that the length task in the present experiment was particularly taxing for the subjects. It required them to use their internal representations to judge the lengths of each pair of test words, whereas the task in Experiment 1 required only that the subject assess the length of a single word from lexically represented information. A further procedural difference, which could have contributed to the difference in outcome of the two experiments, was the provision of a spoken comparison word in Experiment 1. In that experiment, the children were asked to match the length of an object name with one of three words spoken by the experimenter. By being provided with explicit reference words, the children were given benchmarks that could have aided them in their length decisions. In the present experiment, a comparison was required, but no concrete standards were provided.

The discrepancy between the poor readers' use of length information in Experiment 1 compared with Experiment 2 may be viewed as an important indication of one source of difficulty among the poor readers. Thus far, the term "phonological deficiencies" has been used to encompass a deficiency in representing phonological information completely and a deficiency in the processing applied to the representations. Since representations and processes applied to them are interdependent (Anderson, 1978; Palmer, 1978), it can be difficult to distinguish between deficiencies in the two components. In Experiment 1, moreover, it was reasonable to consider the two deficiencies together since they would have the same effect on object-naming performance. Both deficiencies would become manifest after a particular phonological representation had been located. However, a comparison of the poor readers' use of length information in Experiment 1 with that in Experiment 2 indicates that, whatever difficulty the poor readers may have had in representing phonological information fully, they also had a problem using adequately represented information to perform particular metalinguistic tasks. In Experiment 1, the poor readers, like the better readers, were able to use stored phonological information to produce naming responses that, although incorrect, matched the target names in length. In Experiment 2, however, the poor readers had difficulty processing the stored phonological information in order to respond accurately on the metalinguistic length task.

One may ask why the metalinguistic length decisions of Experiment 2 so effectively differentiated the reading groups. The question is the more pertinent in view of the results of Liberman et al. (1974) that showed that poor readers *can* demonstrate their awareness of the length of spoken words by indicating the number of syllables in each. That study showed, moreover, that a matched group of children could not do the more difficult task of indicating the number of phonemes in spoken words. Those findings are among several indications that poor readers lack explicit knowledge of the phonemic units of spoken words (Alegria, Pignot, & Morais, 1982; Treiman & Baron, 1981). In the present experiment, the length task could have been done successfully using either syllabic or phonemic information. Nevertheless, the poor readers could not judge the lengths of words when they had to depend solely on the phonological representations stored in long-term memory in order to generate the necessary information. It is plausible that the poor readers failed on this task because they lacked explicit awareness of the units of their phonological representations, which correspond to the units of spoken words. Thus, although a variety of tasks (naming, reading, metalinguistic judgments) may rely on the same long-term store of phonological information, these tasks may make quite unequal demands on the processors that draw upon that stored knowledge. In keeping with the results of Liberman et al. (1974), the present study offers support for the hypothesis that poor readers generally lack an understanding of the relationship between the units of spoken words and the units of the phonological representations that underlie them. The results also support the notion (Mattingly, 1984) that a major aspect of linguistic awareness differentiating good and poor readers pertains to knowledge of mental representations.

It is to be expected that reading experience would serve to increase sensitivity to word length. There is after all a fairly direct relationship between the spoken length of a word and the number of letters in the orthographic form of the word. Thus reading experience could increase awareness of word length by providing a redundant cue, thereby facilitating word length judgments. Moreover, the better readers may well have seen some of the object names in print; they could have been assisted in their decisions by being able to compare the orthographic forms of the object names. The poor readers would be less able to bring this knowledge to bear on the task. In fact, it is conceivable that if the poor readers found word length decisions unduly difficult, they may have adopted an alternative strategy that was counterproductive. One possibility is that they based their length decisions on the actual sizes of the objects that were pictured rather than on the names of the objects. This possibility can, of course, be tested in the future.

General discussion

The purpose of this two-part study was to examine how underlying phonological deficiencies could affect object naming, metalinguistic decisions, and reading. The first experiment confirmed the existence of naming deficits in poor readers and found that their difficulties in naming are not merely a reflection of individual differences in vocabulary size. It also established a possible role of phonological deficiencies in accounting for the naming deficits. On the metalinguistic tasks of the second experiment, the poor readers were inferior to better readers in the ability to judge the relative lengths of the names of objects, even in those instances in which the children were later able to name the objects aloud. Therefore, the poor readers may lack an awareness of the word lengths specified by their internal phonological representations. The same deficiencies in the phonological domain, then, are implicated in both the object-naming deficits of poor readers and their reading deficits.

Some investigators, notably Denckla and Rudel (1976) and Wolf (1981), have compared the naming deficits of poor readers with what is known about the deficits of aphasics. From the standpoint of the present findings, one may ask specifically to what extent the naming deficits of aphasics, like those of poor readers, can be assigned to phonological deficiencies rather than to deficiency of another ability underlying the naming process. There is evidence that the problem of some aphasics occurs in attempting to locate the correct phonological representations (Mills, Knox, Juola, & Salmon, 1979; Schuell, Jenkins, & Jiménez-Pabón, 1964; Wiegel-Crump & Koenigsknecht, 1973), and this problem could be due, in principle, either to a semantic or a perceptual deficiency. However, in some cases of aphasia, as in children who are poor readers, phonological deficiencies have been implicated as a probable cause of naming failure. For example, it has been supposed (e.g., Luria, 1966) that fluent aphasics with superior temporal damage make errors on object-naming tasks partly because disintegration of phonetic analyzers leads eventually to deterioration of phonological representations. There is, in any case, evidence that aphasics, like the poor readers in the present study, often have knowledge of object names that cannot be spontaneously produced (Barton, 1971; Goodglass, Kaplan, Weintraub, & Ackerman, 1976).

Recently, a particularly compelling case of deficient phonological processing in an aphasic patient was studied in depth by Caramazza, Berndt, and Basili (1983). This individual appeared to have a normal ability to process stimuli visually and semantically, but was apparently incapable of completing any task that required phonological processing. For example, when asked to select objects with rhyming names, he performed at chance. Although this patient's phonological deficiencies were far more serious than those of the poor readers studied here, the similarities merit further comparative study.

It was suggested in the introduction that semantic errors can occur because the phonological representations of the target words are incomplete or because they cannot be processed effectively. Conceivably, many of the semantic errors that are so frequent in cases of aphasia may be due to similar phonological deficiencies. Indeed, explanations along these lines have occasionally been given in the research literature on aphasia. For example, Luria (1966) has suggested that some aphasics substitute semantically-related words on object-naming tasks because of phonological problems. Moreover, others (Baker, Blumstein, & Goodglass, 1981) have proposed that semantic errors may increase in frequency as the phonological processing required of aphasic subjects becomes more taxing. It has also been suggested that some individuals with acquired dyslexia may make semantic reading errors as a result of phonological problems occurring after the correct lexical representation has been located (see Shallice & Warrington, 1980, for a review). The caveat that was applied to the interpretation of misnaming by children with reading disability could apply also to the interpretation of the errors made in acquired anomia: one must be wary of assuming that semantic errors imply a semantic deficiency.

We have seen how phonological deficiencies in processing information stored in long-term memory can lead to errors in naming. Poor readers also have short-term memory problems that are specific to the retention of phonetic material (Liberman et al., 1977; Shankweiler et al., 1979). It was suggested (Shankweiler et al., 1979) that this phonetic memory problem could underlie other problems of poor readers that depend on the short-term retention of words, such as their difficulty remembering item order (Katz et al., 1981) and comprehending sentences (Mann, Shankweiler, & Smith, 1984). In the present study, a parallel case was made that poor readers often fail on tasks requiring knowledge of words stored in long-term memory because of underlying deficiencies in phonological abilities. The deficiencies became manifest in the two tasks of the present study which used pictured objects to elicit stored linguistic representations and corresponding spoken words.

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Appendix A

Experiment 1: Characteristics of Objects selected from the Boston Naming Test

Object name	Difficulty rank	Syllables	Frequency
toothbrush	7	2	1
whistle	9	2	46
helicopter	12	4	17
mushroom	14	2	10
camel	15	2	22
wheelchair	16	2	*
octopus	18	3	3
snail	23	1	13
canoe	24	2	36
raft	25	1	18
wreath	26	1	3
plug	27	1	10
volcano	29	3	26
faucet	30	2	2
dart	32	1	5
seahorse	33	2	*
globe	34	1	35
harmonica	35	4	2
igloo	37	2	1
cactus	39	2	13
acorn	41	2	5
rhinoceros	43	4	2
dominoes	45	3	*
propeller	48	3	7
hammock	50	2	2
medal	51	2	7
unicorn	54	3	*
stethoscope	58	3	1
asparagus	60	4	1
briefcase	62	2	*
pinwheel	63	2	1
hourglass	64	2	2
nozzle	66	2	2
accordion	67	4	2
pyramid	68	3	15
scroll	69	1	2
noose	71	1	1
tongs	74	1	1
sphinx	77	1	1
visor	78	2	1

*Word frequency less than 0.5 per million.

Appendix B

Experiment 2: Stimulus items

Rhyme	Freq.	Nonrhyme	Freq.	Same length	Freq.	Different length	Freq.
cat	Practice	saw	Practice	broom	Practice	toothbrush	Practice
hat		house		comb		tree	
bear	156	[illegible]	159	egg	169	glasses	175
square		head		wheel		bed	
wing	107	dress	111	train	110	apple	109
ring		chair		church		bone	
cake	65	fence	67	bat	65	spider	67
snake		desk		bow		knife	
nail	60	brush	53	bowl	57	balloon	58
whale		pie		pig		bus	
clock	55	pan	51	tank	56	buffalo	54
lock		flag		duck		barn	
lamp	48	chain	43	cage	44	camera	46
stamp		doll		belt		pipe	
drum	31	fox	42	frog	40	banana	30
thumb		pump		owl		net	
skunk	27	tent	29	bee	35	dinosaur	29
trunk		towel		seal		knot	
boot	22	hook	21	pen	23	typewriter	21
flute		rake		pear		ghost	
gear	19	sink	27	drill	21	strawberry	19
spear		fork		hose		whip	
clown	18	skis	19	shark	20	thermometer	18
crown		grapes		glove		spoon	
kite	18	cane	21	sock	14	umbrella	13
knight		soap		mask		screw	
bench	12	witch	12	sword	12	butterfly	13
wrench		dice		mop		harp	
spool	6	braid	4	bride	5	cigarette	7
stool		nun		maze		hoe	

Résumé

On a suggéré que les enfants qui ont des difficultés pour lire ont aussi du mal à nommer des objets et à accomplir certaines tâches qui exigent une analyse ou une "conscience" phonologique. Ce travail étudie la possibilité d'un lien entre ces deux problèmes: les mauvais lecteurs ont peut-être du mal à nommer des objets parce qu'ils ont du mal à former des représentations phonologiques dans la mémoire à long terme et à les utiliser. Une première expérience, dans laquelle on demandait à des enfants de nommer des objets présentés sous forme d'images, a fourni des résultats allant dans le sens de cette hypothèse. Les mauvais lecteurs réussissaient moins bien que les bons lecteurs. Cela était particulièrement frappant avec des mots peu fréquents et des mots longs, qui sont plus difficiles à représenter et à analyser correctement que des mots fréquents et des mots courts. De plus, les réponses incorrectes ressemblaient phonétiquement aux réponses correctes. Lors d'une deuxième expérience, les mauvais lecteurs avaient du mal à prendre une décision pour laquelle ils devaient juger de la longueur des mots, même lorsqu'il était absolument certain qu'ils connaissaient les mots en question. Ceci laisse penser que les mauvais lecteurs n'ont pas conscience de la correspondance entre les unités de représentation phonologique et les unités de la parole. Puisque, selon certaines données, cette conscience jouerait un rôle important dans l'apprentissage de la lecture, les résultats de ces deux expériences montrent que les difficultés des mauvais lecteurs reflètent des étapes communes aux processus de lecture et de nomination.