Relationships of Naming Skills to Reading, Memory, and Receptive Vocabulary: Evidence for Imprecise Phonological Representations of Words by Poor Readers

Anne E. Fowlert

Haskins Laboratories
New Haven, Connecticut

Brook Swainson

Haskins Laboratories and University of Connecticut
Storrs, Connecticut

The main hypotheses addressed in the research were (1) whether imprecision in the phonological representations of lexical items underlies the impaired expressive naming abilities of disabled readers, and (2) whether weak verbal memory might mediate the relationship between naming and reading skills. From samples of 93 first graders and 67 fourth graders, extreme groups of good and poor readers were identified and compared on measures of receptive vocabulary, expressive naming, acceptability judgments for variants of object names, imitation and correction of naming errors by another speaker, pseudoword repetition, and long-term memory. Performance was generally better by older than younger students and by good than poor readers at each age, with little interaction between grade and reader group. The results indicated that for both good and poor readers, imprecise phonological knowledge, especially about long words, contributed to

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children's difficulties on all naming tasks. Memory differences, however, appeared to play only a minor role in explaining the strong association between naming and reading.

It is well established that phonological limitations play a crucial role in the development of reading disabilities (Shankweiler, Crain, Brady, & Macaruso, 1992; Wagner & Torgesen, 1987). Poor readers' phonological weaknesses are evident, not just in their marked difficulty in learning to read (especially, to decode) and spell, but also in their impaired attainment of phonemic awareness (Blachman, 1991; Bradley & Bryant, 1978), their poor verbal memory skills (Brady, 1991; Hansen & Bowey, 1994; Snowling, 1981), and their weak oral naming abilities (Catts, 1986; Denckla & Rudel, 1976; Jansky & de Hirsch, 1972; Katz, 1986; Murphy, Pollatsek, & Well, 1988; Snowling, 1991; Swan & Goswami, 1997a; Wolf, 1991; Wolf & Goodglass, 1986). The hypothesis has been advanced that these difficulties of poor readers may include, and perhaps stem from, a lack of precision in their phonological representations of spoken words in the mental lexicon (Elbro, 1996; Fowler, 1991; Katz, 1986; Gathercole & Baddeley, 1989; Snowling, Wagtendonk, & Stafford, 1988; Swan & Goswami, 1997a). To date, there has been relatively little investigation of this idea, particularly with regard to explaining the bases for the relationship between naming and reading. In this study, we sought to examine how stored lexical representations of the phonological composition of words might differ for good and poor readers, how naming abilities might reflect these differences, and how they might be related to verbal memory skills.

The existence of a naming difficulty is easy to establish, but understanding its basis is not so straightforward. The complexity of interpreting naming performance can be illustrated by considering what is involved when a child is asked to "name" a pictured object (e.g., an escalator). Most fundamentally, naming requires basic conceptual knowledge. A young child who does not conceptually distinguish escalators from ordinary stairs would probably use the term *stairs* for both. Another child may understand the difference between escalators and ordinary stairs, but still lack a specific term in her lexicon for escalators, and might refer to an *escalator* as "moving stairs." Neither of these children, of course, would be expected to reliably recognize escalator as an appropriate label (e.g., on a receptive vocabulary test).

Another child may know the term *escalator* and readily recognize it, but might still be unable to produce the name at will,

or might produce an inaccurate rendition of it. In such instances, the reason may be an imprecise stored representation of the phonological specifications of the word in the child's lexicon. If so, then the child would be likely to have difficulty on other tasks also. For instance, it may be hard to judge which of several phonologically similar choices is the correct name for something, or to correct another speaker's naming errors even when the child knows what word is being attempted. Finally, if limitations in immediate phonological memory contribute to the imprecision of lexical representations, then impaired performance would also be expected when the child is asked to imitate a pseudoword or an erroneous rendition of a known word. Unfortunately, available evidence does not make clear whether, and to what extent, the naming difficulties of poor readers can be traced to insufficient conceptual knowledge, terminological gaps, and/or faulty phonological representations in the mental lexicon.

Children who are (or who are destined to be) poor readers have sometimes been found to exhibit weaker "receptive" vocabulary skills (selecting which of several pictured choices best matches a spoken word) than more able readers do (Gathercole, Willis, Emslie, & Baddeley, 1992; Swanson, Trainin, Necoechea, & Hammill, 2003). This indicates that some conceptual distinctions are lacking, or more likely, that fewer words are adequately represented in the lexicons of at least some poorer readers. Deficits in receptive vocabulary are not consistently observed in poor readers, however, suggesting that their difficulties on "expressive" (or "confrontational") naming tasks cannot be fully explained in those terms. That is, poor readers, particularly those with IQ-achievement discrepancies, are less able than better readers to produce the name for a pictured stimulus (Cohen, Town, & Buff, 1988; Denckla & Rudel, 1976; Jansky & de Hirsch, 1972; Snowling et al., 1988), even for words that can be accurately recognized (Swan & Goswami, 1997a; Wolf, 1991; Wolf & Goodglass, 1986). Research has also shown that expressive naming skill in kindergartners is one of the best predictors of their future reading abilities (Badian, 1994; Bishop & Adams, 1990; Scarborough, 1989; Wolf & Goodglass, 1986), and that naming difficulties are associated with reading skills even among adults (Dietrich & Brady, 2001). The requirement to produce a word orally thus appears to be a crucial component of naming tasks that further differentiates disabled from nondisabled readers.

Several lines of research suggest that name production by poor readers may be inaccurate because the phonological

information that these children have stored about words is ill-specified (incomplete and/or indistinct), making name production difficult even when the name is "known" in the sense of being recognizable. For instance, greater naming difficulty by disabled than nondisabled readers has been found to occur mainly for longer words (Nation, Marshall, & Snowling, 2001; Swan & Goswami, 1997a) and those of lower frequency (Cantwell & Rubin, 1992; Katz, 1986; Swan & Goswami, 1997a), although these effects have not always been found (Dietrich & Brady, 2001; Wolf, 1991). Long words clearly require more phonological features to be stored in the lexicon, and thus their representations would be more likely to be more incomplete, fuzzy, or inaccurate than those for shorter words if the child has difficulty encoding or retrieving phonological information about words. Similarly, words of low frequency have presumably been heard less often, so if children with phonological deficiencies require more experience to establish solid phonological representations, these lexical entries would be more likely than familiar words to be poorly specified and difficult to produce on demand.

A second line of evidence is that expressive naming skills have been found to correlate well with phonological awareness (e.g., Swan & Goswami, 1997b) and memory, suggesting that a common phonological deficiency may, in part, impede performance on such tasks. Of particular interest is that difficulty in expressive naming has been associated with accuracy in imitating pseudowords (Dietrich & Brady, 2001; Gathercole & Baddeley, 1990). Pseudoword repetition is a measure that presumably reflects the ability to encode and reproduce novel phonological stimuli, so weaknesses in these processes may interfere with the formation of well-specified lexical representations of words, and hence may contribute to vocabulary deficits associated with reading disabilities (Gathercole, Hitch, Service, & Martin, 1997).

Third, erroneous responses on expressive naming tasks by both good and poor readers are often phonologically similar to the target item (Katz, 1986; Swan & Goswami, 1997a). Such errors could occur if some phonological information has been stored about the word in question, but is incomplete, unclear, or difficult to access or produce. Dyslexic and nondyslexic children are about equally likely to produce such approximations of the target when they make a naming error, however (Denckla & Rudel, 1976; Katz, 1986; Rubin, Zimmerman, & Katz, 1989). This suggests that all children may have poorly specified

phonological information about some words in their lexicons, and that during vocabulary development, attaining fully specified lexical representations is a gradual, incremental process that may be delayed, but is not necessarily deviant, in children with reading disabilities.

Fourth, evidence for a continuing association between reading disabilities and the distinctiveness of lexical representations has been obtained in a study that gave a judgment task to adults differing in reading ability. Elbro, Nielsen, and Petersen (1994) found that adults with dyslexia were less able than nondyslexic readers (with similar receptive vocabulary levels) to indicate which of several phonologically similar words (e.g., *excursion, exclusion, execution*), presented orally, was similar in meaning to a target phrase (e.g., *capital punishment*). This finding suggests that impaired expressive naming cannot be entirely due to articulatory speech production difficulties, but rather must reflect a deeper weakness in phonological information that is insufficient as a basis for making judgments.

Finally, Elbro, Borstrøm, and Petersen (1998) asked beginning kindergartners to help a puppet (who was said to have a hearing impairment, and who named pictures very indistinctly) to learn to pronounce words correctly. How clearly the children pronounced the words when they corrected the puppet's flawed attempt was one of three measures (along with letter identification and phoneme awareness) that contributed uniquely to the prediction of reading abilities in second grade. Accuracy of young children's phonological representations in this task was also found to predict gains in phonemic awareness over the kindergarten year (Elbro, 1998). These findings suggest that this kind of "correction" task, in a social context that requires name production to be very precise, may be an especially sensitive measure for examining children's phonological knowledge about words.

In this study, we sought to investigate how the phonological representations of words in children's oral lexicons might differ for good and poor readers at the outset of schooling and after several years of reading instruction. Children's production of names, their judgments about the acceptability of phonological variants of names, and their ability to imitate and correct naming errors were examined. Children's recognition of the stimulus words was also assessed to ensure that these terms were in their lexical repertoire. Furthermore, in the stimulus sets we created for these tasks, we included both high and low frequency words that varied in length (number of syllables and

phonemes). We expected that poor readers would have particular difficulty with longer and less frequent words (even those that could be recognized correctly), especially when name production was required or judgments about phonologically similar items had to be made.

METHOD

PARTICIPANTS

The sample included 93 first graders (mean age 6.9 years, range 6.3 to 7.6) and 67 fourth graders (mean age 10.0 years, range 9.4 to 10.8) from four public elementary schools in three small Connecticut towns. At the school with the smallest classes, all children from the five classrooms at these grades were recruited; in the other three schools, each of the 22 classroom teachers was asked to select a group that included two or three poor readers and two or three good readers with roughly equivalent math achievement. (We asked these teachers not to tell us, however, which particular children had received those designations). Children were excluded from consideration if they were non-native English speakers, if they had been retained in grade, or if they had been diagnosed with a learning disability or an impairment of language or hearing. The sample was thus not representative of the distribution of reading skills in these classes; rather, the goal was for above- and below-average readers to be overrepresented through this sampling procedure, enabling comparisons of extreme reader groups to be based on sufficiently large samples.

The participating schools serve middle class communities with very few minority families. Of the nine "education reference groups" used in Connecticut to define socioeconomically similar districts, the four participating schools were ranked at the third through seventh levels, indicating that this was a solidly middle class sample. Similarly, in response to a question about their educational attainment, with response choices ranging from "grade school" (1) to "graduate or professional degree" (6), most mothers of the participants selected "high school diploma," "some college," or "college graduate" ($M = 4.2$, $SD = 1.2$).

Designation of Good and Poor Reader Groups. Scores on the Word Identification and Word Attack subtests of the *Woodcock Reading Mastery Test* (Form G)–*Revised* (Woodcock, 1987) and Form M of the *Peabody Picture Vocabulary Test–Revised* (*PPVT–R*) (Dunn & Dunn, 1981) were used to assign children at

each grade to good and poor reader groups that were as similar as possible in age and receptive vocabulary level. On the Word Identification subtest, a list of words of increasing difficulty must be read aloud; on Word Attack, oral reading of pseudowords is required. In the norming sample for this widely used battery, split-half reliability of these subtests ranged from .91 to .98 for primary grade children. The *PPVT–R* is a measure of lexical comprehension on which the child must indicate which of four pictures corresponds best to a word spoken by the examiner. Alternate form reliability was .82 to 84 for children between seven and 10 years of age in the norming sample for the test. To equate vocabulary more closely across reading groups, we excluded children whose standard scores on the *PPVT–R* fell above 140 (five first graders, two fourth graders) or below 89 (two first graders, three fourth graders) from the good and poor reader groups.

First graders were assigned to the good reader group (n = 33) if their grade equivalent score was 2.0 or higher on both reading tests, and to the poor reader group (n = 41) if both scores were 1.9 or lower. In Grade 4, grade equivalent scores at or above 5.0 on both subtests were required for assignment to the good reader group (n = 25); scores had to be below 4.9 for Word Identification and below 4.6 for Word Attack for a child to qualify for the poor reader group (n = 23). Most analyses involved comparisons between these good and poor readers, but some regression analyses of the entire sample also included data for the children who did not meet criteria for assignment to these extreme groups.

Table I provides a comparison of the reader groups at each grade. By design, there were large standard score differences on both reading subtests at each grade (all $d > 1.5$). Good and poor readers were of similar age in both first grade, d = .22, $t(72)$ = 0.92, p = .36, and fourth grade, d = .41, $t(46)$ = 1.30, p = .20, and group differences in maternal education were small: in Grade 1, d = .31, $t(72)$ = 1.08, p = .29, and in Grade 4, d = .31, $t(46)$ = 1.08, p = .29. Although there was a somewhat higher proportion of boys among fourth grade poor readers than in other groups, this difference was not significant, χ^2 (1, N = 48) = 1.44, p = .23. Substantial *PPVT–R* differences remained, however, despite the attempt to create more equivalent groups by eliminating extreme vocabulary scores: d = .71, $t(72)$ = 3.22, p = .002 for the younger group, and d = .63, $t(46)$ = 2.28, p = .027 for the older children. Hence, in subsequent analyses, *PPVT–R* scores were included as a covariate to control for these receptive vocabulary differences.

TABLE I. Comparison of Reader Groups on Reading, Vocabulary, and Demographic Measures.

	Grade 1			Grade 4		
Measure	Poor Readers	Good Readers	Entire Sample	Poor Readers	Good Readers	Entire Sample
N	41	33	93	23	25	67
Word Identification:						
raw score	23.9 (8.2)	54.9 (8.6)	38.2 (16.9)	63.7 (5.1)	79.1 (5.9)	72.4 (8.9)
standard score	93.1 (10.3)	133.8 (12.8)	111.9 (22.3)	91.6 (7.2)	111.4 (7.6)	102.8 (11.5)
Word Attack:						
raw score	5.5 (3.9)	24.6 (4.5)	13.5 (10.0)	63.6 (5.1)	79.1(5.9)	72.4 (8.9)
standard score	86.8 (10.3)	115.4 (12.8)	99.0 (15.9)	87.9 (7.9	108.2 (5.8)	98.3 (10.0)
PPVT-R: standard score	107.5 (10.6)	115.0 (9.2)	110.3 (12.5)	113.7 (11.6)	120.5 (9.0)	116.5 (13.6)
Age (years)	6.9 (0.3)	6.9 (0.3)	6.9 (0.3)	9.9 (0.3)	10.1 (0.4)	10.0 (0.4)
Maternal Education	4.1 (1.2)	4.3 (1.3)	4.3 (1.2)	4.0 (1.2)	4.4 (1.2)	4.1 (1.2)
Proportion boys	.52	.51	.53	.52	.35	.49

NAMING TASKS AND MEASURES

In order to examine closely the children's knowledge about the phonological representations of words, we devised a variety of tasks from which measures of interest could be drawn. In all tasks, the stimuli varied in frequency (above versus below 45 occurrences per million words of text; Carroll, Davies, & Richman, 1971) and length (1–2 versus 3–5 syllables), and were chosen with the expectation that they would be within the receptive vocabularies of most first graders. Some stimulus words were used in more than one task, as shown in the appendices.

In the scoring of children's productions of names on these tasks, we imposed no penalties for prosodic differences from the target, for allophonic/dialect variation in vowel production, nor for systematic misarticulations (such as lisping). Stress errors and phoneme substitutions or metatheses not attributable to dialect or articulation, however, were considered incorrect.

Expressive Naming. The examiner explained that many pictures would be presented, one at a time, and that for each one, the child was expected to "tell me what the name of the picture is in one word." Sample items were given to illustrate that some items (e.g., *mask*) would be easier than others (e.g., *telescope*), and to emphasize that responses should consist of one word and be made "quickly and carefully." The 41 test items

(listed in Appendix A) included 33 from the *Boston Naming Test* (Kaplan, Goodglass, & Weintraub, 1983), four that had been used by Katz (1986) in naming studies with schoolchildren; and four added by us to increase the number of long, high-frequency items. If the child produced a superordinate term (e.g., *boat* for *canoe*) or a circumlocution (e.g., *They make you taller* for *stilts*), a prompt for greater specificity was given (e.g., *What kind of boat?* or *Yes, and do you know what they are called?*).

The percentage of items correctly named within five seconds was computed as the measure of expressive naming accuracy. In addition, other responses were categorized as delayed retrievals; phonologically similar responses, including recognizable approximations of the target (e.g., *exalator* for *escalator* or *rhino* for *rhinoceros*) and lexical substitutions (e.g., *hamper* for *hammock* or *script* for *scroll*); or other errors, which included nonresponses, circumlocutions, and various labels that were not phonologically related to the target (e.g., *heartbeater* for *stethoscope* or *square* for *triangle*). The percentage of delayed retrievals and the percentage of phonologically related errors were scored.

Receptive Name Recognition. On a receptive picture-matching task, children were instructed to indicate which of four drawings on a page corresponded best to a word spoken by the examiner. There were 56 items, each arrayed with three pictures of semantically related foils (see Appendix B). The test words included the 41 items from the expressive task (represented by a different or modified picture of the object) and 15 additional items from the acceptability judgment task (see below). The percentage of these items that was correctly recognized was scored.

Acceptability Judgments. The children were introduced to four finger puppets who "fought a lot about how to say words the right way," and were asked to look at some pictures with the puppets and decide which puppet(s) produced an acceptable name for that stimulus. The examiner presented a carrier phrase for each item (e.g., for *pretzel*, "A twisted salty snack is called a . . .") and made the puppets produce their differing versions of the word in turn (e.g., *pretzel, prenzel, pencil, spaetzle*). The four versions always included (in random order) the target, a real word of equal or higher frequency than the target, a pseudoword, and either another pseudoword or a lower frequency real word. After each puppet spoke, the child had to indicate whether it was "okay" to say the word that way. If two or more of the puppets' productions were judged to be acceptable, those

versions were repeated and the child was asked to decide which of them was "the best." The 36 items (21 of which had also been stimuli for expressive naming) and their phonologically similar foils are listed in Appendix C.

Acceptability and preference judgments were scored only for recognized items (i.e., those for which the child selected the right picture in the receptive task). For each term that a child had accurately recognized, judgment responses were categorized as "target only" if just the target version was accepted; "tolerant" if in addition to the target, one or more other versions were also deemed to be acceptable; or "target rejected." We then computed the percentage of items for which only the correct term was accepted ("strict" target-only judgments); the percentage of items for which the child exhibited "tolerance" for phonological variation by judging phonologically similar alternatives to be acceptable; and, among responses coded as tolerant, the proportion for which the child judged the correct version to be the best of the two or more renditions that had been deemed acceptable.

Imitation and Correction of Naming Errors. For this task, we used a stuffed parrot into which we implanted a speaker through which a prerecorded stimulus tape was played back. To enhance quality, the stimuli were simultaneously presented via headphones. Children were told that the parrot had learned "a whole bunch of words" but had learned them all from someone who said them "the wrong way." The child's tasks were to "figure out what she's trying to say" and to "teach her how to say the word the right way." For each item, after the parrot had produced the stimulus (incorrectly) twice, the child (1) imitated it "exactly the way she said it;" (2) indicated which of four pictures corresponded to what the parrot was trying to say (to verify recognition); and (3) said the word "the right way" three times, each time saying it "louder and slower." The 34 items for this task are listed in Appendix D.

Imitation responses were scored as accurate (i.e., pronounced exactly as the puppet did), regularized (i.e., using the conventional pronunciation of the word that the puppet mispronounced), or inaccurate. Correction responses were scored as correct on the first attemp, correct on a subsequent attempt, or never correct. The following scores were computed for analysis: percentage of items recognized (i.e., the child correctly identified what the parrot was trying to say); percentage of the parrot's naming errors that were imitated accurately; percentage of imitation errors that were regularized; percentage of the

parrot's naming errors that were corrected accurately; and percentage of accurate corrections that were made on the first attempt. Imitation scores were missing for six children who were unwilling to try to imitate the parrot.

VERBAL MEMORY MEASURES

Because phonological memory differences were hypothesized to contribute to naming skill, the following two measures of verbal memory were administered.

Pseudoword Repetition. An adaptation of the *Children's Test of Nonword Repetition* (Gathercole, Willis, Baddeley, & Emslie, 1994) was used to assess immediate phonological memory. The children were instructed to listen to some "made up" words over headphones and to "repeat exactly what you hear." Four practice items with feedback were given. The 26 1- to 5-syllable test items, in order of administration, were *gickle, shappen, prindle, rubid, glink, ballop, skitticult, glistow, fenneriser, blane, hampent, loddenappish, commerine, fleg, barrazon, woogalamic, poil, sladding, contramponist, pennel, zim, blonterstaping, kest, perplisteronk, bannow,* and *glistering.* These stimuli were recorded by a female speaker and were presented at five-second intervals without feedback. The total number of phonemes in error, summed across all pseudowords, was scored. Children were not penalized for allophonic/dialect variation in vowel production, nor for systematic articulation errors.

Pledge Recall. To assess the ability to store verbal information in long-term memory, we asked children to recite the Pledge of Allegiance. This 31-word statement is recited in unison each morning at the participating schools, so exposure to it is likely to be equivalent for children in the same grade. The number of recall errors was tallied. Each of the following counted as a single error: omission of a word, substitution of a word with a different word or phrase, and insertion of a word or phrase. Disfluencies and systematic misarticulations were not penalized. This test was not administered to two first graders and one fourth grader. Because scores were highly skewed (19% of the sample made no errors), log transformed scores that normalized the distribution were analyzed.

PROCEDURE

All testing was conducted during the last four months of the academic year. Children were individually tested in a small quiet room at the school, with each child seen for four, 20-minute sessions over the course of a month. The second author

administered all of the naming tasks in three sessions approximately one week apart; the expressive naming, pseudoword repetition, and receptive name recognition tasks were given in the first session, the imitation/correction task in the second, and the acceptability judgment task and *PPVT–R* in the third. A research assistant administered the reading tests and the pledge recall task in a fourth session during the same month. The order of tasks and of items within tasks was the same for all children. All responses were recorded on audiotape so that scoring by the examiner during test administration could later be checked for accuracy.

RESULTS

Table II provides a summary of the performance on the naming and memory tasks at each grade by the good and poor reader groups. Unless noted otherwise below, each measure was entered into a four-way mixed model analysis of covariance controlling for *PPVT–R* scores, with reader group and grade as the between group factors and frequency and length as within-subject repeated measures. For clarity, we will report only those interaction effects that involved reader group, since these are of primary interest. Prior to these analyses, distributions of all variables were examined for outliers, severe skewness, and other conditions that might suggest that parametric assumptions were not met, and no such threats to validity were seen.

RECEPTIVE NAME RECOGNITION

We first examined name recognition performance to verify that, as intended, the test items for the expressive naming and acceptability tasks were familiar terms for children at these ages. As shown in table II, mean percentages of names that were recognized were indeed very high, and about equally so for the good and poor reader groups, in Grade 1 (92% to 94%) and in Grade 4 (98% to 99%).

EXPRESSIVE NAMING

Accuracy on the expressive naming task was, as expected, higher for the better than the poorer readers, $\eta^2 = .20$, $F(1,116) = 28.06$, $p < .001$, and in the fourth than the first grade, $\eta^2 = .43$, $F(1,116) = 85.57$, $p < .001$, and there was no group x grade interaction, $\eta^2 = .003$, $F(1,116) = 0.37$, $p = .55$. A main effect of word frequency was also obtained, $\eta^2 = .10$, $F(1,116) = 12.29$, $p = .001$,

TABLE II. Comparison of Contrasted Reader Groups on Naming and Verbal Memory Measures.

	Grade 1		Grade 4	
	Poor	Good	Poor	Good
Tasks and Measures	Readers	Readers	Readers	Readers
N	41	33	23	25
Name Recognition				
% Correct	91.8 (4.7)	94.1 (4.2)	98.8 (1.9)	98.4 (2.4)
Expressive Naming				
% Correct*	51.0 (11.5)	65.6 (10.1)	72.4 (9.1)	83.3 (8.4)
% Delayed Correct Responses	7.3 (4.5)	8.2 (4.8)	8.4 (3.4)	8.1 (4.3)
% of Naming Errors Phon-related	34.7 (15.3)	37.7 (18.8)	43.7 (19.9)	46.9 (23.3)
Acceptability Judgments				
% Accepted Target Only*	69.1 (10.1)	77.0 (8.9)	78.2 (6.9)	81.5 (7.7)
% Tolerant of Phon. Variant(s)*	20.3 (9.0)	17.8 (8.6)	17.2 (9.6)	14.4 (8.5)
% Correct Preference/ Tolerant	73.4 (15.3)	72.8 (21.1)	76.2 (23.8)	75.3 (23.3)
Correction/Imitation of Naming Errors				
% Recognized	88.4 (5.5)	92.8 (6.0)	97.1 (3.9)	97.8 (2.5)
% Correctly Imitated*	52.2 (14.7)	64.6 (12.5)	73.0 (10.4)	79.6 (6.4)
% Imitation Errors Regularized	14.8 (10.9)	13.5 (12.0)	13.5 (13.9)	8.5 (11.1)
% Accurately Corrected*	53.9 (11.7)	68.5 (14.9)	81.9 (9.3)	92.8 (5.3)
% Corrected on 1st Attempt*	89.3 (8.2)	92.5 (6.4)	93.1 (4.4)	96.4 (2.8)
Pseudoword Repetition				
% Phonemes Incorrect*	31.0 (11.5)	24.1 (13.1)	21.9 (9.8)	14.2 (6.2)
Pledge Recall				
% Recall Errors	7.6 (8.1)	7.1 (9.7)	4.9 (5.9)	3.6 (6.7)

*Measures on which the good and poor readers differed (see text).

but the effect for word length was weak and did not quite meet conventional significance criteria, $\eta^2 = .03$, $F(1,116) = 3.21$, $p = .076$. As illustrated in figure 1, there was a four-way interaction (which subsumed several lower-order interaction effects), $\eta^2 = .04$, $F(1,116) = 4.94$, $p = .028$, indicating that in fourth grade, the

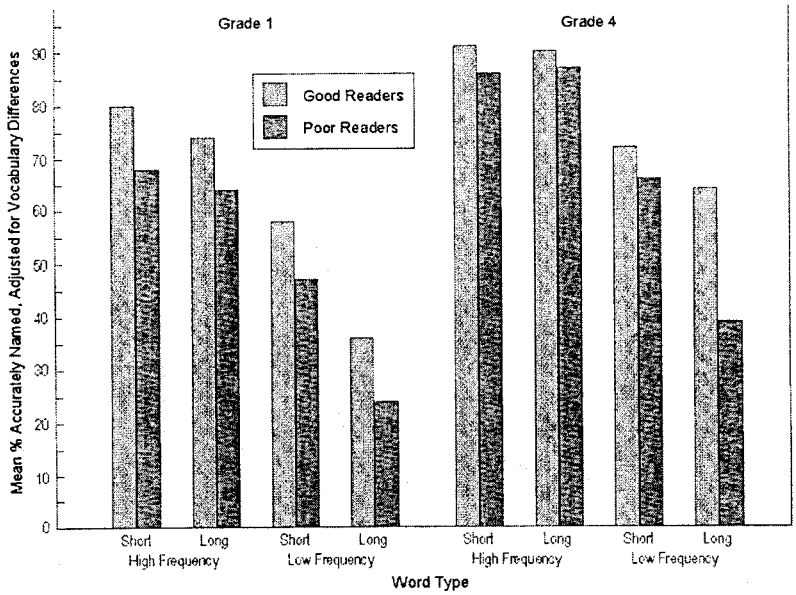

Figure 1. Accuracy of expressive naming by good and poor readers.

good readers strongly outperformed poor readers only on the most difficult (long, high frequency) words, whereas in first grade, the reader group difference was about equally large regardless of item frequency or length.

We next looked at slow and erroneous responding by good and poor readers on the expressive naming task, collapsing over word length and frequency because the total numbers of these responses were relatively small. First, we asked whether delayed production of correct names might be more characteristic of poor than good readers, but this hypothesis was not supported. No main effect was found for reader group, $\eta^2 = .001$, $F(1,116) = 0.02$, $p = .99$, or for grade, $\eta^2 = .09$, $F(1,116) = 0.14$, $p = .76$, nor was there an interaction of group with grade, $\eta^2 = .005$, $F(1,116) = 0.53$, $p = .47$. Instead, as shown in table II, very similar proportions of delayed correct responses were observed for the good and poor readers at both ages.

Second, we examined the percentages of all naming errors that were phonologically similar to the target (40.8% of all errors, over all). There was a weak effect for grade, $\eta^2 = .027$, $F(1,114) = 3.12$, $p = .08$, but not for reader group, $\eta^2 = .00$, $F(1,114) = 0.05$, $p = .83$, and no interaction of grade with group was obtained, $\eta^2 = .00$, $F(1,114) = 0.01$, $p = .94$.

Acceptability Judgments. As shown in table II, when presented with four renditions of a known word by puppets, children usually judged only the correct version to be acceptable ("target only"). It was not uncommon, however, for one or more of the other versions of a word to be judged acceptable also ("tolerant"). In those instances, the correct version was most often selected as the "best" one by both good and poor readers in each grade.

The mean percentages of strict (target only) and "tolerant" acceptability judgments were analyzed jointly. As illustrated in figure 2, there was a three-way interaction among reader group, type of judgment, and length, $\eta^2 = .08$, $F(1,116) = 9.42$, $p = .003$, which qualified several lower-order effects involving these factors That is, regardless of word frequency, at both grades, the poorer readers made fewer strict judgments and more tolerant responses on longer items, and length effects were larger in first than fourth grade.

No effects of grade, group, or their interaction were obtained with regard to the proportion of times the child identified the target item as "the best" when two or more renditions

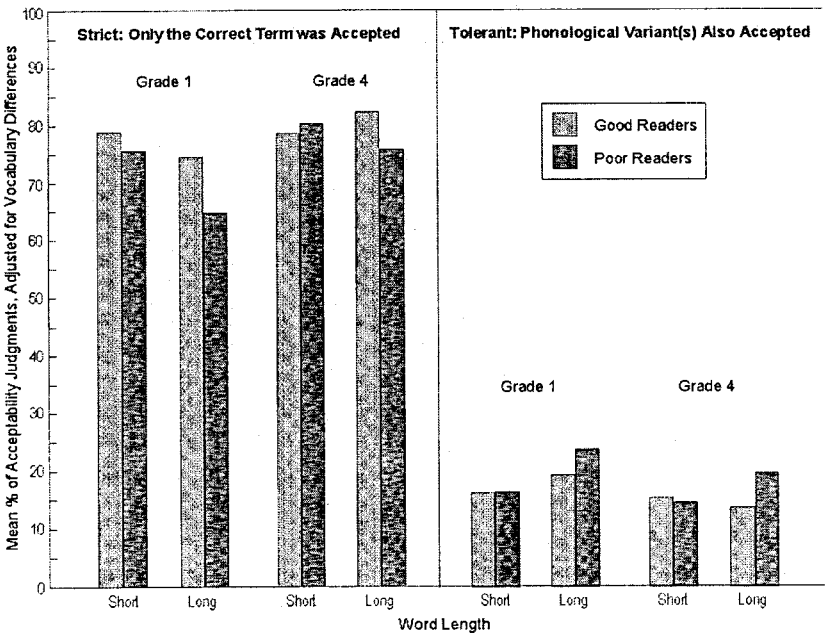

Figure 2. Judgments of the acceptability of phonological variants of words.

were judged to be acceptable; all $F(1,116) < 1$. In sum, poor readers more often tolerated phonological variation in the production of longer words (even though they usually judged the correct version to be the best one), while good readers were more likely to judge only the correct pronunciation to be acceptable.

IMITATION AND CORRECTION OF NAMING ERRORS

As intended, both good and poor readers were highly accurate at recognizing what the parrot was trying to say by selecting the appropriate picture from among semantically related foils. Imitating the parrot's erroneous productions and correcting them proved to be somewhat more difficult, however (see table II). Scores for these tasks were computed based only on items that were accurately recognized.

The parrot was more accurately imitated by fourth than first graders, $\eta^2 = .39$, $F(1,110) = 70.40$, $p < .001$, and by better than poorer readers, $\eta^2 = .07$, $F(1,110) = 8.32$, $p = .005$, but there was no interaction of these factors, $\eta^2 = .01$, $F(1,110) = 1.00$, $p = .32$. (Some erratic word type effects for this stimulus set were obtained, but since none involved reader group differences, they will not be reported.). As shown in table II, relatively few (8% to 15%) imitation errors were regularizations (productions of the target word rather than the parrot's erroneous version of it), and regularization rates were unrelated to grade or reader group, (all $\eta^2 < .02$, $p > .13$).

Correction of the parrot's naming errors was much more accurate by fourth than first graders, $\eta^2 = .56$, $F(1,114) = 146.62$, $p < .001$, and scores were higher for the good than the poor readers at each grade, $\eta^2 = .22$, $F(1,114) = 31.98$, $p < .001$. There were significant interactions of grade with both word length, $\eta^2 = .05$, $F(1,114) = 5.65$, $p = .019$, and word frequency, $\eta^2 = .04$, $F(1,114) = 4.64$, $p = .033$, and these effects were qualified by a length x frequency x grade interaction, $\eta^2 = .06$, $F(1,114) = 6.78$, $p = .01$. This indicated that first graders were much more accurate on the short high-frequency words than on the other word types, but this difference was considerably reduced in fourth grade. No interaction effects involved reader group differences, however. Similarly, as shown in table II, the percentage of accurate corrections that were achieved on the child's first attempt was higher for the older group, $\eta^2 = .06$, $F(1,114) = 7.49$, p = .007, and for the better than the poorer readers at each grade, $\eta^2 = .04$, $F(1,114) = 5.14$, $p = .025$. In sum, correcting the parrot's naming errors was less successful and more effortful for the poorer readers at both grades.

VERBAL MEMORY

The poor readers made more pseudoword repetition errors, $\eta^2 = .05$, $F(1,116) = 6.27$, $p = .014$, and were less accurate than better readers at reciting the Pledge of Allegiance, $\eta^2 = .034$, $F(1,115) = 4.02$, $p = .047$. Scores on both memory measures were higher for fourth than first graders, and no interactions of grade with reader group were obtained.

RELATIONSHIPS AMONG MEASURES

In order to investigate how the various naming skills related to each other and to other skills that were measured, we computed correlations among 10 variables for the entire sample at each age (including the 38 children who had not been assigned to an extreme reader group). The four measures of naming, each of which had differentiated the good and poor reader groups in foregoing analyses, were expressive naming (percentage correct), acceptability judgments (percentage of items on which only the target was accepted), imitation (percentage of parrot naming errors that were accurately imitated), and correction (percentage of naming errors that were accurately corrected). In addition, we looked at the two reading measures (word identification and word attack), the two verbal memory measures (pseudoword repetition and pledge recall), and two measures of receptive vocabulary (*PPVT–R* and the experimental name recognition score).

As shown in table III, all naming measures were moderately intercorrelated in first grade, and except for acceptability judgments, in fourth grade. For the most part, naming abilities also correlated with reading (median $r = .47$) and *PPVT–R* receptive vocabulary scores (median $r = .39$). Long-term verbal memory (Pledge recall) tended to be less strongly associated with naming measures (median $r = .17$) and reading scores (median $r = .27$) than was pseudoword repetition, the short-term memory measure (median $r = .41$ with naming and .37 with reading), and the correlations between the two memory scores were not particularly strong; in first grade, $r = .35$, $p = .001$, and in fourth grade, $r = .21$, $p = .16$.

To examine the relative contributions of naming and memory skills to the prediction of reading scores, we conducted multiple regression analyses of the entire sample at each grade, with forced entry of *PPVT–R* and name recognition scores at the first step of each analysis. In one set of regressions, the naming measures were entered at the second step in order to determine how much additional variance they accounted for after

TABLE III. Correlations of Naming Skills with Each Other and with Memory, Reading, and Receptive Vocabulary Measures.

	Grade 1 (n = 93)				Grade 4 (n = 67)			
	Name	Judge	Imitate	Correct	Name	Judge	Imitate	Correct
Naming								
Expressive Naming	—				—			
Judge Acceptability	.59***	—			.29	—		
Imitate Naming Errors	.48***	.33*	—		.48***	.04	—	
Correct Naming Errors	.66***	.50***	.42***	—	.67***	.25*	.48***	—
Memory[a]								
Pseudoword Repet'n	.25*	.36**	.46***	.37***	.51***	.11	.54***	.45***
Pledge Recall	.01	.29**	.13	.29**	.15	.12	.18	.28*
Reading (WRMT-R)								
Word Identification	.59***	.38***	.42***	.62**	.62***	.39**	.41**	.67***
Word Attack	.57***	.35**	.45***	.48***	.48***	.28*	.29**	.53***
Receptive Vocabulary								
PPVT-R	.58***	.48***	.37***	.50***	.67***	.21	.41**	.63***
Name Recognition	.50***	.37***	.19	.33**	.42***	.13	.09	.29*

[a]All correlations with these error scores are negative; signs have been reversed for clarity of presentation.

*p < .05, two-tailed. **p < .01 ***p < .001.

controlling for receptive vocabulary differences. In the other set, the verbal memory measures were entered at the second step and the naming measures at the third. The results are summarized in table IV, which also includes the standardized regression coefficients (beta weights) for each naming measure in the final model.

TABLE IV. Prediction of Reading From Naming, Memory, and Receptive Vocabulary Measures.

		Grade 1				Grade 4			
		Word Ident		Word Attack		Word Ident		Word Attack	
Step	Variables Entered	R^2 Change	ß	R^2 Change	ß	R^2 Change	ß	R^2 Change	ß
1	Receptive Vocabulary	.195***		.143**		.166**		.095*	
2	Naming	.278***		.243***		.399***		.290***	
	Expressive Naming		.357**		.429**		.298*		.336*
	Judge Acceptability		-.049		-.03		.240*		.138
	Imitate Naming Errors		.107		.198		.125		.016
	Correct Naming Errors		.352**		.150		.483***		.438**
		(Total R = .687)		(Total R = .621)		(Total R = .752)		(Total R = .621)	
1	Receptive Vocabulary	.200***		.145**		.160**		.095*	
2	Verbal Memory	.067*		.072*		.102*		.040	
3	Naming		.213***		.181***		.333***		.261***
	Expressive Naming		.341*		.404**		.274*		.313
	Judge Acceptability		-.074		-.054		.221*		.127
	Imitate Naming Errors		.092		.203		.144		.042
	Correct Naming Errors		.353**		.134		.499***		.468**
		(Total R = .693)		(Total R = .631)		(Total R = .771)		(Total R = .628)	

*p < .05 **p < .01 ***p < .001

Reading scores were well predicted in both grades (R = .62 to .77). Receptive vocabulary skills never accounted for more than 20% of the variance in reading, and verbal memory accounted additionally for only 4% to 10%. The naming measures made substantial contributions to predicting reading above and beyond the effects of receptive vocabulary (24% to 40% increases in the proportion of variance accounted for), and even when memory differences were also controlled in the analyses (18% to 33%). The most influential naming measures were expressive naming accuracy and correction of naming errors, each of which made a unique contribution to predicting reading in all but one of the regression analyses.

SUMMARY OF RESULTS

As expected, accuracy was higher for older than younger students, and for better than poorer readers, on our tests of naming pictured objects, making acceptability judgments, and imitating/correcting naming errors on words, even though the stimulus words could be receptively recognized. In both the first and fourth grades, poor readers made more expressive naming errors, although this effect was largely confined to long, low-frequency items at the older age. Reader group differences were not seen, however, with regard to how often delayed correct responses were made, nor the proportion of naming errors that were phonologically similar to the target. Poorer readers were more often "tolerant" of variation in their judgments of the acceptability of various renditions of a word, especially for long words, and older students were more likely than younger ones to select only the intended target. When more than one version was deemed acceptable, however, good and poor readers were usually quite accurate, and about equally so, at deciding which was the correct pronunciation. Imitating and correcting another speaker's naming errors were less accurately accomplished by first than fourth graders and by poor than good readers at both ages. Although naming measures were moderately correlated with both verbal memory and receptive vocabulary scores, at each grade, they made a significant contribution to the prediction of reading in regression analyses that controlled for those other differences.

DISCUSSION

The results converge with those of prior research in confirming that compared to better readers of the same age, poor readers

are impaired in their expressive naming of words whose names they are able to recognize correctly. These findings make it clear that conceptual or terminological limitations do not fully account for naming difficulties of disabled readers. Rather, it appears that the requirement to produce a term, rather than just to match a spoken word to a picture, is a particular difficulty for them. Hence, although both receptive vocabulary and expressive naming scores were well correlated with each other and with reading abilities, naming accounted for a substantial proportion of the variance in reading, above and beyond that explained by receptive differences.

Having established that, as expected, there was a close association between naming and reading ability in our sample; our central aim was to investigate whether this robust relationship has a phonological basis. More specifically, we sought to evaluate the idea that poorly specified lexical representations of words by poor readers might underlie their naming difficulties (Elbro, 1996; Fowler, 1991; Katz, 1986; Gathercole & Baddeley, 1989; Snowling et al., 1988; Swan & Goswami, 1997a). To address those questions, we compared the performance of good and poor readers on tasks that were designed to reveal more about the nature of their lexical representations of words.

In all tasks, we included words that varied in length and frequency because it has been predicted that phonological information about longer and less familiar words would be especially likely to be incompletely or imprecisely specified in the lexicon, although for somewhat different reasons. On the one hand, frequency could affect phonological representations if poor readers require more exposures to a word in order to form an adequate representation of it, which would likely result in slower vocabulary acquisition. Therefore, although high frequency words are almost always named more accurately (barring floor or ceiling effects) than rare terms by both good and poor readers (Cantwell & Rubin, 1992; Katz, 1986; Swan & Goswami, 1997a), it might be expected that this frequency effect would be exaggerated for disabled readers. For the most part, however, this was not the case in our sample. Aside from the fact that the fourth grade poor readers had difficulties in expressive naming only on the long, high-frequency items, interactions of frequency with group were not obtained. Although stronger frequency effects have sometimes been found for poorer readers on naming tasks (Cantwell & Rubin, 1992; Katz, 1986; Swan & Goswami, 1997b), other researchers have instead found, as we did, that less skilled readers do poorly at naming

both high and low frequency words (Dietrich & Brady, 2001; Wolf, 1991). This inconsistency in the evidence regarding frequency effects is puzzling, and its bearing on the hypotheses under investigation is difficult to evaluate.

Word length, on the other hand, might affect naming skills because representing long words—even familiar ones—undoubtedly requires the specification of more phonological details. Also, longer words are presumably harder to produce, even when their stored representations are well specified. The interactions of length with grade that were obtained in analyses of scores from all of our tasks confirm that longer items are indeed more difficult. Although no interactions of length with reader group were found for our imitation/correction task, these effects did occur when expressive naming and acceptability judgments were analyzed. That is, differences between good and poor readers were larger for long than short words on these tasks, although this effect was seen only in fourth grade for expressive naming accuracy. These results coincide well with prior findings that poorer readers do less well than better readers at naming longer words, even when word frequency is equivalent (Nation, Marshall, & Snowling, 2001; Swan & Goswami, 1997a), although this was not seen in one other study (Cantwell & Rubin, 1992). The observed effects of word length on naming are thus generally consistent with the view that expressive naming difficulties of disabled readers stem from the phonological demands of the task.

Analyses of the children's naming errors also supported this notion. In our sample, 35% to 47% of incorrect naming responses were phonologically similar to the target word. In these instances, therefore, some information about the word's phonological composition must have been stored, and could be located, when the child unsuccessfully attempted to name the word, but it was not adequate for producing the correct name. Furthermore, given that the children demonstrated, on the receptive name recognition task, that the stimulus words were in their lexicons, it is also likely that the other common errors (nonresponses and circumlocutions) resulted from there being insufficient stored phonological information even to produce a response that resembled the target. Although better readers made fewer naming errors, when they did err they were as likely as poor readers to produce phonological distortions or confusions with the target. Similar findings have been reported by others (Denckla & Rudel, 1976; Katz, 1986; Rubin, Zimmerman, & Katz, 1989; Swan & Goswami, 1997a). Hence,

when naming difficulties occur, their basis appears to be similar for good and poor readers. In other words, phonological imprecision is apparently not characteristic only of disabled readers. Rather, inadequate phonological information is available for a greater proportion of such children's lexical entries.

In a modification of the judgment task used by Elbro, Neilsen, and Petersen (1994) with an adult sample, we asked the children to decide which of four renditions of a word (spoken by different puppets who "disagreed about" how to say them) was/were acceptable. Given that scores were based only on stimulus words that the child could receptively recognize, it is not surprising that the correct pronunciation was almost always judged to be acceptable. The poorer readers, however, more often exhibited "tolerance" of phonological variation by selecting not just the correct pronunciation but also one or more variants of it. Despite this tolerance, though, they were as able as better readers to identify which of the acceptable variants was the "best" one. These interesting results suggest that many school children, particularly poor readers, do not fully grasp the notion that (with few exceptions) there is only one right way to say a particular word. Perhaps this misunderstanding arises because a considerable proportion of young children's lexical entries are for words in the process of being acquired, and that the phonological representations of those words are not yet well specified.

Large differences between reader groups were seen on our error correction task, which was similar to the distinctiveness procedure designed and used by Elbro (Elbro, 1998; Elbro, Borstrøm, & Petersen, 1998). Older children were more able to correct a parrot who had learned to say words "the wrong way," but at both ages the poor readers were less accurate than good readers. Because correction scores were based only on words that were correctly recognized on the receptive task, vocabulary deficits cannot account for the poor readers' greater difficulty in modeling the correct pronunciation for the parrot. Rather, as is hypothesized to occur in expressive naming, a lack of precision in phonological representations probably hampered correction responses.

Little support was obtained, however, for the hypothesis that limitations in phonological memory might mediate the relationship between reading ability and naming skills. As expected, reader groups differed in their error rates for pseudoword repetition and for recall of the Pledge of Allegiance, and pseudoword repetition correlated with the experimental

naming tasks, especially among fourth graders. Nonetheless, the memory measures accounted for no more than 10% of the variance in reading (after controlling for receptive vocabulary differences), whereas the naming measures accounted for 24% to 40%. Moreover, even with memory variables entered at an earlier step of regression analyses, the naming measures contributed strongly to the prediction of reading.

It might be presumed that imitating pseudowords and imitating the parrot's mispronounced words in the correction task would be governed by similar processes, since in each case, a novel phoneme sequence must be perceived and reproduced. Correlations between these two measures (.46 in first grade and .54 in fourth grade) were not as high as would be expected if that were the case, however. One possible explanation is that the stimulus words for the two tasks may have differed in word-likeness (Dollaghan, Biber, & Campbell, 1995) or other properties. Another hypothesis is that whereas the encoding of a novel stimulus was required on both tasks, interference from stored lexical information may also have influenced performance when children tried to imitate the parrot's errors.

Not surprisingly, age differences favoring the fourth graders were observed on all tasks. Exposure to new vocabulary, both orally and in print, has been hypothesized to be the main mechanism by which children gain more complete and well-specified lexical information about an increasingly larger corpus of words during the school years. Although this process has mainly been discussed with regard to the growth of word meanings (e.g., Beck, McKeown, & Kucan, 2002), our findings suggest that the picture is similar for the acquisition of phonological representations.

Finally, the difficulties of poor readers on our tasks were evident both at the outset of learning to read and after several years of reading instruction and practice. On the expressive naming task, the group difference in the fourth grade sample was more limited in scope, involving just the most difficult (long, low frequency) set of items. However, no interactions of grade with reader group were obtained on the other tasks. Rather, the differences between better and poorer readers were quite similar in magnitude at both grades on the judgment, imitation, and correction measures. These findings are consistent with the idea that the development of phonological representations in the lexicon is delayed, but not deviant, in children with reading difficulties, such that they apparently have acquired full phonological information about a smaller repertoire of words at any given age.

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Preparation of this manuscript was completed after Dr. Fowler's death by her student and coauthor, B. Swainson, and her colleagues H. Scarborough, S. Brady, and D. Shankweiler. In doing so, they tried to convey her views as closely as possible to the extent that they were known.

Address correspondence to: H. Scarborough, Haskins Laboratories, 270 Crown St., New Haven CT 06511-6695. E-mail hscarborough @att.net

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APPENDIX A

THE 41 ITEMS IN THE EXPRESSIVE NAMING TASK

High Frequency, Short Items (15)	High Frequency, Long Items (8)	Low Frequency, Short Items (10)	Low Frequency, Long Items (8)
broom	caterpillar	acorn	accordion
cactus	elephant	faucet	asparagus
camel	helicopter	hammock	dominoes
canoe	octopus	igloo	escalator
comb	pyramid	pretzel	harmonica
dart	refrigerator	seahorse	stethoscope
globe	triangle	scroll	unicorn
medal	volcano	stilts	rhinoceros
mushroom		toothbrush	
plug		wreath	
raft			
scissors			
snail			
wheelchair			
whistle			

Note: Mean frequencies of occurrence per million words of text (Carroll, Davies, & Richman, 1971): 49.6 for the 15 high frequency short words (1.5 syllables and 4.7 phonemes long, on average); 49.4 for the eight high frequency long words (3.5 syllables, 8.6 phonemes); 40.3 for the 10 low frequency short words (1.7, 5.3 phonemes); and 40.3 for the eight low frequency long words (3.6 syllables, 8.5 phonemes).

APPENDIX B

THE 56 ITEMS (WORDS FROM THE EXPRESSIVE NAMING AND ACCEPTABILITY JUDGMENT TASKS) IN THE RECEPTIVE NAME RECOGNITION TASK

High Frequency, Short Items (18)	Recognition Foils
broom[a, b]	rake, shovel, mop
cactus[a]	rose, tree, potted flowers
camel[a, b]	unicorn, elephant, zebra
canoe[a]	beach, sailboat, lighthouse
comb[a]	toothbrush, hairbrush, curling iron
dart[a]	dartboard, arrow, hypodermic
globe[a, b]	ball, top, map
laundry[b]	detergent, sink, soap
lobster[b]	clam, shark, starfish
medal[a]	necklace, trophy, crown
mushroom[a]	pretzel, pepper, broccoli
plug[a]	light switch, electrical outlet, sprayer
raft[a,b]	water wheel, canoe, firewood
scissors[a]	whistle, spoon, knife
snail[a, b]	fish, squid, turtle
soldier[b]	astronaut, minister, chef
wheelchair[a]	cane, stethoscope, walker
whistle[a, b]	castanets, xylophone, tambourine
High Frequency, Long Items (13)	**Recognition Foils**
astronaut[b]	minister, farmer, mason
caterpillar[a]	beetle, fly, butterfly
elephant[a]	cow, rhinoceros, porcupine
helicoptera,[b]	rocket, balloon, airplane
library[b]	grocery store, mailroom, classroom
magician[b]	janitor, artist, clown
octopus[a,b]	fish, crab, oyster
photographer[b]	entomologist, electrician, hurdler
pyramid[a]	cactus, sphinx, Buddha figure
refrigerator[a]	sink, toaster, oven
thermometer[b]	weather vane, compass, sundial

triangle[a]	circle, oval, square
volcano[a,b]	tornado, mountain, rain cloud
Low Frequency, Short Items (13)	**Recognition Foils**
acorn[a]	pine cone, peanut, leaf
faucet[a,b]	drainpipe, watering can, oil can
hammock[a]	sleeping bag, bed, tepee
hamster[b]	chipmunk, cat, rabbit
igloo[a, b]	adobe house, White House, wood shack
pinwheel[b]	balloon, kite, top
pretzel[a,b]	popcorn, pie, cookie
seahorse[a,b]	dolphin, crocodile, frog
scroll[a]	rolled newspaper, playing cards, dominoes
stiltsa[,b]	ladder, raft, crutches
tongs[b]	cutting board, ice scoop, skewer
toothbrush[a]	hairbrush, makeup brush, comb
wreath[a,b]	(Christmas) stocking, ornament, tree
Low Frequency, Long Stimuli (12)	**Recognition Foils**
accordion[a,b]	piano, drum, harp
asparagus[a]	pepper, cauliflower, peas
dominoes[a]	jacks, dice, blocks
escalator[a,b]	stairs, ladder, elevator
flamingo[b]	peacock, owl, penguin
harmonica[a,b]	cymbals, accordion, triangle
illustrator[b]	nurse, juggler, mother
pediatrician[b]	landscaper, carpenter, medalist
rhinoceros[a,b]	colt, dinosaur, camel
stethoscope[a,b]	binoculars, compass, slide projector
unicorn[a,b]	horse, dog, hippopotamus
veterinarian[b]	teacher, waiter, gardener

[a]Words included in the Expressive Naming Task

[b]Words included in the Acceptability Judgment Task

APPENDIX C

THE 36 ITEMS IN THE ACCEPTABILITY JUDGMENT TASK, WITH THE PHONOLOGICAL FOILS FOR EACH WORD

High Frequency, Short Stimuli (9)	Phonological Foils
broom	groom, broon, prune
camel	candle, cannel, camble
globe	glob, gloave, glofe
laundry	lobby, lawngery, lahngery (lingerie)
lobster	logger, lokster, mobster
raft	craft, braft, reef
snail	snake, smail, slug
soldier	shoulder, soulder, sholdjer
whistle	whisper, this'll, thistle
High Frequency, Long Stimuli (8)	**Phonological Foils**
astronaut	arachnid, astepod, astenot
helicopter	propeller, pelecopter, chopticopter
library	liberty, lybary, lyberary
magician	musician, muhzidgin, mortician
octopus	platypus, ockapus, inkapuss
photographer	philosopher, fographer, pictographer
thermometer	barometer, thermompeter, memometer
volcano	tornado, bolcano, torpedo
Low Frequency, Short Stimuli (9)	**Phonological Foils**
faucet	profit, sawfit, forfeit
hamster	hamper, hampter, hamstring
igloo	glue, ibboo, eggroll
pinwheel	windmill, spinwheel, spinwhirl
pretzel	pencil, prenzel, spaetzle
seahorse	seashell, seafish, horseshoe
stilts	sticks, skints, kilts
tongs	tongues, tongs, thongs
wreath	craft, reef, braft

Low Frequency, Long Stimuli(10)	Phonological Foils
accordion	harpsichord, harcordion, cordion
escalator	elevator, exelator, escalator
flamingo	pimento, pluh-ingo, flamenco
harmonica	harmony, hommica, harpsichord
illustrator	excavator, illisrater, estimator
pediatrician	pedestrian, pedidontist, podiatrist
rhinoceros	dinosaur, rhino-saurus, hornoceros
stethoscope	telescope, exescope, tethescope
unicorn	acorn, unihorn, exicorn
veterinarian	vegetarian, vetinarian, vetrianarian

Note. Mean frequencies of occurrence were: 50.3 for the nine high frequency short words (1.6 syllables and 5.1 phonemes, on average); 49.7 for the eight high frequency long words (3.7 syllables, 8.7 phonemes); 39.8 for the nine low frequency short words (1.7 syllables, 5.6 phonemes); and 39.9 for the 10 low frequency long words (3.8 syllables, 9.0 phonemes).

APPENDIX D

ITEMS USED IN THE PARROT IMITATION/CORRECTION TASK

High Frequency, Short (8)	Parrot Rendition	Recognition Foils
guitar	kitar	drum, chimes, trumpet
pumpkin	punkin	carrot, squash, cabbage
feather	fezzer	talons, nest, beak
sandwich	samwich	pretzel, apple, French fries
breakfast	beffus	cake, lunch, dinner
pencil	prenzel	crayon, marker, pen
dentist	denniss	artist, acrobat, doctor
chimney	chimbley	roof, fire, fire extinguisher
High Frequency, Long (8)	**Parrot Rendition**	**Recognition Foils**
mosquitoes	mistee-os	spiders, flies, ladybugs
arithmetic	ritmetic	shapes, checkers, letters
electricity	lectrizity	fireplace, eggbeater, well
vegetables	vegepuls	fruit bowl, strawberries, mixed nuts
computer	percuter	television, fax machine, calculator
spaghetti	pisgetti	hamburger, hot dog, French fries
secretary	seckatary	cyclist, pianist, nurse
instruments	instaments	tools, kitchen utensils, medicines
microscope	micascope	headphones, binoculars, microphone
Low Frequency, Short (8)	**Parrot Rendition**	**Recognition Foils**
backpack	packpack	purse, grocery sack, briefcase
thermos	fermus	teacup, picnic basket, lunchbox
stapler	stampler	marker, tape, paper clip
chipmunk	chickmunk	wombat, kangaroo, raccoon
ostrich	orstrich	swan, penguin, eagle
penguin	penwin	whale, bear, walrus
sandals	spandals	pumps, rubber boots, running shoes
stroller	scroller	wagon, bed, bassinet

Low Frequency, Long (9)	Parrot Rendition	Recognition Foils
popsicle	poksicle	(ice cream) cone, sandwich, sundae
ornament	ormanent	wreath, Christmas stocking, Christmas tree
dandelion	dandgelion	flower, cactus, ivy
ladybug	lageybug	spider, fly, butterfly
ballerina	dancerina	skateboarder, hair stylist, singer
saxophone	saskephone	piano, drum, harp
tarantula	tranchula	beetle, fly, mosquito
stegosaurus	steckasaurus	scorpion, diplodoccus, platypus
gymnastics	ginnastics	surfing, diving, climbing

Note: Mean frequencies of occurrence were: 51.3 for the eight high frequency, short words (2 syllables and 6.3 phonemes, on average); 52.6 for the nine high frequency long words (3.4 syllables, 9.0 phonemes); 39.9 for the eight low frequency short words (2 syllables, 6.6 phonemes); and 39.9 for the low frequency long words (3.4 syllables, 8.6 phonemes).

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The International Dyslexia Association
Chester Building, Suite 382
8600 LaSalle Road
Baltimore, MD 21286-2044
(410) 296-0232
Website: www.interdys.org
E-mail: info@interdys.org