Vocabulary Acquisition and Reading Ability

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ABSTRACT: Lexical acquisition ability for aurally taught words was studied in fourth-grade children. Reading ability, intelligence, and working memory were evaluated as predictor factors in vocabulary learning. Reading ability was found to predict facility at learning the novel phonological sequences, while intelligence was the only factor which accounted for performance level for the semantic content of the words. The working memory measure, digit span, failed to make a significant contribution to either the phonological or semantic outcome measures. Examination of two subgroups of skilled and less-skilled readers indicated that less-skilled readers had more difficulty acquiring the phonological information for new words. No between-group differences were found in long-term retention or in the ability to provide definitions for the newly learned words. The findings suggest that the vocabulary deficits of less-skilled readers stem, at least in part, from difficulty establishing accurate phonological representations for new words.

KEYWORDS: lexical acquisition, phonological deficits, reading disability, vocabulary

Vocabulary differences between groups of reading disabled children and their normally achieved peers are often reported (e.g., Kail and Leonard, 1986; Vellutino and Scanlon, 1987). In comparing groups that had been used for research studies, Vellutino and Scanlon noted that the reading disabled groups consistently scored lower than the non-disabled groups on measures of both productive and receptive vocabulary. These differences remained even when the groups were matched on nonverbal IQ performance.

Vocabulary deficits in less-skilled readers are no doubt reciprocally related to reading ability. Poor readers generally read less and therefore could be hampered in vocabulary development by less exposure to print (Cunningham and Stanovich, in press; Hayes, 1988; Nagy and Anderson, 1984; Pratt and Brady, 1988; Stanovich, 1986). In addition, children with impoverished vocabularies find it more difficult to comprehend and recall text (Beck, Perfetti, and McKeown, 1982), which may in turn make it more difficult to incorporate words encountered in text into the mental lexicon (Daneman and Green, 1986; Jenkins, Stein, and Wysocki, 1984; though see Nagy, Anderson, and Herman, 1987, for contrary evidence).

Yet vocabulary deficits in disabled readers are not likely to be merely the consequence of less reading experience. Differences in vocabulary knowledge have been observed in very young poor readers (Gathercole,

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Willis, and Baddeley, submitted), raising questions about other factors in vocabulary acquisition. Learning a new word requires accurate perception, storage, and retrieval of the word. Since poor readers have been found to have phonological deficits in each of these areas of processing (for reviews, see Brady, 1991; Liberman and Shankweiler, 1989; and Stanovich, 1985), one might expect them to demonstrate difficulties in vocabulary acquisition, even when new words are encountered outside of text, or aurally. Preliminary evidence confirmed this expectation: Nelson and Warrington (1980) found that a group of dyslexic children produced more errors than a control group on a task of aural vocabulary learning.

Further support for the role of underlying phonological processes in vocabulary learning has come from studies of populations other than the reading disabled. For example, Baddeley, Papagno, and Vallar (1988) reported on the case of an adult patient with a severe deficit in phonological memory who was also deficient on a task of learning nonsense words. Similarly, an association between phonological memory performance and vocabulary acquisition has been reported for prereaders (Gathercole and Baddeley, 1989). Four-year-old children with poor verbal memory scores had smaller receptive vocabularies than those children with better memory performance. A year later, the children who initially had poor phonological recall scores showed lower vocabulary gains, even when the analysis statistically controlled for original vocabulary knowledge. Two studies with adults likewise report a significant correlation between performance on a verbal memory task and achieved vocabulary (Baddeley, Logie, Nimmo-Smith, and Brereton, 1985; Daneman and Green, 1986).

In the present study we wanted to develop a vocabulary learning task in order to confirm whether poor readers have more difficulty acquiring auditorily presented words and to begin investigating underlying phonological factors that may play a role. For this purpose, a game was created in which children help a robot learn words needed for a journey to a distant planet. Fourth-grade children with a broad range of reading skills were taught six new words in the context of this game. We hypothesized that the phonological deficits characteristic of less-skilled readers would impair acquisition of new phonological sequences, but would not impede learning the semantic content. Vocabulary acquisition was scored in terms of phonological errors during training, trials to criterion for correctly producing the words, ability to define the words, and recall and recognition of the new words. Reading ability, intelligence, and working memory were evaluated as predictor factors in vocabulary learning. Performance was assessed for the entire group of subjects and for two sub-groups of skilled and less-skilled readers.

METHOD

Subjects

Subjects were 68 fourth-grade students from a school system in northeastern Rhode Island. The subjects ranged in age from 9 years, 5 months to 10 years, 6 months to limit inclusion to those who had started school at the ages recommended by the school department. Subjects were required to have English as their first language, and to have no known speech or auditory handicaps. In addition, children selected for inclusion scored within the average range on a nonverbal task (the Block Design Subtest of the Wechsler Intelligence Scale of Children-Revised (WISC-R)) (Wechsler, 1974) and were within normal limits on at least one of two verbal measures administered [the Peabody Picture Vocabulary Test-Revised (PPVT-R) (Dunn and Dunn, 1981) and the vocabulary subtest of the WISC-R]. Nine potential subjects were dropped from the final analysis because of failure to meet one or more of the above criteria. One additional subject was dropped because of incomplete data, and two more were eliminated because they failed to reach criterion on the vocabulary learning task within the period allowed in the experiment (see below). The characteristics of the remaining 56 subjects are summarized in Table 1.

Reading groups were formed by using two subtest scores. Word Identification (ID) and Word Attack (ATTACK) from the Woodcock

Table 1. Means for total group of subjects and for two subgroups of skilled and less-skilled readers

	Total group		Skilled readers		Less-skilled readers	
	n = 56		n = 12		n = 10	
	M	(SD)	M	(SD)	M	(SD)
Age	9.8	(0.1)	9.8	(0.3)	9.8	(0.3)
Word ATTACK	6.8	(3.4)	11.3	(2.3)	3.5	(1.1)
Word ID	5.9	(1.7)	8.4	(1.4)	4.1	(0.6)
ESTIQ	106.7	(10.0)	115.5	(12.0)	99.5	(11.9)
PPVT-R	109.2	(13.4)	115.1	(16.0)	103.1	(6.7)
DIGIT	9.6	(2.6)	10.9	(2.4)	8.6	(2.6)
TRIALS	10.6	(3.5)	8.7	(0.8)	11.4	(3.5)
ERRORS	10.2	(6.2)	6.1	(1.6)	10.9	(4.4)
RECALL	1.3	(1.1)	1.8	(1.2)	1.1	(1.0)
RECOG-ST	5.3	(1.1)	5.8	(0.4)	4.6	(1.2)
RECOG-LT	5.4	(0.9)	5.5	(0.6)	5.5	(0.6)
DEFIN	10.0	(5.6)	13.0	(4.2)	8.8	(4.8)

Reading Mastery Test (Woodcock, 1973). Children were ranked according to their scores on these subtests. If a child ranked in the top third of the scores on both subtests, the child was included in the skilled reader group. If a child ranked in the bottom third on both reading measures, the child was included in the less-skilled reading group. Using this method, twelve children fell into the skilled reader group and ten were in the less-skilled reader group. (See Table 1 for descriptive characteristics of the two reading groups.)

Procedure

Each child was tested in three sessions. During the first session, IQ, reading, and working memory measures were administered. In the second session, the children were taught six new words and were then tested for recall and recognition of the trained words. Recognition of the words was again assessed at a third session, conducted at an interval of between one and three weeks from the date of the second session. (The time intervals between sessions two and three were evenly distributed between the reading groups.)

Materials

Predictor measures. All subjects were assessed for reading ability, IQ, and working memory to enable us to examine how strongly each factor related to lexical acquisition ability. As noted above, the Word Identification and Word Attack subtests of the Woodcock Reading Mastery test were utilized to evaluate reading ability. IQ was assessed in two ways. First, the Peabody Picture Vocabulary Test-Revised was administered. Second, the Short form of the WISC-R was given. This includes the Block Design Subtest and the Vocabulary Subtest. An estimated IQ (ESTIQ) was calculated for each subject based on a combination of the two subtest scores as suggested by Sattler (1982). Verbal working memory was assessed with the Digit Span Subtest of the WISC-R (DIGIT).

Experimental Procedure and Materials

Vocabulary Training. Six nonsense words were created for use in this study. Each word was paired with a definition having multiple semantic attributes (see Table 2 for a list of the words and definitions). No one-word English equivalent exists for any of the experimental words. Pictures for each word were painted on 11" × 14" white poster boards.

Each subject was told that they were going to play a game with a robot named Robie. They were told, "Robie is going on an imaginary journey to an imaginery planet. This beautiful planet is golden and has four purple

Table 2. Novel words and definitions

Biffet	— a strange, bald, friendly animal
Corbealyon	— a small, hairy, angry bird
Groshumble	— soft, bouncy, bubble-shaped rain
Pogamer	— a dark and noisy island floating above the ocean
Rimple	— irregularly-shaped, white berries; can be used for robot fuel
Taysum	— a smart, helpful, talking fish

moons. Robie will bring back information about the planet to scientists on Earth. To do this he must enter the information into his memory banks, but sometimes Robie forgets the words he is supposed to remember. Your part in the game is to tell Robie what he needs to remember. These are pictures of what Robie will see on the planet. After you learn the words for them, you will be able to help Robie."

The words were taught to the child in blocks of three. Each of the three words was pronounced and defined while the picture was being shown. The child repeated the word (with correction, if necessary). At the end of the block of three words, the experimenter displayed the pictures for those items and asked the child to name them. (If errors were made, the child was corrected after all three had been shown.) The same group of three words was then presented in another trial block. The order of the words within each block varied. A word was counted as learned if it was correctly produced by the child on two successive blocks of trials. Each group of words was presented at least four times regardless of whether or not the criterion of two successful recalls for all three words had been met. A maximum of ten trials was selected as a cut-off. Children who did not reach the criterion of two consecutive successful trials for each word were not considered for inclusion in the study. (Two children, one skilled reader and one less-skilled reader, were eliminated from the experiment on this basis.) After the first group of three words was learned, the second group was taught using the same procedure.

Performance during the training period was scored for the number of times a block of three words was presented until all three words were learned (TRIALS; possible scores, 4—20). In addition, the number of errors made during vocabulary training was calculated (ERRORS; possible scores, 0—48). The following were classified as errors: 1) a phonologically incorrect form of the target; 2) a phonologically correct or incorrect form of another experimental word; or 3) any other word or a failure to respond.

Assessing Knowledge of Definitions. Immediately following the training, the examiner said the words and asked the child to supply the definitions. If the child did not correctly pair the words and the definitions during testing, the examiner paired the definition components given by the child

with the appropriate target. This corrective feedback was given only after all six definitions had been tested. Scores were obtained by counting the number of components of each definition which the child supplied. The total definition score (DEFIN; possible scores, 0—24) was calculated by tallying the semantic characteristics provided for all six words.

Recall and Recognition. Following the training phase, children were introduced to the robot (a small, remote-controlled robot with a tape deck). Short-term recall was then assessed in a game. The robot described an encounter with an object on the planet in terms which closely matched the learned definitions. The child was then asked to provide the correct target word for each given definition. (Example: Robot, "It is almost time for me to go now. I think my fuel is getting low. I have been told that robot fuel grows on this planet. I see some bushes with white berries of many different shapes. Is this robot fuel? What is it called?") All six words were used in the game. The number of words correctly recalled when presented with the definitions were totalled for a recall score (RECALL; possible scores, 0—6).

Following the game, a recognition task was administered. The children were given a booklet containing the pictures of several items on each page. The child was asked by the experimenter to mark a particular target on each page. The number of targets correctly chosen were tallied for a recognition score (RECOG-ST; possible scores: 0—6).

Long-term recognition. A repeat of the booklet task was done at an interval of between one and three weeks from the initial presentation. In this session the robot said the words. A long-term recognition score was tallied for the number of targets correctly chosen (RECOG-LT; possible scores: 0—6.) Plans to also repeat the recall task during this session were abandoned because performance on the initial recall task had been low for all subjects.

RESULTS

The purpose of this study was to examine factors related to lexical acquisition ability in fourth-grade children. We were particularly interested in the the association between reading level and the ability to learn new words. The results were analyzed for the entire group of subjects and for two subgroups of skilled and less-skilled readers.

Evaluation of the Entire Group of Subjects

Several multiple regressions were performed to assess which factors (reading ability, IQ, digit span) best related to the various aspects of

vocabulary learning performance. In selecting the variables to be entered into the multiple regression analyses we were concerned to minimize problems arising from multicolinearity between measures (See Table 3 for a correrlation matrix for all measures.) The two IQ estimates (PPVT-R and ESTIQ) had a correlation of 0.53. Since debate continues as to how to assess IQ in poor readers (e.g., using verbal measures, including a mix of verbal and nonverbal tests, or using nonverbal techniques), two complete sets of multiple regressions were performed. One set used the PPVT-R as the predictor variable for intelligence, the other used ESTIQ. The results were comparable, and the regressions which used the ESTIQ are reported below.

A second issue concerned the choice of reading measures. A correlation of 0.71 was obtained between the Word Attack and Word Identification measures. Once again, two separate sets of multiple regressions were executed. A virtually identical pattern of results was obtained. Though Word Identification scores accounted for a slightly higher proportion of variance in the outcome measures, the correlation with ESTIQ was somewhat high (0.44) for this form of analysis, so we report the analyses using Word Attack scores.

When factors potentially related to vocabulary learning were assessed (i.e., intelligence (ESTIQ), reading ability (Word Attack), and memory span (DIGIT)), two findings emerged. First, reading ability was found to make the greatest contribution to performance on the phonological measures of word learning. The regression analyses pertaining to how many blocks of trials (TRIALS) were necessary to learn the phonological sequences and to how many errors of production (ERRORS) were made during those blocks both yielded a single measure, Word Attack, accounting for a significant proportion of variance in performance (TRIALS: F (1,54) = 5.73, p = 0.02, R^2 = 0.10); ERRORS: F (1,54) = 6.18, p = 0.02, R^2 = 0.10). Likewise, when regression analyses were computed for the short-term recall and recognition measures, only the reading ability measure (ATTACK) met the stay requirements for the final models (RECALL: F (1,54) = 8.14, $p < 0.01$, R^2 = 0.13; RECOG-ST: F (1,54) = 6.83; $p < 0.01$, R^2 = 0.11). In contrast, the intelligence measure was the only factor accounting for a significant proportion of the variance for the semantic outcome measure (DEFIN: F (1,54) = 21.5, $p < 0.001$, R^2 = 0.29) or for the measure of long-term recognition (RECOG-LT: F (1,54) = 5.98, $p < 0.02$, R^2 = 0.10). Thus, there is an interesting difference between the factors influencing the acquisition of phonological patterns and the factors relevant to the long-term and semantic aspects of word learning. The working memory measure (DIGIT) failed to make a significant contribution to any of the vocabulary acquisition outcome measures.

Table 3. Intercorrelations among variables in the study (n = 56)

Variable	1	2	3	4	5	6	7	8	9	10
1. Word ID										
2. Word ATTACK	0.71**									
3. ESTIQ	0.44**	0.33*								
4. PPVT-R	0.53**	0.18	0.53**							
5. DIGIT	0.20	0.32*	0.08	−0.03						
6. TRIALS	−0.36**	−0.31*	−0.21	−0.30*	−0.22					
7. ERRORS	−0.35**	−0.32*	−0.22	−0.23	−0.21	−0.88**				
8. RECALL	0.38**	0.36**	0.31*	0.26	−0.06	−0.13	−0.12			
9. RECOG-ST	0.36**	0.27**	0.31*	0.41**	0.11	−0.23	−0.17	0.28*		
10. RECOG-LT	0.14	0.06	0.32**	0.42**	0.14	−0.11	−0.03	0.29*	0.60**	
11. DEFIN	0.29*	0.15	0.53**	0.44**	0.17	−0.18	−0.09	0.14	−0.17	0.52**

* $p < 0.05$
** $p < 0.01$

Comparison of Skilled and Less-Skilled Readers

As described earlier, we also focussed on two subgroups representing more marked differences in reading ability. The skilled and less-skilled readers differed in initial vocabulary scores as measured on both PPVT-R (F (1,21) = 4.62, p = < 0.04) and the ESTIQ (F (1,21) = 4.96, p < 0.04). To control for differences in previous vocabulary knowledge as well as for potential differences in general aptitude, the ESTIQ score was used as a covariate in ANCOVA analyses.

The reading groups did not differ significantly on the ANCOVA comparing their ability to provide the definitions for the newly learned words. On the other hand, the reading groups were found to differ on several of the phonological measures of word learning performance. Nearly significant group differences were obtained on the ANCOVA examining the number of trials required to learn the words (F (1,19) = 4.11, p < 0.056). On the more sensitive measure of number of phonological errors made during training, the poor readers were found to make a significantly greater number of errors (F (1,19) = 6.59, p < 0.02). The retention measures yielded a mixed pattern of results. Accuracy on the short-term recall measure did not differ for reading-groups, perhaps because performance was uniformly low on this task. However, on the short-term recognition measure, good readers were superior at identifying the words' referents (F (1,19) = 4.97, p < 0.02).

A repeated measures ANOVA, for recognition scores of groups over time (short and long term recognition), failed to produce any significant results. Indeed, both the skilled and less-skilled readers had near perfect performance on the long-term task. This ceiling effect on a fairly simple recognition task may be obscuring ongoing difficulties poor readers encounter retaining phonological sequences. A further concern is whether some of the children may have cheated on the long-term recognition measure which, unlike the other tasks, was administered in small groups. Since a small number of cases of cheating were detected by the tester, the results of this measure must be taken tentatively. On the other hand, the significant correlation between the RECOG-LT measure and the ESTIQ measure for the entire group of subjects suggests that other cognitive or linguistic factors may be more critical for long-term retention.

DISCUSSION

The present study suggests that reading skill is linked with the ability to establish and maintain accurate phonological representations when words are first being learned. Performance on the measures tapping phonological components of word learning, such as the number of errors made produc-

ing the phonological sequences during training, was found to be more strongly associated with reading ability than with an estimate of general intelligence. Differences between subgroups of skilled and less-skilled readers were apparent on the phonological measures, even when intelligence, including prior vocabulary knowledge, was statistically controlled. In contrast, there was a lack of correspondence between reading skill and ability to retain the conceptual or semantic information for the new words.

These results, which must be considered preliminary, have several interesting implications. First, it is noteworthy that the occurrence of phonological deficits previously documented for poor readers has been extended to include vocabulary acquisition for words introduced aurally. One consequence is that the gap between reading groups in vocabulary knowledge may be expected to widen over time, not only because of lack of exposure or of so-called "Matthew effects" (where reading experience develops other reading-related cognitive abilities), but also because of more basic linquistic deficits that impede vocabulary learning. Unfortunately, the present study did not allow a careful evaluation of long-term retention of words. In a follow-up study, it would be desirable to modify the procedure to permit a long-term recall task which could provide information about the phonological accuracy of words in the lexicon. In an earlier experiment poor readers were found to have inaccurate phonological descriptions for lexical items (Katz, 1986). Long-term follow-up of trained words could help clarify whether observations such as those by Katz stemmed from poor readers' problems learning the correct pattern initially or from difficulty retaining the pattern once it has been acquired.

A second point is that the cognitive difficulties of poor readers do not appear to arise from the semantic or conceptual components of processing. In the present study, performance recalling the semantic attributes of the word was not strongly tied to reading ability. Similarly, Vellutino, Scanlon, and Tanzman (1990) found poor readers to be as sensitive as better readers to the semantic attributes of printed words. Nonetheless, deficits in vocabulary knowledge can be expected to impede both listening and reading comprehension (Beck et al., 1982).

Third, the current findings have implications for instruction. If teachers assume the learning difficulties of poor readers are specific to reading tasks, they may have unrealistic expectations for other tasks or may fail to make necessary modifications in instructional methods. For example, reading disabled children would appear to require more frequent exposure for mastery of words introduced orally. Likewise, the present study adds to the concerns about how to assess the intellectual abilities of poor readers and about the use of IQ scores in allocating services (Stanovich, in press). The difficulty acquiring new lexical items, and the correspondingly lower vocabulary and verbal IQ scores, may cause some children to fail to meet the criteria of 'adequate intelligence' required to qualify for the

dyslexia label (and hence for remedial services). One might argue that these children have an even greater need for extra instruction, and may particularly need the benefits to vocabulary growth and comprehension gained from reading experience (e.g., Hayes, 1988; Stanovich and West, 1989).

The findings reported in this study conform with the considerable evidence for phonological deficits in poor readers, yet the results need to be replicated and extended. The vocabulary learning task used might be altered to provide a better metric of word learning performance. The proporation of variance accounted for in the present study was noteworthy, but low (10%—29%). Perhaps if the total number of words acquired were increased, but if fewer were taught in a single session, sources of variability (such as attention, fatigue, etc.) would diminish.

Related to this, it will be important to further investigate the role of underlying phonological processes in vocabulary learning. In order to learn a newly encountered word, a phonological representation must be created in working memory. In the present study, digit span was used as an estimate of working memory, and this variable was not a good predictor of word learning. Yet, Turner and Engle (1989) note that reading group differences on this task are inconsistent. They suggest using a more complicated measure which involves a background task, to avoid the use of rehearsal and grouping strategies. Alternatively, since vocabulary learning in young children has been strongly linked with the ability to repeat pseudowords (Gathercole and Baddeley, 1989), it would also be worthwhile to use this sort of task when exploring working memory factors associated with poor readers' difficulties acquiring new words.

If the acquired word is to be retained for a longer duration, it is of course necessary to retain the phonological and semantic information in the lexicon. While the phonological representation in working memory will have consequences for the nature of this representation in the lexicon, it is also possible that difficulties in acquiring new vocabulary items may stem from processes entailed in storage or retrieval from the lexical system. Poor readers tend to be slower on tasks requiring the rapid naming of visual stimuli such as colors, numbers, letters, or pictured objects (for reviews see: Stanovich, 1985; Wagner and Torgesen, 1987). They also have been reported to make more errors in retrieving phonologically complex labels (i.e., words such as thermometer or stethoscope (Catts, 1986)). These findings suggest it would be worthwhile to explore what effect differences in naming facility have on vocabulary learning. Likewise, the link between working memory and lexical processes warrants scrutiny. Daneman and Green (1986) found that subjects with poorer memory scores were also slower on a lexical retrieval task.

In closing, poor readers are often found to have smaller vocabularies than their better-reading peers. In the study reported here, it was demon-

strated that the ability to establish accurate phonological representations for new words is associated with reading skill, but the ability to learn the semantic attributes of words is not. This intriguing outcome suggests that phonological processes involved in lexical acquisition may play a role in reading-group differences in vocabulary. Since vocabulary knowledge, in turn, is central to comprehension performance, a difficulty acquiring words could have wide-spread repercussions. It will be important to replicate these findings and to explore which aspects of phonological processing are implicated.

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