

Explaining Speech Production Deficits in Poor Readers

Alan G. Kamhi, Hugh W. Catts, and Daria Mauer

The purpose of the present study was to further examine speech production abilities of young poor readers. Fourteen poor readers and 14 age-matched nondisabled subjects were taught to produce four novel, multisyllabic nonsense words. A recognition task was part of the training procedure. Retention of the words was also probed. The poor readers took significantly longer than the nondisabled children to produce three of the four words. The recognition data indicated that encoding limitations, rather than speech production limitations, were primarily responsible for the longer acquisition times. Speech production deficiencies seemed to account for only a small portion of the difficulty the poor readers experienced learning the novel words. The data are consistent with previous research that has documented encoding limitations in poor readers.

During the last 10 to 15 years, research has accumulated showing that deficits in phonological processing are related to reading failure in a large number of otherwise normally developing children (e.g., Frith, 1981; Liberman & Shankweiler, 1985; Stanovich, 1986; Wagner & Torgesen, 1987). This research has demonstrated that poor readers have difficulty storing and retrieving phonological information from memory. Such deficits are thought to disrupt the acquisition and automatization of word-recognition skills (Catts, 1989; Jorm & Share, 1983; Stanovich, 1986). Phonological processing deficits are also thought to explain some of the difficulties poor readers have in speech production/articulation (Catts, 1986, 1989; Snowling, 1981; Snowling, Goulandris, Bowlby, & Howell, 1986).

Evidence of speech production problems in poor readers comes from clinical observations (Blalock, 1982; Klein, 1986; Miles, 1974) and experimental reports (e.g., Catts, 1986, 1989; Kamhi & Catts, 1986; Kamhi, Catts, Mauer, Apel, & Gentry, 1988; Snowling, 1981; Snowling et al., 1986; Taylor, Lean, & Schwartz, 1989). In these studies, poor readers made more speech errors than good readers when producing both words and phrases.

In a representative study, Catts (1986) found that 20 preadolescent and adolescent readers with disabilities made significantly more errors than 20 nondisabled

readers naming picture objects with phonologically complex names (e.g., *ambulance*) and repeating phonologically complex words and phrases. The speech errors made by the subjects with reading disabilities (RD) were generally word-specific substitutions or omissions of sound segments: Subjects did not misarticulate the same sound across words. Catts suggested that in, some cases, this error pattern reflected difficulty encoding the phonological detail contained in multisyllabic words. That is, problems in creating accurate phonological representations led to inaccurate productions of the words.

Although many of the speech errors in Catts's (1986) study could be explained by deficient encoding processes, some could not. For example, most of the subjects with dyslexia made errors in the production of phrases consisting of common monosyllabic words (e.g., "brown and blue plaid pants") that were likely to have been represented accurately. Catts suggested that difficulty in planning speech-sound sequences or articulating those sequences might account for these errors. In a subsequent study, Catts (1989) found that adults with dyslexia were significantly slower and less accurate than nondisabled peers in rapidly repeating a series of phonologically complex phrases. The findings from this study provided additional evidence that individuals with dyslexia are less proficient in planning and/or articulating phono-

logical segments for speech production.

The purpose of the present study was to further examine the speech production abilities of young poor readers. In the previous studies that have examined speech production abilities in poor readers, subjects were asked to repeat a word or phrase after hearing it one time. In the present study, we used a procedure in which children were trained to produce four novel multisyllabic words. The procedure, which has been used by researchers studying lexical acquisition in young children (Apel & Kamhi, 1987; Apel, Kamhi, & Dollaghan, 1985; Dollaghan, 1985, 1987), includes an acquisition phase and a retention phase. During the acquisition phase, children receive a series of trials in which they are trained to produce a novel word. A trial consisted of four tasks: (a) exposure, (b) comprehension, (c) production, (d) recognition. Each of these tasks will be described in detail in the next section. Children were given up to 10 trials to produce each word correctly. The retention phase of the study, which follows the acquisition phase, provides information about the durability of the memory code. Recognition ability and durability of the memory code have generally not been considered in studies using speech repetition tasks.

METHOD

Subjects

Subjects were 14 second- and third-grade children reading below age level and 14 children reading at grade level. The poor readers ranged in age from 8-0 to 9-11; the nondisabled children ranged in age from 8-2 to 9-5. There were 6 female and 8 male poor readers and 8 female and 6 male nondisabled readers. Subjects were all enrolled in a public elementary school in a small city 10 miles outside of Memphis. The children came from middle class and lower middle class homes. Four children in each group were black.

The poor readers had been diagnosed by a psychoeducational team as exhibiting a reading impairment that was not associated with sensory, emotional, or intellectual problems. These children were all enrolled in regular classrooms but

were being seen by a reading resource teacher on a regular basis. To supplement the diagnosis of reading disability, each child was administered the Word Attack and Word Identification subtests from the Woodcock Reading Mastery Tests (Woodcock, 1973) and the Gates-MacGinitie Comprehension Test (Gates & MacGinitie, 1965). To be included in the study, the children had to perform at least 1 year below age level on two of these three measures. In actuality, 8 of the children performed at least 1.5 years below age level on all three measures; 2 additional children performed at least 1.5 years below age level on two of the measures. All the children also had to score within normal age limits on the Test of Nonverbal Intelligence (TONI) (Brown, Sherbenou, & Johnsen, 1982) and on the Test of Language Development (TOLD) (Newcomer & Hammill, 1982). The mean nonverbal IQ for the poor readers was 106.1 ($SD = 5.2$) compared with 105.0 ($SD = 7.3$) for the nondisabled children. The poor readers obtained a mean Spoken Language Quotient of 106.7 ($SD = 7.5$) on the TOLD (see Table 1).

The nondisabled children were matched for chronological age and mental age, based on the TONI, to the children with reading disabilities. These children were obtained from the same regular classrooms as the poor readers. They had no history of speech, language, hearing, or reading problems.

Procedure

Testing for the poor readers was conducted in two sessions. During the first session, the three reading measures and the TOLD were administered. The lexical acquisition tasks and the TONI were administered in the second session. The nondisabled children received the TONI and the lexical acquisition tasks in one session. For both groups, the TONI was administered after children reached acquisition criterion. As indicated earlier, the tasks used were adapted from previous studies that have examined lexical acquisition processes in young children (Apel & Kamhi, 1987; Dollaghan, 1985).

The procedures consisted of two phases: an acquisition phase and a retention phase. During the acquisition phase, children received one or more trials in which

Group	CA (months)	TONI IQ	TOLD (SLQ)	Woodcock WA	Woodcock WI	Gates-MacGinitie Reading Comprehension
Poor readers						
Mean	107.1	106.1	106.7	-1.7	-1.5	-1.4
SD	6.7	5.2	7.5	.5	.5	.4
Nondisabled						
Mean	107.4	105.0				
SD	5.4	7.3				

Note. TONI = Test of Nonverbal Intelligence; TOLD-SLQ = Test of Language Development – spoken language quotient; Woodcock = Woodcock Reading Mastery Test. Difference between expected grade and grade score.

they were trained to produce a novel word. A trial consisted of four tasks: (a) exposure, (b) comprehension, (c) production, and (d) recognition. Children were given up to 10 trials to reach acquisition criterion, which was defined as a correct production of the target word. With the exception of one poor reader, all of the children met criterion within 10 trials. This poor reader failed to reach criterion on one of the four words.

The retention phase occurred approximately 30 minutes after the child reached acquisition criterion. During this 30-minute period, the TONI was administered and children played with toys if they finished the test in less than 30 minutes. For the retention phase, children were administered the production and recognition tasks from the acquisition phase.

Each child received four novel, multisyllabic words to learn: *tribibly* [tribibli], *shabafidy* [sabafadi], *gidackic* [gidækik], and *disibis* [disibes]. These words were derived from the real words *probably*, *philosophy*, *didactic*, and *specific*. Previous research has found that poor readers have difficulty producing these words (Kamhi et al., 1988). Each of these words was paired with a novel object. Order of presentation of the four words was randomized. The four acquisition tasks are described in detail below, using the novel word *disibis* as an example.

1. Exposure task. This task consisted of a hiding game in which the child was requested first to hide two familiar objects (a ball and a spoon) and then the novel item, the *disibis*. The hiding places were a box, a bowl, and a piece of wrapping paper. The novel item was hidden

last in each case so that the context for determining the referent was completely unambiguous. Thus, for the novel item, the experimenter might say, "Hide the *disibis* in the bowl."

2. Comprehension task. In this task, two additional novel items were added to the original array of three items. The child was then asked to give the experimenter, one at a time, the *ball*, the *disibis*, and the *spoon*. Object order was randomized.

3. Production task. In this task, the child was asked to name the novel item. The experimenter held up the *disibis* and asked the child what it was. Children were encouraged to guess. Responses were phonetically transcribed and recorded. Note that the child had heard the name of the novel object only twice (in the exposure and comprehension tasks) before being asked to label it.

4. Recognition task. The recognition task was administered after an incorrect production response. (Note that after the recognition task was administered, a new trial was immediately begun.) Children were given three randomly ordered choices: the correct label, a preselected, phonetically similar label, and the child's error production. For example, if the child said "disivis" [disivas] for the *disibis*, the examiner held up the object and asked the child:

- Is it a *disibis* [disibas]? (correct label)
- Is it a *sigibis* [sigibas]? (phonetically similar foil)
- Is it a *disivis* [disivas]? (child's error response)

In some cases the three separate questions were combined into one long one:

"Is it a *disibis*, a *sigibis*, or a *disivis*?" Children either responded "yes" or "no" to the questions or repeated the word immediately after it was said. A child did not have to produce the word correctly in order to be given credit for a correct recognition response. For example, if the child said, "Yes, dikibis" or simply "diki-bis" in response to the question, "Is it a *disibis*," a correct response would be scored.

All production and recognition responses were phonetically transcribed during the experimental tasks and tape-recorded for subsequent analysis. Independent reliability checks were conducted on the recognition data by two of the authors. Agreement was 93.5%. Discrepancies were resolved by the judges' joint consent after listening to additional presentations of the recordings.

RESULTS AND DISCUSSION

All of the children in both groups responded correctly to all of the items in the exposure and comprehension tasks, indicating that the children had little difficulty learning the associations between the novel words and objects. This finding is consistent with previous research that has used these tasks with preschool nondisabled children and children with language impairment (Apel & Kamhi, 1987; Dollaghan, 1985).

Table 2 presents the mean number of trials the poor readers and nondisabled children needed to produce each word correctly. A multivariate analysis of variance indicated that there was a significant group difference among the means for the four words, Hotellings $T^2(4,23) = 6.92, p < .001$. Follow-up univariate analyses indicated that the poor readers took significantly longer than the nondisabled children to produce three of the words correctly: *disibis*, $F(1,26) = 6.53, p < .05$; *gidackic*, $F(1,26) = 21.7, p < .001$; *shabafidy*, $F(1,26) = 10.38, p < .001$. For two of the words, *disibis* and *shabafidy*, the poor readers needed twice as many trials as the nondisabled children to produce the words correctly. The poor readers needed three times as many trials to learn the word *gidackic*. No significant group difference ($p = .08$) was found for the fourth word (*tribably*); however, the

Group	<i>disibis</i>	<i>gidackic</i>	<i>shabafidy</i>	<i>tribably</i>
Poor readers				
Mean	3.6	6.1	4.4	3.3
SD	3.2	2.7	2.8	2.3
Nondisabled				
Mean	1.4	2.0	2.0	2.0
SD	.5	1.8	.6	1.4

poor readers needed an average of 3.3 trials to learn the word, compared to only 2.0 trials for the nondisabled group. The group differences on this task support previous clinical reports and experimental literature showing that poor readers have difficulty repeating nonsense words and phonologically complex phrases (Blalock, 1982; Catts, 1986, 1989; Kamhi et al., 1988; Snowling et al., 1986; Taylor et al., 1989).

Table 3 presents the proportion of correct and incorrect responses on the recognition task. Two incorrect responses were possible: a phonetically similar foil and the child's production error. The data are presented as proportions, because there was a large discrepancy in the frequency of recognition responses between the two groups. Recall that the recognition task was given only after a child produced a word incorrectly. The nondisabled children produced about half of the words (26/56, 46.4%) correctly on the first trial and as a result were never given the recognition task. In comparison, the poor readers produced only seven words correctly on the first trial (7/56, 12.5%). Across all four words, the poor readers made 189 recognition responses, compared to 46 for the nondisabled children. The proportion of correct responses was relatively comparable across groups. As can be seen in Table 3, both groups were much more likely to select their production error response than the correct label. The phonetically similar foil was rarely chosen. The relatively high proportion (.40) for the nondisabled children for *disibis* reflected only two responses out of a total of five. The relatively low proportion of correct recognition responses for both groups suggests that inaccurate representations of the words were primarily responsible for the incorrect speech productions.

This suggestion was further supported by data from the trial-by-trial analyses.

The trial-by-trial analyses involved examining the occurrence of correct recognition responses relative to the acquisition trial (i.e., the trial on which the word was produced correctly). If children's difficulty producing the target words were due to problems encoding phonological information in memory, one would expect that correct recognition responses would occur on the trial immediately preceding the acquisition trial. Instances in which no correct recognition responses occurred would also be consistent with encoding limitations. In these cases, the child presumably developed an accurate representation during the exposure or comprehension tasks on the acquisition trial. Alternatively, if a child's difficulty producing the target words was due to a speech production problem, one would expect to find instances of correct recognition responses followed by incorrect speech productions. Note, however, that some of these latter response patterns might also reflect encoding limitations rather than speech production deficiencies. A higher quality representation might be needed to produce a word correctly than to recognize the word. Thus, a child's representation of a word might be adequate to make a correct recognition response (i.e., choose between three response choices), but inadequate to produce the word correctly.

The trial-by-trial recognition responses were tabulated for each subject and each word. For each group, 56 response patterns were observed (14 subjects x 4 words). A simple count was made of the correct recognition responses that were followed by an incorrect speech production. Both groups of children produced relatively few response patterns of this type. The nondisabled group had only

two, whereas the poor readers had 11. The 11 response patterns were divided among seven children, meaning that half of the children never exhibited one of these response patterns. Thus, the vast majority of response patterns for the nondisabled children (96.4%, 54/56) and the poor readers (80.4%, 45/56) contained either no correct recognition response or one that immediately preceded the acquisition trial. These data suggest that encoding limitations accounted for essentially all of the difficulty the nondisabled children had in producing the target words correctly. For the poor readers, although the majority of errors can be attributed to encoding problems, about 20% of the errors may be due to speech production deficiencies.

The production and recognition data from the retention phase were analyzed next. To our surprise, only one child in the entire study was able to produce a word correctly 30 minutes after reaching criterion. This child (a nondisabled one) produced two of the words correctly. The actual productions were then examined to determine whether the two groups differed in the type of errors produced. The poor readers may have produced less accurate responses or more "no responses" than the nondisabled children. For this analysis, a word was scored as correct if the target word was "recognizable." Errors were easy to distinguish from recognizable words because they were either "no responses," other target words, or completely different words. No group differences were found when the data were analyzed in this way. The number of correct responses increased to 13 for both groups. Both groups also had approximately the same number of "no responses" (four for the poor readers and six for the nondisabled group).

The two groups clearly performed similarly in this phase of the study. However, it is important to remember that the poor readers had many more exposures to the words than the nondisabled children in the acquisition phase of the study. Despite the advantage of hearing the target words significantly more times, the poor readers still could not remember the words 30 minutes later. The nondisabled children's retention of the words probably would have been greater if they had heard the words as often as the poor

TABLE 3
Mean Proportion of Correct and Incorrect Recognition Responses in the Acquisition Phase

Words	Correct		Production error		Foil	
	Poor readers	ND	Poor readers	ND	Poor readers	ND
<i>disibis</i>						
Mean	.38	.20	.57	.40	.05	.40
SD	.43	.45	.41	.55	.09	.55
<i>gidackic</i>						
Mean	.27	.27	.61	.63	.12	.10
SD	.32	.43	.29	.42	.16	.15
<i>shabafidy</i>						
Mean	.34	.31	.49	.54	.17	.15
SD	.31	.45	.33	.50	.19	.39
<i>tribably</i>						
Mean	.20	.44	.72	.54	.08	.03
SD	.44	.50	.39	.48	.19	.07

Note. ND = Nondisabled children.

TABLE 4
Number of Children Who Produced a Correct Recognition Response in the Retention Phase

Group	<i>disibis</i>	<i>gidackic</i>	<i>shabafidy</i>	<i>tribably</i>
RD	4	1	2	6
Nondisabled	10	5	8	10

readers did in the acquisition phase.

The data for the recognition task are presented in Table 4. As can be seen in this table, the nondisabled children correctly identified the names of the four objects more frequently than the poor readers. The nondisabled children made 33 correct recognition responses (of 56 possible) compared to only 13 for the poor readers across the four words. A significant group difference was found only for the word *disibis* (Fischer Exact Probability Test, $p < .05$) (Siegel, 1956). These data suggest that the nondisabled children tended to maintain more accurate representations of the words than the poor readers. This finding is particularly impressive given the relatively few exposures to the words the nondisabled children had compared to the poor readers.

CONCLUSION

The principal purpose of this study was to examine speech production abilities in young poor readers. Poor readers and nondisabled peers were taught four novel, multisyllabic words using a learning paradigm that consisted of an acquisition and a retention phase. The poor

readers took significantly longer to produce three of the words correctly than their nondisabled peers. The recognition data indicated that encoding limitations rather than speech production limitations were primarily responsible for the longer acquisition times. Speech production deficiencies seemed to account for only a small portion of the difficulty the poor readers had in learning the novel words. No doubt, further studies that combine speech production and recognition tasks with different populations of poor readers are needed to substantiate this claim.

The findings from this study are consistent with previous research that has documented encoding limitations in poor readers (Brady, Shankweiler, & Mann, 1983; Kamhi et al., 1988; Snowling et al., 1986; Vellutino, Steger, Harding, & Phillips, 1975). Such limitations might account for many of the problems poor readers have in storing, retrieving, and reflecting on phonologically coded information. For example, inaccurate or poor quality (e.g., "fuzzy") representations might lead to inferior performance on tasks tapping verbal short-term memory (Cohen & Netley, 1981; Mann, Liberman, & Shankweiler, 1980), rapid naming (Wolf, 1984, 1986), and phonological

awareness (Blachman, 1989; Wagner & Torgesen, 1987). Indeed, the ability to form accurate phonologically based memory codes might be the basic cognitive process that best explains young children's differing performance levels on phonological processing tasks and early reading activities.

ABOUT THE AUTHORS

Alan G. Kamhi received his PhD in speech and hearing science from Indiana University. He is currently an associate professor in the Department of Audiology and Speech Pathology at Memphis State University. His research focuses on normal language development and spoken and written language disorders. **Hugh W. Catts** is currently an associate professor in the Department of Speech, Language, and Hearing at the University of Kansas. He teaches classes in reading and language learning disabilities. His research interests include language disorders and the early identification of reading disabilities. **Daria Mauer** is a doctoral candidate in the Department of Audiology and Speech Pathology at Memphis State University. She is currently working on her dissertation that is examining the influence of visual and phonetic factors in the acquisition of novel phoneme-grapheme correspondence pairs. Address: Alan G. Kamhi, Department of Audiology and Speech Pathology, Memphis State University, 807 Jefferson Ave., Memphis, TN 38105.

AUTHORS' NOTE

The authors wish to thank Ann Carpenter and the Marion County Schools for making children available for this study.

REFERENCES

- Apel, K., & Kamhi, A. (1987, November). Language-impaired children's fast-mapping skills: A muke is a muke. Paper presented at the annual conference of the American Speech-Language-Hearing Association, New Orleans.
- Apel, K., Kamhi, A., & Dollaghan, C. (1985, November). Fast-mapping skills of young children: Name that word. Paper presented at the annual conference of the American Speech-Language-Hearing Association, Washington, DC.
- Blachman, B. (1989). Phonological awareness and word recognition: Assessment and intervention. In A. Kamhi & H. Catts (Eds.), *Reading disabilities: A developmental language perspective* (pp. 133-159). Austin, TX: PRO-ED.
- Blalock, J. (1982). Persistent auditory language deficits in adults with learning disabilities. *Journal of Learning Disabilities*, 15, 604-609.
- Brady, S., Shankweiler, D., & Mann, V. (1983). Speech perception and memory coding in relation to reading ability. *Journal of Experimental Psychology*, 35, 345-367.
- Brown, L., Sherbenou, R., & Johnsen, S. (1982). *Test of nonverbal intelligence*. Austin, TX: PRO-ED.
- Catts, H. (1986). Speech production/phonological deficits in reading-disabled children. *Journal of Learning Disabilities*, 19, 504-508.
- Catts, H. (1989). Speech production deficits in developmental dyslexia. *Journal of Speech and Hearing Disorders*, 54, 422-428.
- Cohen, R., & Netley, C. (1981). Short-term memory deficits in reading disabled children in the absence of opportunity for rehearsal strategies. *Intelligence*, 5, 69-76.
- Dollaghan, C. (1985). Child meets word: Fast mapping in preschool children. *Journal of Speech and Hearing Research*, 28, 449-454.
- Dollaghan, C. (1987). Fast mapping in normal and language-impaired children. *Journal of Speech and Hearing Disorders*, 52, 218-222.
- Frith, U. (1981). Experimental approaches to developmental dyslexia: An introduction. *Psychological Research*, 43, 97-109.
- Gates, A., & MacGinitie, W. (1965). *Gates-MacGinitie reading tests*. New York: Teachers College Press.
- Jorm, A., & Share, D. (1983). Specific reading retardation and working memory: A review. *British Journal of Psychology*, 74, 311-342.
- Kamhi, A., & Catts, H. (1986). Toward an understanding of developmental language and reading disorders. *Journal of Speech and Hearing Disorders*, 51, 337-347.
- Kamhi, A., Catts, H., Mauer, D., Apel, K., & Gentry, B. (1988). Phonological and spatial processing abilities in language- and reading-impaired children. *Journal of Speech and Hearing Disorders*, 53, 316-327.
- Klein, H. (1986). The assessment and management of some persisting difficulties in the learning disabled. In M. Snowling (Ed.), *Children's written language difficulties: Assessment and management* (pp. 59-79). Windsor, Berkshire, England: Nfer-Nelson.
- Lieberman, I., & Shankweiler, D. (1985). Phonology and the problems of learning to read and write. *Remedial and Special Education*, 6, 8-17.
- Mann, V., Lieberman, I., & Shankweiler, D. (1980). Children's memory for sentences and word strings in relation to reading ability. *Memory and Cognition*, 8, 329-335.
- Miles, T. (1974). *Understanding dyslexia*. London: Priory Press.
- Newcomer, P., & Hammill, D. (1982). *Test of language development*. Austin, TX: PRO-ED.
- Siegel, S. (1956). *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill.
- Snowling, M. (1981). Phonemic deficits in developmental dyslexia. *Psychological Research*, 43, 219-234.
- Snowling, M., Goulandris, N., Bowlby, M., & Howell, P. (1986). Segmentation and speech perception in relation to reading skill: A developmental analysis. *Journal of Experimental Child Psychology*, 41, 489-507.
- Stanovich, K. (1986). Cognitive processes and the reading problems of learning-disabled children: Evaluating the assumption of specificity. In J. Torgesen & B. Wong (Eds.), *Psychological and educational perspectives on learning disabilities* (pp. 87-131). New York: Academic Press.
- Taylor, H., Lean, D., & Schwartz, S. (1989). Pseudoword repetition ability in learning-disabled children. *Applied Psycholinguistics*, 10, 203-219.
- Vellutino, F., Steger, J., Harding, C., & Phillips, F. (1975). Verbal vs. nonverbal paired-associate learning in poor and normal readers. *Neuropsychologia*, 15, 75-82.
- Wagner, R., & Torgesen, J. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin*, 101, 192-212.
- Wolf, M. (1984). Naming, reading, and the dyslexias: A longitudinal overview. *Annals of Dyslexia*, 34, 87-134.
- Wolf, M. (1986). Rapid alternating stimulus naming in developmental dyslexias. *Brain and Language*, 27, 360-379.
- Woodcock, R. (1973). *Woodcock reading mastery tests*. Circle Pines, MN: American Guidance Service.