

Novel Word Learning in Children With Hearing Impairment

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This study examined novel word-learning abilities in young school-age children with mild-to-moderate hearing losses. We questioned whether degree of hearing loss or measures of language and phonological processing abilities were more likely to be related to novel word-learning ability. Subjects were 20 children with hearing impairment ($M = 9:0$) and 20 children with normal hearing ($M = 6:5$) matched for receptive vocabulary knowledge. Children were administered measures of language and phonological processing. The novel word-learning task consisted of an acquisition and retention phase in which children received a series of trials to learn to produce four novel words.

Half of the children with hearing impairment performed comparably to the children with normal hearing on all of the measures obtained, whereas the other 10 children with hearing impairment performed more poorly than the higher functioning children with hearing impairment and all of the children with normal hearing on most of the measures of language, phonological processing, and novel word learning. Degree of hearing loss was not related to language or word-learning abilities. These findings suggest that the population of children with mild-to-moderate hearing loss may contain two distinct groups: a group of normally developing children who have a hearing loss and a group of children with language impairment who have a hearing loss. The implications of this categorization will be discussed.

KEY WORDS: hearing impairment, phonological processing, language impairment, novel word learning, mild-to-moderate hearing loss

It is commonly acknowledged that the reading and academic difficulties of children with hearing impairments are due largely to language deficits (e.g., Osberger, 1986). Language deficits are often cited as the single most widely cited characteristic of children with hearing loss (Kretchmer & Kretchmer, 1978; Laughton, 1989). Reviews of the language abilities of children with hearing impairments (e.g., Levitt, 1987; Osberger, 1986; Shaw, 1994) delineate deficits in all of the major language domains: syntax, morphology, semantics, pragmatics, and phonology. A common question in this research has concerned the relationship between the severity of the hearing loss and the severity of the language impairment. Few studies have examined basic processing abilities in children with hearing impairment because it has often been assumed that the hearing loss or some related factor is largely responsible for whatever language deficits exist.

In the present study, we were interested in the relationship between lexical and phonological processing abilities in children with mild-to-moderate hearing loss. Receptive vocabulary deficits have been well-documented in children with hearing impairments. In a large scale study of 150 subjects (ages 4:6-20:2) with severe-to-profound hearing impairments, Moeller, Osberger, and Eccarius (1986) found delays ranging from 2 years at 6 years of age to 9 years at 18 years of age on both the

Peabody Picture Vocabulary Test—Revised (PPVT-R) and receptive vocabulary subtest on the Test of Language Development (TOLD) (Newcomer & Hammill, 1988). Moeller et al. (1986) found a similar pattern of performance on other measures of receptive language. A striking feature of the data was the lack of improvement in language skills with age. On the average, subjects reached language age equivalents of 6–8 years on lexical/semantic measures, with little growth occurring after 12–13 years of age. No significant relationship was found between hearing level and receptive or expressive language skills.

Receptive vocabulary delays have also been found in children with mild-to-moderate losses. Davis and her colleagues (Davis, Elfenbein, Schum, & Bentler, 1986) examined the relationship between language and academic performance in 45 children ranging in age from 5–18 years. Sixteen of the children had pure-tone averages (PTAs) less than 44 dB; 15 had PTAs between 45 and 60 dB; the remaining 15 children had PTAs greater than 61 dB. As a group, these 45 children performed well below age level on the PPVT-R (Dunn & Dunn, 1981). Only six of the children scored above age norms; three of the children had mild losses, one a moderate loss, and two had severe losses. Not surprisingly, performance on the PPVT-R was highly correlated with various measures of academic achievement. In fact, only the verbal IQ score was a better predictor of academic achievement than the PPVT-R. Degree of hearing loss was not related to performance on the PPVT-R, verbal IQ, or academic achievement. The findings in this study indicate that even the mildest hearing losses are associated with delays in vocabulary development, low verbal IQ scores, and poor academic achievement. The receptive vocabulary deficiencies in children with hearing impairment strongly suggests that they have difficulty learning new words. Novel word-learning abilities have not been previously examined in children with hearing impairments. To examine novel word-learning ability, we used a word-learning procedure that was initially used by Carey and Bartlett (1978) to study lexical acquisition in young children. The procedure consists of two stages: acquisition and retention. During the acquisition stage, the children received a series of trials in which they learned to accurately produce a novel word. The retention stage probed children's ability to produce the novel word after acquisition criteria had been met. These procedures are described in more detail in the next section.

Carey and Bartlett's (1978) studies with young children led them to theorize that lexical acquisition consisted of two phases: a fast-mapping phase and an extended mapping phase. During the fast-mapping phase, children create a partial representation of a word that is sufficient to recognize the word but not to produce it. During the extended-mapping phase, children accumulate additional knowledge about the new word and produce it. Data from a number of investigations have supported Carey and Bartlett's two-phase theory. Preschool children recognize words after one or two encounters with a novel word (Carey & Bartlett, 1978; Dickinson, 1984; Dollaghan, 1985; Heibeck & Markman, 1987; Rice & Woodsmall, 1988), but need additional encounters with the word in order to produce it accurately (Apel,

Kamhi, & Dollaghan, 1985). Word mapping ability has also been found to improve with age and developmental language level (Rice, Buhr, & Nemeth, 1990; Rice & Woodsmall, 1988).

A few studies have examined novel word-learning abilities in children with specific language impairments (SLI). Dollaghan (1987) found that preschool SLI children were less skilled than their normal age peers in producing novel words after minimal exposures to the word. Apel and Kamhi (1987) reported similar findings with 3- and 5-year-old SLI children. The 5-year-old children needed significantly more trials to learn to produce novel words than younger normally developing children. The difficulty the SLI children had learning the novel words was attributed to problems in encoding and storing the phonological structure of the words. Other studies have found strong links between lexical knowledge and phonological processing abilities. Gathercole and Baddeley (1989, 1990), for example, have argued that phonological storage abilities and vocabulary acquisition are closely related in normally developing children as well as in children with language impairments. Phonological storage abilities were assessed by having children repeat nonsense words. In the first study, Gathercole and Baddeley (1990) found that 7- and 8-year-old SLI children had more difficulty repeating single nonwords and recalling word lists than younger children of comparable verbal abilities. Other studies (e.g., Catts, 1993; Kamhi, Catts, Mauer, Apel, & Gentry, 1988; Menyuk et al., 1991) have found more widespread phonological processing deficits in young school-age children with SLI. These studies suggest that children with SLI have encoding and retrieval problems as well as storage problems and that other aspects of language (e.g., syntactic, morphologic) may be related to phonological processing abilities.

In the present study, we questioned whether children with hearing impairments suffer from the same phonological processing deficits as children with SLI. In light of previous research, we expected that the HI children's ability to encode, store, and retrieve information would be more closely related to their novel word learning abilities and receptive vocabulary knowledge than level of hearing loss. Such a finding would suggest that children with hearing impairment may suffer from the same types of language and processing deficiencies as children with developmental language impairments.

In summary, the present study examined novel word-learning abilities in children with mild-to-moderate hearing losses. We questioned whether these children would differ from normally hearing children in acquiring and retaining four novel words and whether word-learning ability was related to (a) hearing level, (b) vocabulary knowledge, (c) phonological processing abilities, and (d) other measures of language.

Method

Subjects

Subjects were 20 children with normal hearing (NH) between the ages of 5:1 and 9:7 years ($M = 6:5$) and 20

children with mild-moderate hearing losses ranging in age from 7:9 to 10:7 years ($M = 9:0$). There were nine boys in the hearing-impaired (HI) group and seven boys in the normal hearing (NH) group. Each group contained nine African American children. Children in the HI group were aural/oral children with bilateral, primarily sensorineural, mild-to-moderate hearing loss. Unaided SRT scores in the better ear ranged from 5 to 65 dB HTL (mean = 35.35, $SD = 17.18$). Table 1 presents means and standard deviations for the group of children with HI for other measures of hearing including pure-tone thresholds and pure-tone averages. All of the children had been fit with binaural amplification for sensorineural hearing loss by a certified audiologist and were currently mainstreamed in public schools at least part of each school day. Prior to task administration, the examiner (MG) performed a quick listening check of amplification devices worn by the children with HI. All of the children with HI wore personal hearing aids except for two children who wore mild-gain FM systems with a Walkman-style headset. One child wore a Phonic Ear Easy Listener and had hearing within normal limits from 500 through 2000 Hz, with a moderate loss at 4000 Hz rising to the mild loss range at 8000 Hz. The other child wore a Comtek Companion and had hearing within normal limits from 500 through 2000 Hz, with a moderate loss at 4000 and 8000 Hz. The children with NH had no history of speech-language or learning disabilities. All of the children with NH passed a hearing screening administered at a level of 20 dB HTL for 500, 1000, 2000, and 4000 Hz.

Only subjects who performed within normal limits on the Test of Nonverbal Intelligence (TONI) (Brown, Sherbenou, & Johnsen, 1981) and the Arizona Articulation Proficiency Scale (Fudala & Reynolds, 1986) were included in the study. Children in the NH group were approximately 2 1/2 years younger than children in the HI group to ensure that children in both groups would have approximately the same receptive vocabulary level as measured by the PPVT-R (Dunn & Dunn, 1981). Table 2 presents group means and standard deviations for age, cognitive level, receptive vocabulary, and articulation abilities.

Procedures

Testing was typically completed in two sessions lasting 45 to 60 minutes. Each child was seen individually in a quiet room. The TONI, PPVT-R, Arizona Articulation Proficiency Scale, as well as the battery of language tests were administered during the first session. The language battery included the Expressive One-Word Picture Vocabulary Test (EOWPVT) (Gardner, 1979), the Structured Photographic Expressive Language Test II (SPELT-II) (Werner & Kresheck, 1983), and the Grammatical Understanding subtest of the Test of Language Development—2 (GU-TOLD) (Newcomer & Hammill, 1988). Black English phonological variations (Owens, 1988) from Standard American English were noted during administration of the Arizona and the SPELT-II, but were not scored as errors. The hearing screening was also performed on the NH group during the first session.

During the second session, the lexical acquisition task was administered. Subjects were administered the acquisition phase of the word-learning paradigm followed by the five measures of phonological processing in randomized order and the retention phase of the word-learning paradigm. The word-learning paradigm and the five measures of phonological processing are described in detail below.

Word-Learning Paradigm

The word-learning paradigm consisted of two stages: acquisition and retention. During the acquisition stage, the children received a series of trials in which they learned to accurately produce a novel word. A total of four words were administered in randomized order. Each trial consisted of four tasks: (a) exposure, (b) comprehension, (c) production, and (d) recognition. Subjects were given up to 10 trials to reach acquisition criterion for each word. Acquisition criterion was defined as two consecutive correct productions of the target word during the production task. The target words were *tam*, *jaften*, *shabaffidy*, and *gadakik*. The two three-syllable words were spoken with primary stress on the second syllable. These four words varied in phonological complexity and had been used in a previous study by the second author (Kamhi, Catts, & Mauer, 1990). An example of

TABLE 1. Means and standard deviations for pure tone thresholds and threshold averages for the children with hearing impairment.

	Thresholds				
	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Mean	36.50	41.00	48.50	62.50	59.25
SD	20.74	20.59	20.38	19.18	16.07

	Pure Tone Averages		
	3 frequency	4 frequency	5 frequency
	(500, 1K, 2K)	(500, 1K, 2K, 4K)	(500, 1K, 2K, 4K, 8K)
Mean	42.00	46.13	48.75
SD	21.16	21.88	21.50

TABLE 2. Group means (M) and standard deviations (SD) for chronological age, standardized test scores, and language age equivalents for the vocabulary measures.

	Hearing impaired		Normally hearing
Chronological age (in months)	108.40 10.22	M SD	77.35 14.59
Standard scores			
^a Test of Nonverbal Intelligence	104.80 8.41	M SD	101.50 22.21
^b Arizona Articulation Proficiency	98.88 1.09	M SD	98.98 1.96
^c Grammatic Understanding (TOLD)	9.65 3.36	M SD	10.75 2.69
^d Structured Photographic Expressive Language Test II	-.10 1.76	M M	.32 .82
^a Peabody Picture Vocabulary Test—Revised	73.20 22.81	M SD	107.05 11.39
^a Expressive One Word Picture Vocabulary Test	89.95 21.73	M SD	103.00 14.18
Language age equivalent (in months)			
Peabody Picture Vocabulary Test—Revised	80.10 26.39	M SD	84.20 15.37
Expressive One Word Picture Vocabulary Test	97.10 30.36	M SD	82.70 16.30

^aquotient, mean = 100^brange = 0 to 100^crange = 0 to 15^drange = -2.33 to +2.33

the task sequence for each trial is shown in Table 3, with *tam* as the target word. The tasks are described in detail below.

The exposure task consisted of a hiding game in which the child was asked to hide two familiar objects (a ball and a spoon) and then the novel item. The hiding places were a box, a bowl, and a cloth. The novel item was always hidden last so that the context for the referent was unambiguous. During the comprehension task, two additional novel items (unlabeled) were randomly arranged with the target item. These objects were never used as target items. The child was asked to give the examiner the target item (the tam for example). The response was scored as correct or incorrect.

The child was then asked to name the target item for the production measure, and was encouraged to guess if unsure of its name. The response was transcribed by the examiner using broad phonetic transcription. Only responses that were totally accurate phonologically were counted as correct. The recognition task was administered after the production task. The child was asked to identify the target word by responding "yes" or "no" to three randomly ordered choices. If the child's production response was correct, the three choices were the correct label and two phonetically similar foils (e.g., *tam*, *tan*, *tang*; *jaften*, *jasten*, *tapten*; *shabaffidy*, *bashaffidy*, *shasasethy*; *gadakik*, *dagadik*,

TABLE 3. Sample sequence for a word-learning trial using *tam* as the target word.

Task	Examiner's request	Response
Trial begins with two familiar items and one unfamiliar training item in the array.		
1. Exposure	"Hide the cup under the towel." "Put the spoon in the bowl." "Hide the tam under the box."	S hides it. S responds. S responds.
Training item is placed back in front of child along with two new, unfamiliar items.		
2. Comprehension	"Give me the tam."	S gives it.
3. Production	"What is this?"	S names it.
Examiner transcribes the response and proceeds to next step.		
4. Recognition	"Is it a tan?" "Is it a tam?" "Is it a tang?"	S responds "yes" or "no" each time

takakik). When the production response was incorrect, the three choices were the error production, a foil, and the correct label. For example, if the child produced *kam* for the item, the examiner held up the object and said:

Is it a *kam*? (child's error)

Is it a *tam*? (correct response)

Is it a *tan*? (similar foil)

A response was counted as correct when the subject chose only the target word; any other response pattern was considered incorrect. Although the children were reminded to choose only one word, some children in each group responded "yes" to more than one choice. Only selection of the correct response by itself was considered correct. Responses were scored as "production errors" if children selected their own production error alone, in conjunction with the correct choice, or with the foil. Responses were scored as "foil/other" if the child chose the foil alone, in conjunction with the correct choice, or the child responded "yes" or "no" to all three choices or to two foils. For the retention phase, three of the original four tasks were readministered: the production task followed by the recognition task and then the comprehension task. The production task was administered first because we wanted to see if children would be able to produce the words without first hearing them.

Phonological Processing Tasks

The five phonological processing tasks had been used in a previous study by Kamhi et al. (1988). The tasks were administered in randomized order following the acquisition phase of the word-learning paradigm. Three of these tasks involved word repetition of novel monosyllabic words, multisyllabic words, and three-item novel monosyllabic words. There were 25 monosyllabic consonant-vowel-consonant (CVC) nonsense words (e.g., /vaæ, dap, tif/), 25 multisyllabic nonsense words (e.g., /manəməm, /rəbeslt/), and 10 3-item sequences of monosyllabic nonsense words (e.g., /tab, gul, flv/). These tasks provide an indication of children's ability to encode phonological information. The words for each of these tasks are provided in Appendix A.

The three word repetition tasks were presented via a Sony tape recorder with a 4" × 4" size speaker at a distance of approximately 18 inches from the child's head. Each child was seated facing the speaker. Each of the tasks contained a few practice items to familiarize children with the task. Recall that there were two children with HI with mild-gain FM systems (Comtek Companion, Phonic Ear Easy Listener). For these children, the FM microphone was placed approximately 4 inches from the center of the speaker. The other children with HI wore personal ear-level hearing aids during administration of the phonological processing tasks. The intensity level of the stimuli was adjusted to a comfortable listening level for each child by using an introductory phrase at the beginning of the tape. Subject responses to the word repetition tasks were immediately transcribed by the examiner using broad phonetic transcription. Responses were also tape-recorded using a Sony cassette recorder with an external microphone for later verification of responses and reliability checks. Dialectal variations and distortions were

not scored as errors. Each word repeated with 100% accuracy was scored as correct.

The first author initially compared all of the transcriptions to the tape-recorded productions. Then a second judge independently transcribed all of the words produced by four children from each group. Point-to-point phonemic interjudge agreement was 97%. Each phonemic discrepancy was resolved through discussion following the procedures described in Shriberg, Kwiatkowski, and Hoffman (1984). The other two tasks involved rapid naming of objects and letters, numbers, and colors. Rapid naming tasks provide a measure of retrieval abilities, but retrieval speed depends in large part on storage and elaboration of information in memory. Each child was asked to name, from left to right and row to row, each item as quickly and accurately as possible. A brief practice was given prior to the test trials to ensure that each child was able to name all of the items on each chart. These items are listed in Appendix B. Each chart was made of 1/4" white 327-C formecor board, size 11" by 14".

The object labelling chart had pictures of five different common objects (key, scissors, umbrella, hand, comb) displayed in a repeated pattern in randomized order. The letters, numbers, and colors chart consisted of five letters, five numbers, and five colors in an A-B-C repeating pattern in randomized order. There was a total of 50 items on each chart. Letters and numbers were made from 1/2" Normatype transfers, Has-Helvetica Medium (#61 6022-48L & #61 6022-48N). Colors were represented by 1/2" × 1/2" color chips made of silk-screened, color-aid Rorhue paper of maximum hue intensity.

An electronic stopwatch was used to measure (in .01 seconds) naming speed. Time for errors and self-corrections were included in the overall latency measures (Kamhi et al., 1988). If an error or self-correction resulted in serious faltering on the part of the subject, the procedure was stopped and the subject was allowed to start again.

Results

The results from the word-learning paradigm are presented first followed by the results of the phonological processing measures. Correlational analyses and step-wise regression procedures are then presented that examine the relationship between measures of phonological processing, receptive and expressive language, and novel word-learning ability.

Word Acquisition, Recognition, and Retention

All of the children responded correctly to the exposure and comprehension tasks for all words in the word-learning paradigm. The initial analysis compared children's production and recognition performance on the first trial. Performance on the first trial is considered to reflect fast-mapping abilities. These data are presented in Table 4. A Fischer Exact Probability Test (Siegel, 1956) revealed significant group differences in favor of the children with NH for the words *jaften* ($p = .002$) and *shabaffidy* ($p = .023$) on the

production task. No significant group differences were found on the recognition task, although the NH group performed consistently better on this task for the three more difficult words. As can be seen in Table 4, both groups had little difficulty producing and recognizing *tam*, but had considerable difficulty producing and recognizing *gadakik*.

The next analysis compared the number of trials it took each group to produce the word correctly. The acquisition data are presented in Table 5. A 2 (group) \times 4 (word) repeated measures analysis of variance found significant main effects for group [$F(1, 38) = 13.7, p < .01$] and word [$F(3, 114) = 36.8, p < .01$]. A follow-up test for simple main effects indicated that the HI group required significantly more trials than the NH group to reach acquisition criteria for the words *jaften* [$F(1, 38) = 10.09, p < .05$] and *shabaffidy* [$F(1, 38) = 6.00, p < .05$]. Post-hoc Tukey analyses were used to examine the within-group word differences. For the HI group, *tam* was acquired more quickly than *jaften* and *shabaffidy*, which, in turn, were learned more quickly than *gadakik* (Tukey's HSD = 2.05, $p < .05$). The NH group needed significantly more trials to produce *gadakik* correctly than the three other words ($p < .05$).

The next series of analyses evaluated the recognition data across the acquisition trials. Table 6 presents the total proportion of correct and incorrect responses on the recognition task. The data are presented as proportions because the frequency of recognition responses varied according to the number of trials administered. As can be seen in this table, both groups performed at high levels of accuracy for the simple word, *tam*. For the other three words, however, the children with NH more frequently chose the correct recognition response than did the children with HI. Results of chi square analyses (2 \times 2 contingency table) (Siegel, 1956) indicated that the children with NH performed significantly better than the children with HI for the words *jaften* ($X^2 = 25.87, p < .05$), *shabaffidy* ($X^2 = 11.36, p < .05$), and *gadakik* ($X^2 = 5.86, p < .05$). There was no significant difference found for the word *tam*.

Trial-by-trial analyses of the recognition data were conducted to determine the accuracy of the developing phonological representations over time. Of interest was whether correct productions in the acquisition trial were preceded by correct recognition responses. Results of the trial-by-trial analyses indicated that for both groups of children, the

TABLE 4. Number and proportion of children responding correctly to the production (P) and recognition (R) tasks for each word in the fast-mapping trial.

Word	Task	Group	
		HI	NH
<i>tam</i>	P	19/20 (95%)	20/20 (100%)
	R	16/20 (80%)	15/20 (75%)
<i>jaften</i>	P	9/20 (45%)	18/20 (90%)
	R	9/20 (45%)	13/20 (65%)
<i>shabaffidy</i>	P	7/20 (35%)	14/20 (70%)
	R	10/20 (50%)	13/20 (65%)
<i>gadakik</i>	P	5/20 (25%)	5/20 (25%)
	R	5/20 (25%)	8/20 (40%)

TABLE 5. Group means and standard deviations for the number of total trials to acquisition for each word.

Group		Word			
		<i>tam</i>	<i>jaften</i>	<i>shabaffidy</i>	<i>gadakik</i>
HI	M	2.05	5.25	5.65	8.50
	SD	.22	3.73	3.76	2.91
NH	M	2.00	2.20	3.20	6.95
	SD	.00	.52	2.53	3.53

majority of correct productions (72% HI, 88% NH) were preceded by a correct recognition response. The response patterns of words that were never acquired were also examined. If difficulty producing the words was due to difficulty encoding phonological information in working memory, incorrect productions in the acquisition trial would be preceded by incorrect recognition choices. The children with HI correctly recognized 23% of the words that they never learned to produce compared to 13% for the NH group. Difficulty producing words for both groups thus appeared to be caused primarily by problems encoding phonological information in the novel words.

The next analyses considered the retention data. These data are presented in Table 7. As can be seen in this table, all of the children performed poorly on the production task. There was a total of only seven correct production responses, six by the children with HI and one by a child with normal hearing. Performance on the recognition task was somewhat better, with correct responses ranging from 4 to 13 per word. The NH and HI groups performed comparably on three of the words, but 12 children with HI responded correctly for the word *shabaffidy*, compared to only four children in the NH group. A significant group difference was found only for the word *shabaffidy* (Fischer Exact Probability Test, $p = .01$) (Siegel, 1956).

Phonological Processing Measures

Table 8 presents the group data for the five measures of phonological processing. A 2 (group) \times 5 (task) multivariate analysis of variance indicated a significant difference between the group means on the measures of phonological processing (Hotellings $T^2 [5, 34] = 23.78, p < .001$). Statistical significance for follow-up analyses was adjusted to the .01 level to control for Type I error. Follow-up univariate analyses indicated the children with NH performed significantly better than the children with HI on the three word-repetition tasks, whereas the children with HI performed significantly better than the children with NH on the rapid-naming tasks.

Correlational Analyses

Correlational and stepwise regression analyses were performed on data from the children with HI to explore the relationships between novel word-learning ability (# of trials to reach acquisition criteria), degree of hearing loss, vocabulary knowledge, syntactic/morphologic knowledge, and

TABLE 6. Proportion of correct and incorrect recognition responses during the acquisition phase.

Word	Correct		Incorrect			
	HI	NH	Production error		Foil/Other	
			HI	NH	HI	NH
<i>tam</i>						
M	.829	.900	.000	.000	.171	.100
SD	.376	.300	.000	.000	.377	.300
<i>jaften</i>						
M	.324	.795	.552	.000	.124	.200
SD	.468	.400	.479	.000	.330	.400
<i>shabaffidy</i>						
M	.381	.656	.522	.172	.097	.172
SD	.486	.475	.500	.377	.296	.377
<i>gadakik</i>						
M	.247	.381	.518	.432	.235	.187
SD	.431	.486	.500	.495	.424	.390

phonological processing skills. The correlational data are presented in Table 9. Performance on the word-learning task was highly correlated and significantly related to performance on the PPVT-R ($r = .73, p < .01$) and moderately correlated to performance on the EOWPVT ($r = .56, p < .01$), and the SPELT-II ($r = .45, p < .05$). Word-learning performance was not significantly related to any of the phonological processing measures. Degree of hearing loss as indicated by SRT and three-, four-, and five-frequency averages was not related to word-learning performance. Performance on the monosyllabic word repetition task was moderately correlated with SRT ($r = -.58, p < .01$), three-frequency average ($r = -.57, p < .01$), and four- and five-frequency averages ($r = -.73, p < .01$). Performance on the multisyllabic word repetition task was moderately correlated with four-frequency ($r = -.47, p < .05$) and five-frequency ($r = -.48, p < .05$) averages, and was also moderately correlated with the PPVT-R ($r = .49, p < .05$). Step-wise multiple regression analyses confirmed that the PPVT-R score was the sole predictor of word-learning task performance, accounting for approximately 53% of the variance. The PPVT-R score was the first and only variable that was entered into the regression equation.

Correlational and stepwise regression analyses were also performed on the data from the children with NH. Correlational data are shown in Table 10. Word-learning perfor-

mance was not significantly related to any of the other measures for the children with NH.

HI Subgroup Comparisons

Examination of the individual subject data for the children with HI revealed a bimodal distribution in the mean number of trials needed throughout the word-learning paradigm to learn to produce all four words. Half of the children with HI needed a mean number of 15.7 trials (SD = 4.19), similar to the mean number of 14.4 trials (SD = 4.98) needed by the children with NH. The modal number of trials, 16, also was identical for these two groups of children, as seen in Figure 1. In contrast, the other 10 children with HI needed 27.2 trials (SD = 3.49) throughout the word-learning paradigm. Recall that the HI group required significantly more trials than the NH group to reach acquisition criteria for the words *jaften* and *shabaffidy*. Closer examination of the data for these two words revealed that the 10 children with HI who performed similarly to the children with NH acquired both of these two words in an average of only 2.7 trials. In contrast, the 10 lower-functioning children with HI needed an average of 8.3 trials for these two words and did not acquire both words in the maximum number of trials allowed. Seven of the 10 children in the lower-functioning subgroup were African American compared with two of the 10 children in the higher-functioning subgroup. Each HI subgroup contained one child who had worn a mild-gain FM system during administration of the phonological processing tasks.

Table 11 compares the two HI subgroups on the various cognitive, language, and phonological processing measures obtained in the study. The performance of the two subgroups was analyzed using a 2 (group) \times 12 (task) multivariate analysis of variance (MANOVA) with follow-up one-way analyses. Results of the MANOVA indicated a significant difference between the group means (Hotellings $T^2 [1, 38] = 11.22, p < .01$). Follow-up one-way analyses indicated the higher functioning subgroup performed significantly better than the lower functioning subgroup on the number of

TABLE 7. Number of children who obtained a correct production (P) or recognition (R) response in the retention phase.

Group	Task	Word			
		<i>tam</i>	<i>jaften</i>	<i>shabaffidy</i>	<i>gadakik</i>
HI	P	5	1	0	0
	R	13	7	12	5
NH	P	1	0	0	0
	R	10	10	4	4

TABLE 8. Performance on the five phonological processing measures and results of univariate F-tests.

	HI		NH		F	p
Word repetition tasks (# words correct)						
Monosyllabic (25 possible)	12.70 4.53	M SD	21.90 1.45		74.80	<.001
Multisyllabic (25 possible)	8.80 3.56	M SD	14.35 2.60		31.66	<.001
Three-item (30 possible)	11.10 3.82	M SD	16.35 4.36		16.41	<.001
Rapid naming tasks (time in seconds)						
Object naming	52.05 11.64	M SD	69.97 11.42		24.15	<.001
Letters, numbers, & colors	37.16 7.33	M SD	74.96 26.89		36.78	<.001

word-learning trials, the PPVT-R,¹ the EOWPVT,¹ and the TONI. There was also a trend toward significance ($p < .06$) for the SPELT-II and two of the measures of phonological processing (three-item and multisyllabic word repetition). The HI subgroups differed the most on the word-learning trials and the PPVT-R. Although there was a significant subgroup difference on the TONI, the lower-functioning subgroup performed well within normal age limits on this measure ($M = 99.6$). It is also important to note that the higher-functioning children performed within normal age limits on all of the language measures. In contrast, the lower-functioning children performed below age limits on

the PPVT-R, the EOWPVT, and close to one standard deviation below the mean ($-.84$) on the SPELT-II.

Discussion

The principal purpose of the present study was to determine whether or not children with hearing impairments suffered from a more general language impairment that affected their lexical development as well as other aspects of language performance. We addressed this question by comparing novel word-learning ability in children with HI and children with NH. We also questioned whether lexical acquisition and knowledge would be related to measures that tapped children's ability to encode, store, and retrieve phonological information. Previous research by Gathercole and Baddeley (1989, 1990) has found a strong relationship between phonological encoding (memory) abilities and vo-

¹Because of the heterogeneity of variance indicated by the standard deviations, Mann-Whitney *U* tests were performed for the results from the PPVT-R ($U = 11, p = .003$) and the EOWPVT ($U = 25.4, p = .06$).

TABLE 9. Pearson product-moment correlation coefficients for the children with HI between the measures of novel word-learning ability, degree of hearing loss, articulation, nonverbal IQ, language, and phonological processing.

	AGE	SRT	3HZ	4HZ	5HZ	ARIZ	TONI	PPVT	EOW	TOLD	SPELT	MONO	MULTI	3-ITEM	OBJ	LNC	TRIALS
AGE	1.00	.25	.35	.40	.38	.19	.20	.08	.16	.14	-.04	-.39	-.22	-.28	-.42	-.20	-.06
SRT		1.00	.92**	.84**	.75**	.04	.40	.20	.28	.15	.16	-.57**	-.26	-.11	-.22	-.12	-.36
3HZ			1.00	.95**	.89**	-.08	.45*	.06	.23	.10	.03	-.67**	-.35	-.20	-.17	-.00	-.25
4HZ				1.00	.97**	-.21	.41	.02	.18	.12	-.01	-.73**	-.47*	-.30	-.19	.03	-.15
5HZ					1.00	-.29	.39	-.00	.16	.13	-.04	-.73**	-.48*	-.25	-.24	.01	-.11
ARIZ						1.00	-.14	.23	.26	.36	.42	-.12	-.08	.09	-.25	-.32	-.09
TONI							1.00	.45*	.57**	.43	.30	-.22	.19	.16	-.08	-.07	-.41
PPVT								1.00	.83**	.68**	.82**	.34	.49*	.32	-.33	-.59**	-.72**
EOW									1.00	.71**	.73**	.07	.37	.26	-.27	-.52*	-.55*
TOLD										1.00	.71**	.00	.08	.06	-.22	-.43	-.27
SPELT											1.00	.34	.27	.24	-.31	-.57*	-.44*
MONO												1.00	.44	.05	-.15	-.28	
MULTI													1.00	.69**	.02	-.16	-.39
3-ITEM														1.00	-.18	-.11	-.34
OBJ															1.00	.79**	.19
LNC																1.00	.39
TRIALS																	1.00

* = $p \leq .05$

** = $p \leq .01$

OBJ = Rapid naming of objects; LNC = Rapid naming of letters, numbers, & colors

TABLE 10. Pearson product-moment correlation coefficients for the normally hearing subjects.

	AGE	ARIZ	TONI	PPVT	EOW	TOLD	SPELT	MONO	MULTI	3-ITEM	OBJ	LNC	TRIALS
AGE	1.00	.35	-.03	-.30	-.46*	.01	.22	-.26	.25	.27	-.59*	-.59*	-.08
ARIZ		1.00	-.31	-.28	-.06	-.27	.25	-.45*	-.16	.12	-.21	-.19	-.04
TONI			1.00	.04	.25	.41	.18	-.01	.46*	-.01	-.28	-.11	-.22
PPVT				1.00	.41	.11	.27	.00	-.05	-.26	-.02	.03	-.01
EOW					1.00	.23	.15	.07	.26	-.29	.15	.20	-.29
TOLD						1.00	-.02	.11	.46*	.07	-.08	-.15	-.05
SPELT							1.00	-.51*	.18	-.10	-.29	-.41	-.16
MONO								1.00	.20	-.18	.38	.38	-.39
MULTI									1.00	.10	-.28	-.41	-.22
3-ITEM										1.00	-.04	-.47*	.02
OBJ											1.00	.47*	-.10
LNC												1.00	-.03
TRIALS													1.00

* = $p \leq .05$ ** = $p \leq .01$

OBJ = Rapid naming of objects; LNC = Rapid naming of letters, numbers, & colors

cabulary acquisition in normally developing children as well as in children with language impairments.

The findings were surprisingly clear-cut. The 20 children with hearing impairment divided evenly into two groups. Half of the children with HI performed comparably to the children with NH on all of the measures in the study, whereas the other 10 children with HI exhibited lower performance levels than the NH and 10 higher functioning children with HI on all but a few of these measures. The lower-functioning children with HI seem to be best characterized as language-impaired. This characterization, of course, needs to be confirmed by future studies that include larger numbers of children with hearing impairment and a more comprehensive battery of language and cognitive measures. However, the

performance profile of the lower-functioning HI subgroup is consistent with this characterization. These children had considerable difficulty acquiring two of the novel words, *jaften* and *shabaffidy*, and performed more poorly than the higher-functioning group on the measures of language and two measures of phonological processing (3-item, multisyllabic). Importantly, the lower performance levels of these children did not seem to reflect a more general cognitive deficit. As noted earlier, the children in the low-functioning group performed well within normal age limits on the TONI ($M = 99.6$). In fact, the HI children in this subgroup and the NH children had almost identical mean scores on the TONI (NH group $M = 101.5$). Consistent with previous studies (Davis et al., 1986), degree of hearing loss was not significantly related to word-learning ability or measures of language performance. In fact, the higher-functioning children with HI actually had poorer SRT scores ($M = 42.2$) than the lower-functioning group ($M = 28.5$). The best predictor of novel word-learning task ability was performance on the PPVT-R ($r = .73$, $r^2 = .53$). Performance on the PPVT-R was also one of the best predictors of educational performance in the Davis et al. (1983) study. Other factors related specifically to hearing loss might have influenced performance on the word-learning task, such as age of onset of hearing loss, age of identification of hearing loss, and age of amplification fitting. Previous research, however, has not shown these factors to be related to language abilities or academic success in children with mild-to-moderate hearing impairments (Davis et al., 1986; Kamhi & Gilbertson, 1989).

Although vocabulary knowledge was more strongly related to word-learning performance than any other factor, vocabulary knowledge alone cannot explain the difficulty children had learning novel words. As suggested by Gathercole and Baddeley (1990), the development of vocabulary in children is tied to phonological memory skills or, more specifically, the ability to construct and maintain phonological codes in memory. The findings in the present study support this strong link: The NH and children with HI who performed the best on the word-learning task also performed the best on the two phonological processing tasks

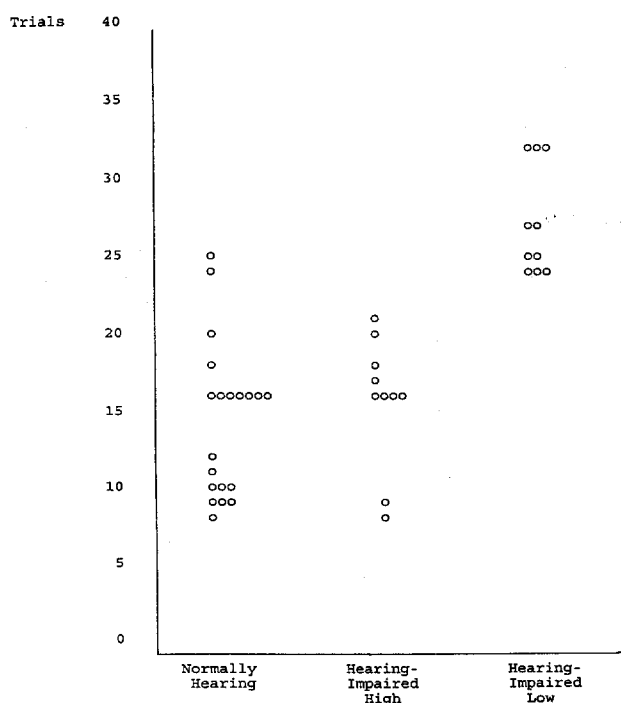
**FIGURE 1. Scatterplots of the number of trials to acquisition in the word learning paradigm for the four words.**

TABLE 11. Comparison of high and low subgroup performance.

	Subgroup			F-value
	High		Low	
Peabody Picture Vocabulary Test-Revised	88.30 22.26	M SD	58.10 9.83	15.40***
Expressive One-Word Picture Vocabulary Test	101.50 25.61	M SD	78.40 6.64	7.62*
Structured Photographic Expressive Language Test-II	.64 2.03	M SD	-.84 1.11	4.11
Grammatical Understanding (TOLD)	10.80 3.49	M SD	8.50 2.95	2.53
# Trials (40 possible) to acquire four novel words	15.70 4.19	M SD	27.20 3.49	44.46***
Test of Nonverbal Intelligence (quotient)	110.00 5.60	M SD	99.60 7.60	12.13**
Chronological age (mos.)	109.90 9.88	M SD	106.90 10.86	.41
Monosyllabic word repetition	13.20 5.39	M SD	12.20 3.71	.23
Multisyllabic word repetition	10.30 3.53	M SD	7.30 3.06	4.12
3-item word repetition	12.70 4.27	M SD	9.50 2.64	4.06
Rapid naming of objects	50.44 14.29	M SD	53.66 8.72	.36
Rapid naming of letters, numbers, colors	35.82 8.77	M SD	38.49 5.71	.64

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

(three-item and multisyllabic) that best reflected phonological memory skills.

The recognition data also support this interpretation of the findings. Recall that trial-by-trial analyses of the recognition responses were conducted to determine the accuracy of children's representations of each word prior to correct production. Of interest was whether the recognition response preceding the acquisition trial (i.e., the second consecutive correct production) was also correct. If difficulty producing the words was due to difficulty encoding phonological information in working memory, correct productions in the acquisition trial would be preceded by correct recognition choices. Consistent with previous research (Kamhi, Catts, & Mauer, 1990), results of the trial-by-trial analyses indicated that the majority of correct productions were preceded by correct recognition responses in the acquisition trial for all of the children. When words were not acquired, incorrect productions were preceded by incorrect recognition responses. This occurred for all children regardless of group or performance level. The recognition data thus indicate that encoding difficulties were primarily responsible for the production difficulties for both groups of children. Because the lower functioning children with HI had the most difficulty learning novel words, they must have the poorest encoding abilities. Their poor performance on the

measures of phonological processing supports this conclusion.

Before discussing the implications of the findings, it is necessary to address the possible influence of sociocultural factors on the subgroup data. As indicated earlier, the racial composition of the two subgroups was not the same. Seven of the nine African American children with HI were in the lower functioning group. This imbalance would suggest that sociocultural factors may have had some effect on children's performance on the various language measures and word-learning task. A recent study by Washington and Craig (1992) has shown, for example, that low-income, urban African American preschool and kindergarten children performed more than one standard deviation below the mean on the PPVT-R. The sociocultural factors that contribute to low scores on the PPVT-R may also account for the relatively poor performance of the African American children with HI in the present study. Although this possibility cannot be ruled out, it seems unlikely in light of the age-level performance of all nine African American children with NH and two of the African American children with HI on all of the language measures and the novel word-learning task. All of the children were drawn from public schools but their particular backgrounds and socioeconomic status were not known. It may be that African American children with HI are

more likely to have language and other processing deficiencies than other children with HI. Future studies need to investigate this possibility.

Implications and Conclusions

In a recent chapter on language abilities in children with HI, Shaw (1994) includes a brief section entitled "A Language Disorder Masked by Hearing Loss." In this section she cites research indicating that there may be a group of children with HI who have concomitant learning disabilities (Bunch & Melnyk, 1989). She goes on to state that: "It is possible that the language performances of some children with HI can be accounted for only in part by their hearing losses. The hearing impairment would add to an existing language problem or possibly mask a language disorder" (p. 270). Statements such as these reflect the prevailing view in the literature on hearing impairment that there is a strong link between severity of hearing loss and language/educational performance. For example, earlier in the same chapter, Shaw had made the following statements: "Generally, the greater the hearing loss, the more difficulty the child will have in perceiving and understanding speech" (p. 259) and "the extent of the [syntactic and morphologic] delay varies widely and is generally related to the severity of the hearing loss" (p. 267).

The prevailing view about the relationship between degree of hearing loss and language ability has been maintained despite studies (e.g., Davis et al., 1986) and clinical experiences that provide evidence against this view. For example, even though we found the previous evidence against the prevailing view convincing, we were still more than a little surprised that our findings so clearly repudiated this view. Moreover, despite our belief that language and educational performance were affected by factors other than the hearing loss, we were completely surprised to discover the two distinct performance profiles within the group of children with HI. The numerical equivalence of the two distinct groups, of course, had to be serendipitous. The characteristics of the two subgroups were no accident at all, however. One group of children performed within normal age limits on measures of language, phonological processing, and novel word-learning abilities whereas the other group performed significantly below age limits on these same measures.

The higher-functioning group may be best characterized as normally developing children who have a hearing impairment. Importantly, there is no reason to expect that this group of "normally" developing children with hearing loss should be any more homogeneous than a group of normally developing children without hearing loss. Given a supportive home environment and appropriate educational placements, these children should demonstrate language, social, and academic strengths and weaknesses within the normative range. Unfortunately, some of these children may encounter people who expect them to have speech, language, and learning difficulties. In some cases, these lower expectations may lead to lower levels of achievement. The sad irony is that, in these cases, misconceptions about the effects of hearing loss will have more of an adverse effect on language and learning than the hearing loss itself.

Whereas the higher-functioning group may be best characterized as normally developing children who have a hearing loss, the lower-functioning children may be best characterized as language-impaired children with a hearing impairment because they perform below normal age limits on measures of language. The variability of language and learning skills within this group of children is presumably no greater than the variability of normal-hearing language-impaired children. It is important to recognize, however, that the prevalence of language impairment in children with hearing impairment may be much higher than it is in normal-hearing children. If the findings in the present study prove to be accurate, then one out of every two children with a hearing impairment will be language-impaired. The children with language impairment need to be identified as early as possible in order to begin treating the language disorder. Since the severity of the hearing loss is not a determining factor, one must find other factors that identify the infants and young children most likely to be language-impaired.

In light of these points, it should be apparent that a hearing loss never masked a language disorder. The language disorder was always there to be found. What masked the language disorder was the view that a language disorder was an expected consequence of a hearing loss. This view was based on the notion that a language disorder can be caused solely by a hearing loss. Although a hearing loss clearly is a major risk factor for a language disorder, a significant proportion of children with hearing impairments in the mild-to-moderate range do not have language-learning difficulties. A hearing impairment in and of itself thus cannot cause a language impairment. Factors associated with language disorders in children (e.g., perceptual, cognitive, and linguistic processing deficits; see Kamhi, in press, for a review) may have a tendency to co-occur with hearing loss. More likely, however, is that the children with HI without language-learning deficits probably have above-average cognitive and linguistic processing skills as well as supportive and nurturing learning environments. For example, the higher functioning HI subgroup in the present study performed above the mean on the TONI ($M = 110$). Above-average processing skills and environmental support help these children overcome the potential negative consequences of the hearing loss. In contrast, the children with HI who are language-impaired probably have average or below average processing skills and less-than-ideal language-learning environments.

In conclusion, it is time to shift the burden of proof to those who still maintain the belief that language disorders are an expected consequence of hearing loss. This belief can have negative consequences for children with hearing loss who have normal language-learning abilities. The acknowledgment that many children with hearing impairment have normal language-learning abilities must be balanced, however, by the recognition that an equal number of children with hearing impairments do have language-learning difficulties. Future clinical and research efforts should be devoted to identifying these different groups of children as early in life as possible.

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Appendix A

Word Repetition Tasks

Monosyllabic Words

1. fat	10. l^p	18. var
2. maə	11. zæŋ	19. dap
3. slg	12. f^t	20. fun
4. pum	13. blz	21. klz
5. rlv	14. dok	22. dæf
6. kEI	15. sEə	23. tan
7. væg	16. w^g	24. slb
8. nls	17. tlf	25. zol
9. gEf		

Multisyllabic Words

1. tʃəlatls	10. plEtrəfjud	18. wətafədl
2. manəməm	11. bəkətəpl	19. brəbeskl
3. səklslp	12. rldəfən	20. dəsɪpələ
4. vəslləzet	13. bəsələnəd	21. sənəmənən
5. trlbəbl	14. spəplstlks	22. vəslfəs
6. rəbeslt	15. səkəvlt	23. rəbəl
7. fæθəsls	16. fEtəsabən	24. spEθəstəplk
8. kəsəbən	17. səfəfəsl	25. bEəfəd
9. pEθətəullk		

3-Item Sequences

1. tab gul flv	6. tlf va məŋ
2. klr vəŋ nəz	7. slg pEb zol
3. sa zəŋ dok	8. fəəm sEə glb
4. væg lom nls	9. p^ŋ dəə bls
5. zEI bod r^p	10. dap won gEf

Appendix B

Rapid Automatized Naming Tasks

Objects

key	scissors	umbrella	hand	comb	scissors	key	
hand	comb	umbrella	hand	umbrella	scissors	comb	
key	comb	scissors	key	hand	umbrella	comb	
key	hand	umbrella	comb	umbrella	comb	key	
hand	scissors	umbrella	hand	comb	key	scissors	
hand	scissors	umbrella	key	comb	hand	scissors	
umbrella	comb	key	comb	key	scissors	umbrella	hand

Letters, Numbers, and Colors

S	2	red	p	4	blue	A	7	black	D
4	yellow	c	6	black	S	2	green	A	9
yellow	P	7	blue	C	2	green	S	4	red
A	6	black	S	9	yellow	P	2	blue	D
7	green	C	9	red	D	7	blue	A	6