

The Efficacy of Utilizing a Phonics Treatment Package with Middle School Deaf and Hard-of-Hearing Students

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Research indicates that the acquisition of phonemic awareness and phonic skills is highly correlated with later success in learning to read. Numerous studies support the hypothesis that deaf and hard-of-hearing children are able to utilize alternative systems to develop phonological awareness that are not dependent on the ability to hear sounds or accurately pronounce words. A quasi-experimental, pre- and posttest design was employed in this study that evaluated the efficacy of implementing a phonics treatment package with middle-school-aged students. Results indicate that treatment students were able to demonstrate acquisition and generalization of the phonic skills taught. Additionally, acquisition of these skills did not appear to be related to degree of hearing loss.

Reading achievement among deaf and hard-of-hearing children has received considerable attention over the past two decades. Despite this increased attention, the evidence continues to document severe reading deficits for this population. Results of standardized tests of reading achievement have consistently shown that deaf and hard-of-hearing students graduating from high school read at approximately a fourth-grade level (Holt, 1994; Myklebust, 1960; Pintner & Patterson, 1916; Traxler, 2000).

It is generally accepted that deaf and hard-of-hearing children learn to read following the same sequence of skill development that hearing children do (Chall, 1996; Hanson, 1989; King & Quigley, 1985; Paul, 1998, 2001). Therefore, it appears as though deaf

and hard-of-hearing individuals, like hearing individuals, could benefit from the development of phonological processing skills as part of their beginning reading instruction. Leybaert (1993) suggested that our failure to appropriately address the phonological components of reading instruction is precisely what underlies the reading problems of deaf and hard-of-hearing individuals.

As English is an alphabetic language, beginning readers are typically taught to associate sounds with the letters and the letter sequences they represent. Although many deaf and hard-of-hearing students are unable to hear sounds clearly, if at all, Nielsen and Luetke-Stahlman (2002) maintain that “they still can and must develop phonological awareness if they are to read the sound-based printed words and phrases of English” (p. 12). Many teachers of deaf and hard-of-hearing children, however, dismiss this notion, assuming that an inability to access phonological information auditorially is a barrier to phonological processing skill acquisition. Hanson (1989), however, refutes this view:

To assume that deaf readers lack access to phonology because of their deafness confuses a sensory deficit with a cognitive one. While the term phonological is often used to mean acoustic/auditory or sound, this usage reflects a common misunderstanding of the term. Phonological units of a language are not sounds, but rather a set of meaningless primitives out of which meaningful unites [sic] are formed (p. 73).

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Adams (1990) concurred and further explained that the ability to hear the difference between phonemes and articulate them properly is not essential. Rather, the main goal of acquiring phonological knowledge is to understand that phonemes are the building blocks of a language. These building blocks can be manipulated and combined to form a variety of morphemes, the smallest meaningful units of the English language. Additional evidence indicates that skilled deaf and hard-of-hearing readers do utilize phonological information (Hanson, 1989; Hanson & Fowler, 1987; Hanson & Lichtenstein, 1990; Schaper & Reitsma, 1993). Therefore, the current study was predicated on the notion that deaf and hard-of-hearing readers can benefit from instruction to develop these critical beginning reading skills.

There is research evidence to suggest that the ability to use phonological information while reading is a distinguishing variable when comparing accomplished deaf and hard-of-hearing readers to average deaf and hard-of-hearing readers (Conrad, 1964; Engle, Cantor, & Turner, 1989; Hanson, 1982; Hanson & Fowler, 1987; Hanson & Lichtenstein, 1990; Hanson, Goodell, & Perfetti, 1991; Kelly, 1993; Leybaert, 1993; Musselman, 2000; Perfetti & Sandak, 2000). These findings imply that effective programs and strategies for teaching deaf and hard-of-hearing children these skills may be the key to obtaining higher levels of reading achievement for this population. Unfortunately, survey studies of instructional methods employed by teachers of deaf and hard-of-hearing children indicate that the overwhelming majority of teachers do not incorporate the teaching of phonology in their reading instruction (Coley & Bockmiller, 1980; Hasenstab & McKenzie, 1981; LaSasso, 1978, 1987; LaSasso & Mobley, 1997). Recently, in a summary of effective teaching strategies, the National Reading Panel (2000) recognized the efficacy of systematic and explicit instructional approaches to teach the phonological components of reading such as phonemic awareness and phonics.

The Direct Instruction *Corrective Reading-Decoding* series is characterized as a systematic, explicit remedial phonics program containing four levels (A, B1, B2, and C) that provides hierarchical skill development in reading for students in grades three through twelve

(Engelmann, Carnine, & Johnson, 1999; Engelmann, Meyer, Carnine, et al., 1999; Engelmann, Meyer, Johnson, & Carnine, 1999). Research findings have documented the effectiveness of the *Corrective Reading-Decoding* series with remedial readers (Campbell, 1988; Gregory, Hackney, & Gregory, 1982), non-categorical poor readers (Holdsworth, 1984–85; Kasendorf & McQuaid, 1987), and special education students (Thompson, 1992; Thorne, 1987). The results of two related unpublished studies indicated that, with proper modifications, these phonics programs could also address the reading needs of deaf and hard-of-hearing students (Oregon Center for Applied Sciences, 2001; Trezek, 2000).

The goal of the present study was to investigate whether the *Corrective Reading-Decoding A* curriculum could be modified to meet the unique needs of deaf and hard-of-hearing learners and result in the students' ability to demonstrate acquisition and generalization of phonic skills. The research questions that guided this inquiry were (a) Given instruction from a phonics treatment package, can deaf and hard-of-hearing students demonstrate knowledge of phonics as measured by the accuracy of (i) sound identification in isolation, (ii) sound identification within words, and (iii) word reading? and (b) Given instruction from a phonics treatment package, can deaf and hard-of-hearing students demonstrate generalization of phonics as measured by the accuracy of (i) sound identification within pseudowords and (ii) pseudoword reading?

Method

Participants and Setting

The sample population that was recruited for this study was housed in a large, urban, Midwestern school district serving more than 100,000 students preschool through twelfth grade. The self-contained deaf and hard-of-hearing program for middle-school-aged students served as the study site. The first author shared a written description of the proposed study with the principal overseeing the deaf and hard-of-hearing school program and a meeting was arranged to answer questions regarding the study. Upon receiving administrative consent for participation, the principal was

asked to furnish the names of the teachers in sixth through eighth grade.

The written description of the proposed study was then shared with teachers and a meeting to answer questions was arranged. Once informed consent of the teacher participants was obtained, teachers were asked to mail consent letters to the parents/guardians of potential student participants. Only those students whose current Individualized Education Programs (IEPs) indicated that they could receive a different reading curriculum than their general-education peers and who were enrolled in grades six through eight at the time of the study were considered for participation.

All 26 of the students enrolled in the middle school program at the time of the study met criteria for inclusion. Of those, parental permission was obtained for 23. Parental permission was also requested to obtain information about (a) degree of hearing loss, (b) hearing status of parents, and (c) history of reading achievement from the students' school records. Students with parental permission to be included in the study were invited to assent by completing a written assent form. All 23 students completed the form and agreed to participate in the study.

The three middle-school teachers serving deaf and hard-of-hearing students at this school were recruited for the research project. One teacher provided instruction for the students in the treatment group, one teacher for the students in the comparison group, and the third teacher provided instruction for those students who did not have parental permission to

participate in the study. Teachers were assigned to conditions in coordination with the principal. Rather than randomly, teachers were assigned to conditions based on logistical and programmatic constraints (e.g., one student's IEP dictated that he receive reading instruction from a specific teacher). All three teachers held K-12 state Hearing Impaired certification and each one had more than 25 years of experience teaching deaf and hard-of-hearing students in a public school setting.

Degree of hearing loss was obtained from students' most recent audiological evaluation. A single audiologist employed by the school district conducted all the evaluations within the last two years. Based on Pure Tone Average (PTA) in the better ear, of the 11 students in the treatment group, one student had a slight hearing loss, one a mild hearing loss, 2 had a moderate hearing loss, 2 had a severe hearing loss, and 5 a profound hearing loss. It should be noted that student T6 was diagnosed with auditory neuropathy. This condition is characterized as the inability to properly process auditory stimuli despite having normal, high-frequency peripheral hearing for each ear. The student with auditory neuropathy was the only participant with deaf parents.

Of the 12 students in the comparison group, one student had a slight hearing loss, 2 a mild hearing loss, 4 students had a moderate hearing loss, 2 students had a severe hearing loss, and 3 had a profound hearing loss. Note that student C6 had a bilateral, moderate conductive hearing loss. None of the students in the comparison group had deaf parents. See Table 1

Table 1 Summary of hearing loss, reading achievement and age for participant pairs ($n = 22$)

Student Pair Number	Degree of Hearing Loss		SAT-9 Scores 2003		Age	
	Pure Tone Average in Better Ear		Grade Equivalent		Year/months	
	Treatment	Comparison	Treatment	Comparison	Treatment	Comparison
1	100 dB	110 dB	2.0	NA	14.3	11.10
2	106 dB	93 dB	2.7	2.5	14.1	12.9
3	113 dB	73 dB	2.3	2.2	12.9	14.0
4	118 dB	96 dB	2.3	2.6	13.8	14.0
5	76 dB	58 dB	2.3	1.7	13.6	15.4
6	48 dB	48 dB	2.5	2.8	13.0	14.6
7	101 dB	70 dB	2.9	3.3	13.9	13.9
8	16 dB	54 dB	2.0	2.2	13.10	13.0
9	76 dB	46 dB	2.9	3.1	13.9	14.9
10	60 dB	8 dB	2.9	2.5	14.1	13.0
11	36 dB	35 dB	2.7	2.2	12.10	12.2

for a summary of degree of hearing loss for the participants.

To gauge the history of reading achievement for each student in the study, the scores reported on the Reading Comprehension subtest of the Stanford Achievement Test-9th Edition (SAT-9) for the last 3 years were collected. The grade-equivalent scores obtained for each student derive from the normative data reported for deaf and hard-of-hearing students. In other words, these scores reflect a comparison between the students participating in this study and their deaf and hard-of-hearing peers nationwide.

The scores revealed that the grade-equivalent scores on the Reading Comprehension subtest for students in the treatment group ranged from 2.0 to 2.9 with a mean of 2.5 in 2003, from 1.8 to 2.9 with a mean of 2.4 in 2002, and 1.8 to 2.6 with a mean of 2.2 in 2001. For students in the comparison group, the grade equivalent scores ranged from 1.7 to 3.3 with a mean of 2.3 in 2003, 1.3 to 3.4 with a mean of 2.4 in 2002, and 1.4 to 2.6 with a mean of 2.2 in 2001. See Table 1 for a summary of scores obtained in 2003.

At the onset of the study, each student's age and grade placement was noted. The students in the treatment group ranged in age from 12 years, 9 months to 14 years, 3 months with a mean age of 13 years, 5 months. Of the 11 students in the treatment group, 4 students were enrolled in seventh grade while the remaining 7 were in eighth grade. The students in the comparison group ranged in age from 11 years, 6 months to 15 years, 4 months with a mean age of 13 years, 4 months. Of the 12 students in the comparison group, 4 students were enrolled in sixth grade, 3 in seventh grade, and 5 in eighth grade. See Table 1 for summary. All 23 students were retained over the eight-week study of students' ages.

Procedures

Teaching Materials

The instructional materials utilized differed according to group assignment. The students in the comparison group continued to receive the standard reading curriculum that was utilized prior to the onset of this study, while the students in the treatment group

received instruction from a phonics treatment package. The phonics treatment package utilized the first 20 lessons of the *Corrective Reading-Decoding A* program (Engelmann, Carnine, et al., 1999) as the basis for instruction. The presentation of lessons was modified to meet the unique needs of deaf and hard-of-hearing students, and lessons were supplemented using computer technology. The three components of the phonics treatment package are described below, followed by a description of the instructional materials used with the comparison group.

Phonics Treatment Package

Decoding A curriculum. The *Decoding A* program provides numerous phonemic awareness and phonic activities within a lesson, integrates cumulative review between lessons and furnishes teachers with the necessary steps to effectively teach the presented phonemic awareness and phonic skills. A teacher script provides teachers with precise wording to teach the skills in each lesson component. In the *Decoding A* program, skills are first introduced in isolation, then practiced over time, and finally incorporated in meaningful, decodable, connected text (Engelmann, Carnine, et al., 1999).

In each lesson of the *Decoding A* program, the teacher guides students through three activities: pronunciations, sound introduction, and word reading. These activities are the cornerstone of the phonemic awareness and phonics instruction included in the program. To maximize the amount of practice students receive, students respond in unison during all teacher-directed activities. In addition to the teacher-directed portions of the lessons, these skills are further reviewed and reinforced through workbook activities (Engelmann, Carnine, et al., 1999).

The pronunciation activities in the *Decoding A* program require students to say sounds and words without seeing the printed form of them. These activities were developed to ensure that when these same sounds and words are later presented in print, students would have previous experience with the sounds, words, and their correct pronunciations (Engelmann, Carnine, et al., 1999). The purpose of these pronunciation activities for deaf and

hard-of-hearing students is relative. Deaf and hard-of-hearing students must learn to consistently pronounce sounds and words that are reasonable versions of “normal” phonetic production. For example, students learn that, although the movement of the lips is visually similar, the difference between the pronunciation of a /d/ and /t/ sound involves voicing the /d/ and not voicing the /t/.

Modifications to the pronunciation activities required deaf and hard-of-hearing students to use a variety of strategies to guarantee that consistent and appropriate representations of sounds and words were achieved. Speechreading, articulatory feedback, and Visual Phonics (described below) are all appropriate means of acquiring the skills presented in the pronunciation activities of *Decoding A* and were used in combination in this study.

Visual Phonics. Visual Phonics is a system of 46 moving hand cues, used in conjunction with spoken language and speechreading, that look and feel like the individual phonemes they represent (International Communication Learning Institute, 1996). For example, the hand cue for the /t/ sound is produced in

three steps. First, the hand is held in a fist near the mouth with the fingers facing the body. Second, the index finger is quickly extended upward representing the tongue striking the roof of the mouth. In the third step of the hand cue, the index finger is returned to the original position. In order to use Visual Phonics successfully, the students required additional instruction in how to match the teacher’s speech production on the mouth, form the Visual Phonics cue, and/or feel the teacher’s throat to determine if the sound was voiced as in /d/ or unvoiced as in /t/.

Baldi. To ease the acquisition of these critical pronunciations, a semi-transparent “talking head” called Baldi (see Massaro, in press) was available in the computer program that was utilized in this study (Oregon Center for Applied Sciences, 2001). The animations provided by Baldi reveal how the mouth shape, lip movement, and tongue placement work in concert to produce specific sounds and words. These animations provided the deaf and hard-of-hearing student participants with a visual representation of how sounds and words are produced. See Figure 1 for an example of the Baldi technology.

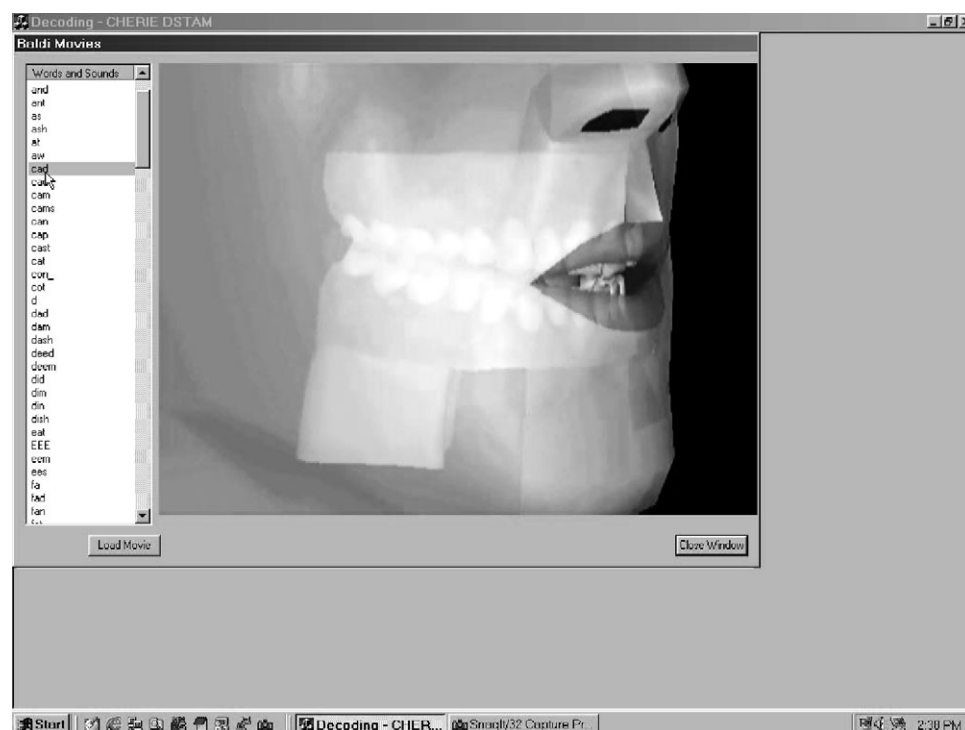


Figure 1 Example of a 45° rotation and 30° elevation from the Baldi software program.

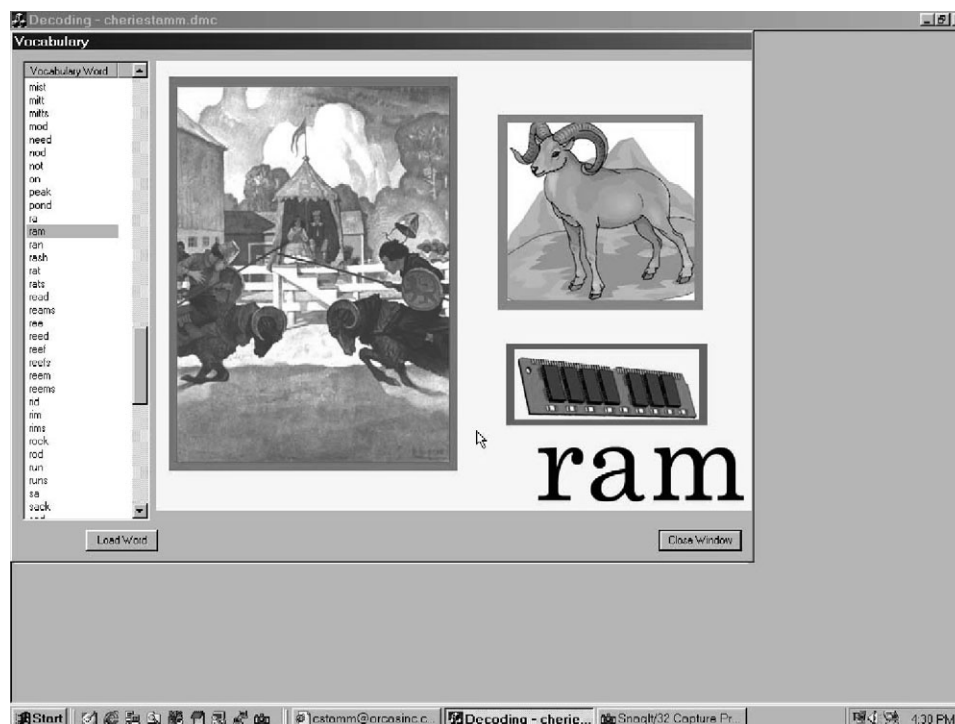


Figure 2 Sample screenshot from the computerized pictorial glossary.

To construct these animations, a speech engine and toolkit software from Center for Spoken Language Understanding (CSLU), a division of the Oregon Graduate Institute of the Oregon Health and Sciences Center, was used. Different orientations of the talking head were utilized in order to provide optimal visual information to deaf and hard-of-hearing students. For example, a 45° rotation and 30° elevation was used for sounds formed at the back of the mouth such as /k/ and /g/; a 15° rotation and 15° elevation was used for sounds produced with the tongue in the front of the mouth such as /t/, /d/, and /ch/; and a 15° rotation and 0° elevation was used for sounds visible at front of mouth such as /p/, /b/, and /m/ (Oregon Center for Applied Sciences, 2001). The talking head animations supported the pronunciation activities of the *Decoding A* program and also enhanced the sound introduction activities.

Pictorial glossary. The majority of the words taught in the word-reading activities of the *Decoding A* program are within the normal speaking vocabulary of hearing students; therefore, direct teaching of vocabulary is not usually incorporated into the curriculum. However, for deaf and hard-of-hearing

children, many of these words may be unknown and the students may require pictorial representations to enhance vocabulary acquisition. To assist teachers in teaching the meaning of the unknown words, a pictorial glossary was created as part of the computer program. In the pictorial glossary, various pictures are used to demonstrate the range of meanings for each word presented in the word-reading activities. For words that cannot be explained with still graphics, such as *is*, sample sentences are provided to demonstrate the word's usage (Oregon Center for Applied Sciences, 2001). See Figure 2 for an example of a page from the pictorial glossary.

Standard Reading Curriculum. In the deaf and hard-of-hearing program that was solicited for this study, individual teachers establish their own reading curriculum. Prior to the onset of this study, the school had purchased three published reading programs that teachers could choose to use with students. These programs included *Reading Milestones* (Quigley & King, 1985), *Pair-It Books* (Steck-Vaughn Company, 1998), and the *Wildcat Series* (Wright Group, 2001). Teachers at the participating school design their

reading curriculum using one or more of the reading series mentioned above. In addition, teachers create units to accompany trade books that include vocabulary and comprehension worksheets. The comparison teacher in this study did not use a phonic-based approach to teaching reading and was not familiar with Visual Phonics. No attempt (e.g., staff development activities aimed at improving reading instruction) was made to alter the reading curriculum or instruction for students in the comparison group.

Measures

A curriculum-based pre- and posttest and generalization test was created specifically for this study. The first section of the pre- and posttest was designed to assess the participants' ability to identify individual sounds in isolation. The 15 sounds taught in the first 20 lessons of the *Decoding A* program were listed and students were asked to identify each sound. The second section of this test was created to assess students' ability to identify individual sounds within words and read whole words taught in the *Decoding A* program. The maximum points possible on the pre- and posttest were 45.

To construct the generalization test, a list of 15 pseudowords was created. Pseudoword decoding is an indicator of phonological decoding capability and a strong predictor of reading ability at all levels (Stanovich, 1988). A pseudoword decoding task was chosen for the measure of generalization because this task not only assesses a student's ability to apply phonic skills to the reading of unknown words, but also ensures that the student is not simply providing a correct response because the word is in his/her sight word vocabulary.

During the first 20 lessons of the *Decoding A* program, students are taught 15 sounds. These 15 sounds are incorporated into 120 words that the students learn to read during word-reading tasks. The 15 sounds were used in combination to form a list of pseudowords that mimic the phonological structures of the words taught in the *Decoding A* program. The generalization test was administered to students in both groups after the completion of the 20-lesson intervention and was worth a maximum of 30 points.

Individual administration and scoring of all tests was conducted by the first author, who was previously trained in Visual Phonics, has served as a consultant for several deaf and hard-of-hearing programs utilizing Visual Phonics in conjunction with the Direct Instruction reading programs, and had previous experience assessing both phonics production and Visual Phonics cues as part of a prior research and development projects conducted by the Oregon Center for Applied Sciences. This individual is also certified as a teacher of the deaf and hard of hearing with 10 years of teaching experience, five of which included assessing the phonics skills of deaf and hard-of-hearing students. In addition, the students' classroom teachers directly observed several of the actual assessments and all test scores were summarized and shared with the participating teachers following the assessments.

All directions and questions addressed to students were communicated using speech and sign language simultaneously. Students who typically used amplification, such as a hearing aid or FM assistive listening device, were asked to utilize their device during the test session. Although fingerspelling or the Visual Phonics cues may have accompanied responses to the test items, answers on the first section of the pre- and posttest were only considered correct if the appropriate mouth movements and vocal sensations (voiced vs. unvoiced) were produced. For example, the sounds /d/ and /t/ both appear on the test. These sounds have identical mouth movements, but the vocal sensation produced is different. In this example, the responses were scored as correct if the student was able to provide a voiced response for the /d/ and an unvoiced response for the /t/.

For the second section of the pre- and posttest and also the generalization test, a similar criterion was used to determine a correct response. A student must have shown distinct mouth movements and vocal sensations for each phoneme in the word. For example, if reading the word *cats*, the student was required to provide four mouth movements and the four associated vocal sensations to receive full credit for the response. Partial credit was not awarded. To increase the likelihood that the treatment and comparison groups were similar with respect to knowledge of phonics, the pretest scores for the students were rank ordered, lowest to

highest, and students were randomly assigned to either the treatment or comparison group.

Group Assignment. A coin was tossed to determine the assignment for students, heads determining assignment to the comparison group and tails determining assignment to the treatment group. The coin was tossed and the first ranked student was assigned to either the treatment or comparison group. The second ranked student was assigned to the other group. The first and second ranked students constituted a matched pair. The third ranked student was assigned to the same group as the second ranked student while the fourth student was assigned to the same group as the first ranked student. The third and fourth ranked students also constituted a matched pair. A coin was then tossed to determine the assignment for the fifth ranked student and the procedure was repeated until all students were placed.

Teacher Training. The teacher who implemented the phonics treatment package with students in the treatment group received a full-day training (approximately 6 h) conducted by the first author. Prior to the onset of this study, the treatment teacher had no previous training or experience with either the *Decoding A* curriculum, Visual Phonics cues, or the computer program. The training was divided into three sections (a) research summary, (b) Visual Phonics presentation and practice and (c) phonics treatment package overview. The first section of the training provided the teacher with a summary of the literature supporting phonics-based reading instruction for deaf and hard-of-hearing students. In addition to a brief literature review, prior results of using the components of the phonics treatment package with deaf and hard-of-hearing students were presented and discussed.

The second section of the training focused on teaching the Visual Phonics cues. The teacher was taught the necessary hand cues required to present the 20 lessons of the phonics treatment package. Ample time to practice and memorize the cues was provided. The third and final section of the training allowed the teacher to learn and practice the presentation techniques employed in the *Decoding A* program. It also served as an opportunity for the teacher to familiarize

herself with the accompanying computer program. The lesson presentation techniques and Visual Phonics cues were practiced for approximately 1 h at the end of the training session.

Intervention. In order to form instructionally practical groups and allow the teacher to monitor students' responses more easily, the treatment group was divided into two groups for instruction. The division of students was made based on students' scores on the pretest. The pretest scores for students T1 through T5 ranged from 1 to 6 while the scores for students T6 through T11 ranged from 15 to 33. For the instructional groupings, students T1 through T5 were placed in one group and students T6 through T11 were placed in the second group in the treatment classroom. When a group was not working with the teacher, they were working on Social Studies activities with the teacher assistant in another part of the classroom. Similarly, students in the comparison group were grouped based on their ability and were taught reading by the teacher and Social Studies by the teacher assistant. All groups received 45 min of daily reading instruction over the eight-week intervention period.

The first author taught the students in both instructional groups in the treatment classroom on the first day of the intervention in order to model the teaching techniques for the treatment teacher. On the following day, the classroom teacher began providing instruction using the phonics treatment package and the first author observed. Modeling and coaching was provided to the teacher on an as-needed basis during the first 2 days that she presented the instruction.

After the initial training and implementation phase that spanned 4 days, the first author returned to the school on a weekly basis to observe the teacher and provide feedback. During the 8-week intervention, the first author observed 8 of the 30 teaching sessions or 27% of the sessions. A procedural reliability form was completed during each observation. This form reflected all aspects of the phonics treatment package including teaching techniques, Visual Phonics, and use of the computer program. The form provided a system of rating the eight critical areas of instruction: (1) Set up and Prep, (2) Signals, (3) Expectations, (4) Pacing, (5) Individual Turns, (6) Behavior Management,

(7) Visual Phonics and (8) Computer Program. The treatment teacher was observed to implement all eight components during 100% of the observations of procedural reliability.

To monitor fidelity of implementation, teachers of students in both the treatment and comparison groups were asked to document information related to reading instruction on a log sheet. This information included start and end time of instruction, name of absent students, curriculum covered, and specific observations of students' progress. Examples of observations of students' progress included observations of students' attitudes and abilities, changes in articulation of speech sound, and ability of students to utilize the Visual Phonics cues.

Analysis

A quasi-experimental, pre- and posttest research design with a treatment and comparison group was employed in this study. The nonparametric Matched-Pair Wilcoxon statistical test was utilized to analyze the data. The main reason for employing a paired test in a study is to control for experimental variability. Factors that are not specifically controlled for through the experimental design will affect both the before and after measurements equally; therefore, these factors should not affect the differences obtained in the study. Furthermore, the Matched-Pair Wilcoxon test not only provides information about the mean difference in a population, but also provides information about the magnitude of the difference (Motulsky, 1999).

The nonparametric Matched-Pair Wilcoxon test was an appropriate statistical test in this study for two reasons. First, because the student participants were solicited from a population of deaf and hard-of-hearing students, the assumption of normality of population distribution was violated. For this reason, a nonparametric, rather than a parametric, test was needed. Second, because students were rank ordered, matched, and assigned to groups based on their performance on the pretest, a statistical test that compares two related groups was warranted. In addition to the Wilcoxon test, bivariate correlations were conducted for continuous variables of interest such as degree of hearing loss and performance on test measures.

Results

Because there were an odd number of students who agreed to participate in this study ($N = 23$), the scores for student C12 were not included in the analysis because they lacked a match in the treatment group. Therefore, the following results are based on the scores for 11 matched pairs.

Pretest

The pretest scores for students in the treatment group ranged from one correct response to 33 correct responses ($M = 14.9$, $SD = 11.92$). The pretest scores for students in the comparison group also ranged from one correct response to 33 correct responses ($M = 14.9$, $SD = 11.56$). Correlations were calculated for each student's PTA in the better ear and his or her pretest score. It should be noted that scores for student T6 were not included in the correlations because we were unable to calculate a PTA for this student because she was diagnosed with auditory neuropathy. The analysis revealed a strong correlation between degree of hearing loss and performance on the pretest for both students in the treatment, $r(10) = -.730$, $p = .017$, and comparison groups, $r(11) = -.813$, $p = .002$. In other words, on the pretest, students with more significant hearing losses did not perform as well as those students with less significant hearing losses.

Posttest

The posttest scores for students in the treatment group ranged from 43 to 45 correct responses ($M = 44.7$, $SD = .65$). The posttest scores for students in the comparison group ranged from 1 to 33 correct responses ($M = 14.9$, $SD = 12.05$). The Matched-Pair Wilcoxon was again utilized to calculate the differences between the scores obtained for the two groups of students on the posttest. Results indicated that there was a highly significant difference ($z = -2.936$, $p = .003$) between the performance of the treatment and comparison students on the posttest, with students in the treatment group performing substantially better.

As with the pretest data, an analysis was conducted to determine if there was a correlation between degree of hearing loss and performance on the posttest. This analysis revealed that, for students in the treatment

Table 2 Summary of test scores for participant pairs ($n = 22$)

Student Pair Number	Pretest (Maximum 45 points)		Posttest (Maximum 45 points)		Generalization Test (Maximum 30 points)	
	Treatment	Comparison	Treatment	Comparison	Treatment	Comparison
1	2	1	45	1	30	0
2	3	3	45	2	30	0
3	4	5	45	6	30	0
4	5	4	45	2	30	4
5	6	6	42	13	29	0
6	15	14	45	10	28	3
7	20	19	45	17	30	3
8	22	24	44	18	28	1
9	25	27	45	32	30	6
10	31	27	45	27	30	8
11	33	33	45	33	30	19
Group Mean	14.9	14.9	44.7	14.9	29.54	4.00

group, there was no longer a statistically significant correlation between degree of hearing loss and performance on the posttest, $r(10) = .350$, $p = .332$. However, a statistically significant correlation between degree of hearing loss and performance on the posttest, $r(11) = -.835$, $p = .001$, still existed for students in the comparison group.

Generalization Test

The scores on the generalization test for students in the treatment group ranged from 28 to 30 correct responses ($M = 29.5$, $SD = .82$). The scores on the generalization test for students in the comparison group ranged from 0 to 19 correct responses ($M = 4$, $SD = 5.7$). The Matched-Pair Wilcoxon results of the final analysis indicated that there was again a highly significant difference ($z = -2.941$, $p = .003$) between the performance of the treatment and comparison students on the generalization test. See Table 2 for a summary of test results.

As with the pre- and posttest data, an analysis was conducted to determine if there was a correlation between degree of hearing loss and performance on the generalization test. Interestingly, this analysis revealed that for students in the treatment group, there was a statistically significant correlation between degree of hearing loss and performance on the generalization test, $r(10) = .639$, $p = .047$, with more significant

hearing loss associated with higher scores on the generalization test. However, for students in the comparison group, there was not a statistically significant correlation between degree of hearing loss and performance on the generalization test, $r(11) = -.553$, $p = .078$. This phenomenon is explored further in the discussion section.

Teacher Log Sheets

The changes in reading behavior observed in the posttesting seemed to also translate to real changes in the day-to-day school experiences of the students in the treatment group. Anecdotal evidence from the treatment teacher's daily log indicated that students in the treatment group readily applied their new knowledge of letter-sound correspondences to the reading of novel words. Students also reportedly began to notice how a subtle change in the order of the letters could drastically change the meaning of a word. For example, without prompting, students noted that the words *cats* and *cast* both contain the same four phonemes, although the order of the phonemes in the word clearly changed the meaning.

Another observation provided by the treatment teacher was in regards to the students in the second instructional group who had profound hearing losses ($PTA > 100$). The students with more significant hearing losses typically did not produce speech sounds

or provide mouth movements when responding to items on the pretest. Moreover, these 4 students also did not produce speech sounds for communicative purposes and relied primarily on sign language to communicate. The treatment teacher observed that these students expressed an increased interest in speech production and the desire to learn to articulate sounds properly. The teacher reported that the students were particularly intrigued with learning the tactile and kinesthetic differences between voiced/unvoiced pairs of sounds such as /d/ and /t/ and between similar vowel sounds such as the short /a/ and short /i/.

Discussion

The purpose of this study was to investigate the ability of deaf and hard-of-hearing students to learn and generalize phonic skills taught. Two research questions were developed to address this inquiry: (a) Given instruction from a phonics treatment package, can deaf and hard-of-hearing students demonstrate knowledge of phonics as measured by the accuracy of (i) sound identification in isolation, (ii) sound identification within words, and (iii) word reading? and (b) Given instruction from a phonics treatment package, can deaf and hard-of-hearing students demonstrate generalization of phonics as measured by the accuracy of (i) sound identification within pseudowords and (ii) pseudoword reading?

The first research question examined the effectiveness of the phonics treatment package to develop phonics knowledge. The second research question examined the effectiveness of the phonics treatment package to develop the ability to generalize phonics knowledge. For the first research question, it was hypothesized that the mean score of the treatment group would be greater than the mean score of the comparison group on the posttest measure. Similarly, for the second research question, it was hypothesized that the mean score of the treatment group would be greater than the mean score of the comparison group on the generalization test.

The results of this study support the hypothesis stated for each research question. The students in the treatment group who received instruction from the

phonics treatment package had a higher mean score on the posttest compared to students in the comparison group who did not receive this instruction. The students in the treatment group also had a higher mean score on the generalization test compared to students in the comparison group. The findings in this study are considered statistically significant.

Because the students in this study were randomly assigned to either the treatment or comparison group as matched pairs, the students were very similar with regard to their knowledge of phonics at the onset of the study. In fact, results of the Matched Pair Wilcoxon revealed that there was not a statistically significant difference between the performances of the two groups on the pretest. However, after receiving 20 lessons of instruction from the phonics treatment package over an 8-week period, the students in the treatment group scored significantly better on the posttest and generalization test than the students in the comparison group. In fact, the *z*-scores obtained in these analyses indicate that the mean score of the comparison group was nearly 3 standard deviations below the mean score achieved by the treatment group on each of these measures. These findings are considered highly significant.

Although the research design of this study did not specifically address the interaction between degree of hearing loss and performance on dependent measures, several interesting findings related to participants' degree of hearing loss emerged. While students were assigned to groups based on pretest scores, the groups were also matched *de facto* on the basis of hearing loss. Perhaps not surprisingly, the students in both the treatment and comparison groups with lower pretest scores were, in general, those students with more significant hearing losses (i.e., students T1-T5 and C1-C5). These students reportedly had severe to profound hearing losses and had an average PTA of approximately 95 dB. The higher pretest scores obtained by students with less significant hearing losses (i.e., T6-T11 and C6-C11) could possibly be attributed to the access to speech sounds not afforded to those students with more significant hearing losses. These higher-scoring students reportedly had moderate hearing losses with an average PTA of approximately 60 dB.

In terms of student performance on the pretest, students with less significant hearing losses typically

produced speech sounds when responding to test items. For example, during the administration of the pretest, students were asked to say each sound in a word slowly and then say the whole word fast. During this process, it appeared as though the students with less significant hearing losses could simply reduce their rate of speech to produce the sounds in the word and then repeat the word at a normal speaking rate thereby receiving full credit for the response on the pretest. This strategy was particularly successful when students responded to a word that was most likely in their vocabulary repertoire such as the word *cats*, but not nearly as successful with a less common word such as *mist*. One may infer from this observation that, despite having auditory access to many phonemes and the ability to articulate sounds verbally, these students may not have learned to apply phonology to the reading of words; rather they were accessing the words as sight words.

Students with more significant hearing losses, on the other hand, typically did not produce speech sounds when responding to items on the pretest; therefore, these students could not rely on the same strategy described above to produce a correct response. Furthermore, these students did not provide mouth movement to accompany their responses. Instead, these students either simply fingerspelled their response or gave no response at all. This may account for the significant difference in pretest scores for students 1 through 5 versus 6 through 11 in both the treatment and comparison groups. What is most interesting, however, is that a similar division of scores associated with degree of hearing loss was not apparent for the students in the treatment group on the posttest.

In observing response patterns of students in the treatment group on the posttest, the students with less significant hearing losses provided a response that included speech production just as they did on the pretest. However, their responses on the posttest now also included the corresponding Visual Phonics cues. For the students with more significant hearing losses, responses on the posttest now included mouth movements and the Visual Phonics cues. The presence of mouth movements in their responses may indicate that the students with more significant hearing losses were learning to connect letters to articulatory move-

ments. These observations underscore research findings reported by Chalifoux (1991) and Chincotta and Chincotta (1996) who hypothesized that deaf and hard-of-hearing individuals are able to link the speech that is visible on the mouth to printed letters and words and retain this information in visual-spatial storage in a manner similar to hearing readers who connect printed letters to sounds and retain them in acoustic storage. At posttest, the scores of the students with more significant hearing losses were not discernable from the scores of the students with greater access to speech.

One may infer from this finding that instruction from the phonics treatment package was successful in developing knowledge of phonics for deaf and hard-of-hearing students in the treatment group regardless of degree of hearing loss. This conclusion is also supported by studies indicating that the ability to hear phonemes and articulate them properly is not essential to the acquisition of phonological knowledge (Adams, 1990; Hanson, 1989). Moreover, access to phonological knowledge is possible despite the presence of a profound hearing loss (Hanson, 1990; Hanson & Fowler, 1987; Hanson & Lichtenstein, 1990; Schaper & Reitsma, 1993).

The performance of students in the treatment group on the generalization test was again exceptionally strong with scores ranging from 93–100% correct. As with the posttest, degree of hearing loss did not appear to be a factor affecting student performance on this measure. These findings suggest that, after receiving instruction from the phonics treatment package, deaf and hard-of-hearing students with varying degrees of hearing loss were able to generalize their phonics knowledge to the reading of pseudo-words. The students in the comparison group did not fare as well on the generalization test with scores ranging from 0–63% correct.

Of particular interest is the performance of students C6–C11, or those students in the comparison group with less significant hearing losses. The scores on the generalization test for these 6 students were 3, 3, 1, 6, 8, and 19 out of a possible 30 points ($M = 6.67$ or 22%). The same 6 students' scores on the pretest were 14, 19, 24, 27, 27, and 33 out of a possible 45 points ($M = 24$ or 53%). Although the actual task involved

in completing the pretest (saying each sound in a word slowly and then saying the whole word fast) was identical to that of the generalization test, the performance of these 6 students in the comparison group was quite different on the two measures. These results support an earlier statement that the students with less significant hearing losses, or those having auditory access to many of the phonemes in the English language, did not actually appear to be applying phonological information to the reading of words. It is likely that many of the words on the pre- and posttest were in these students' sight word vocabularies allowing them to receive credit for words they were not actually decoding phonetically. The generalization test, however, required students to read pseudowords. Because none of the pseudowords would have been in the students' sight-word vocabularies, it was clear that their reading was not based on phonology. This statement is further supported by the lack of a significant correlation, $r(11) = -.553$, $p = .078$, between degree of hearing loss and performance on the generalization test for students in the comparison group.

The results of this study indicate that students receiving instruction from the phonics treatment package were able to acquire knowledge of phonic skills and apply this knowledge to the reading of pseudowords. The fact that the acquisition of these skills does not appear to be related to degree of hearing loss is quite compelling. Despite the presence of severe to profound degrees of hearing loss, no use of amplification and inability to produce speech sounds verbally, several students in the present study were not only able to demonstrate acquisition and generalization of phonic skills, but their performance in some cases exceeded the performance of their peers with less significant hearing losses. This situation accounts for the positive correlation between degree of hearing loss and performance on the generalization test for students in the treatment group.

The correlation analyses revealed that although degree of hearing loss was highly correlated with performance for all students on the pretest, the correlation between hearing loss and performance on the posttest was no longer significant for students in the treatment group after the intervention. This

finding is not only striking, but also very encouraging in terms of planning future research studies and rethinking reading instructional practice for deaf and hard-of-hearing students with various degrees of hearing loss.

Social Validity

In terms of the social appropriateness of the intervention procedures utilized in this study, the teacher in the treatment condition was complimentary about the phonics treatment package, and the two non-treatment teachers who participated in the study inquired about training for themselves at the conclusion of the study. Additionally, at the end of the school year in which this study took place, the principal of the program requested that the other teachers in the school receive a demonstration of the teaching method and techniques utilized in the treatment package.

One component of the intervention that would not be readily available to teachers outside this participating school is the Baldi software. Although this software is publicly available, the specific configurations used in this study are not. Any future replication of this study would require the acquisition of the computer program developed by the Oregon Center of Applied Sciences. However, it should be noted that the treatment teacher commented in her log during the intervention that the Baldi technology was rarely needed to reinforce the production of individual sounds and words. The teacher stated that once the students learned the verbal, visual, tactile, and kinesthetic characteristics of sounds and associated them with the corresponding Visual Phonics cue, the cue alone was a sufficient aid for remembering the proper articulation, tactile sensation and kinesthetic movement of a sound. Future research could address the benefit of this particular component, above and beyond the benefit of the other components in the treatment package.

Limitations

We acknowledge several limitations to this research. First, because of the difficulty of locating individuals who are qualified to assess deaf and hard-of-hearing students in both phonics production and in the use of Visual Phonics cues, a single individual was responsible

for the administration and scoring of the pre-, post- and generalization tests. Additionally, this one individual was also aware of group assignment at the time of testing, posing a potential threat to the internal validity of this study. While we acknowledge this limitation, we also draw attention to several aspects of the study that mitigate this limitation. Specifically, in this study, the magnitude of change exhibited by the students in the treatment condition was marked and overtly apparent to many of the professionals who worked in the participating middle school at the time of the study. Additionally, the students' teachers observed several of the individual assessment sessions, and all test results were shared with the participating teachers following the assessments.

Another possible limitation of the findings in the current study is that phonemic awareness and phonic skills were the only reading skills addressed and measured. However, it should be noted that research indicates that the development of reading typically follows a hierarchical sequence of stages in which the acquisition of skills at each stage is a prerequisite for progression to the next (Adams, 1990; Chall, 1996). Phonemic awareness and phonic skills may be viewed as the foundation upon which higher-level reading skills such as fluency, vocabulary, and comprehension are built (Chall, 1996) and important skills to address in beginning reading instruction (National Reading Panel, 2000). Therefore, we suggest that further inquiries such as the present study must be conducted and promising results achieved before investigations of higher-level reading skills can be conducted. We also suggest that future studies evaluate implementation of the phonics treatment package over a longer period of time. Increasing the duration of the implementation would address the potential concern that phonemic awareness and phonic skills were the only reading skills assessed since skills such as structural analysis, spelling from dictation, decoding irregular words, story reading, and comprehension strategies are covered later in the specific curriculum utilized in this study.

Conclusion

The results of the current study demonstrate that instruction in phonemic awareness and phonics can

benefit deaf and hard-of-hearing students. Future research of this type will need to establish a relationship between this instruction and the acquisition of other reading skills such as fluency, vocabulary, and comprehension. Of particular interest would be investigations that examine whether gains in word and pseudoword reading are correlated with gains in reading comprehension. Studies of this kind should be conducted with deaf and hard-of-hearing students with varying degrees of hearing loss and in a wide-range of grade placements. Inquiries spanning at least one full year of instruction would be especially beneficial in establishing a link between the acquisition of phonemic awareness and phonic skills and improved comprehension.

The study's findings represent one step toward establishing a foundation of intervention research aimed at improving reading instructional practice for deaf and hard-of-hearing students. This research will hopefully have a positive influence on how future deaf and hard-of-hearing children are taught to read.

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References

- Adams, M. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.
- Campbell, M. L. (1988). Corrective Reading program evaluated with secondary students in San Diego. *Direct Instruction News*, 7(4), 15–17.
- Chalifoux, L. M. (1991). The implications of congenital deafness for working memory. *American Annals of the Deaf*, 136, 292–299.
- Chall, J. S. (1996). *Stages of reading development* (2nd ed.). Fort Worth, TX: Harcourt Brace and Company.
- Chincotta, M., & Chincotta, D. (1996). Digit span, articulatory suppression, and the deaf: A study of the Hong Kong Chinese. *American Annals of the Deaf*, 141, 252–257.
- Coley, J., & Bockmiller, P. (1980). Teaching reading to the deaf: An examination of teacher preparedness and practices. *American Annals of the Deaf*, 125, 909–915.
- Conrad, R. (1964). Acoustic confusion in immediate memory. *British Journal of Psychology*, 55, 75–84.

- Engelmann, S., Carnine, L., & Johnson, G. (1999). *Corrective reading decoding level A: Word-attack basics*. Columbus, OH: Science Research Associates (SRA).
- Engelmann, S., Meyer, L., Carnine, L., Becker, W., Eisele, J., & Johnson, G. (1999). *Corrective reading decoding level B: Decoding strategies*. Columbus, OH: Science Research Associates (SRA).
- Engelmann, S., Meyer, L., Johnson, G., & Carnine, L. (1999). *Corrective reading decoding level C: Skill applications*. Columbus, OH: Science Research Associates (SRA).
- Engle, R. W., Cantor, J., & Turner, M. (1989). Modality effects: Do they fall on deaf ears? *Quarterly Journal of Experimental Psychology*, 41, 273–292.
- Gregory, R. P., Hackney, C., & Gregory, N. M. (1982). Corrective reading programme: An evaluation. *British Journal of Educational Psychology*, 52, 33–50.
- Hanson, V. L. (1982). Short-term memory recall by deaf signers of American Sign Language: Implications for order recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 8, 572–583.
- Hanson, V. L. (1989). Phonology and reading: Evidence from profoundly deaf readers. In D. Shankweiler & I. Liberman (Eds.), *Phonology and reading disability: Solving the reading puzzle* (pp. 69–89). Ann Arbor, MI: University of Michigan Press.
- Hanson, V. L. (1990). Recall of order formation by deaf signers: Phonetic coding in temporal order recall. *Memory and Cognition*, 18, 604–610.
- Hanson, V. L., & Fowler, C., (1987). Phonological coding in word reading: Evidence from deaf and hearing readers. *Memory and Cognition*, 15, 199–207.
- Hanson, V. L., Goodell, E. W., & Perfetti, C. A. (1991). Tongue-twister effects in the silent reading of hearing and deaf college students. *Journal of Memory and Language*, 30, 319–330.
- Hanson, V. L., & Lichtenstein, E. (1990). Short-term memory coding by deaf signers: The primary language coding hypothesis reconsidered. *Cognitive Psychology*, 22, 211–224.
- Hasenstab, M. S., & McKenzie, C. D. (1981). A survey of reading programs used with hearing-impaired students. *The Volta Review*, 83, 383–388.
- Holdsworth, P. (1984–1985). Corrective reading tested in U.K. *ADI News* 4(2), 1–4.
- Holt, J. (1994). Classroom attributes and achievement test scores for deaf and hard of hearing students. *American Annals of the Deaf*, 139, 430–437.
- International Communication Learning Institute. (1996). *See the sound visual phonics*. Edina, MN: International Communication Learning Institute.
- Kasendorf, S. J., & McQuaid, P. (1987). Corrective reading evaluation study. *ADI News* 7(1), 9.
- Kelly, L. P. (1993). Recall of English function words and inflections by skilled and average deaf readers. *American Annals of the Deaf*, 138, 288–296.
- King, C. M., & Quigley, S. P. (1985). *Reading and deafness*. San Diego: College-Hill Press.
- LaSasso, C. (1978). A national survey of materials and procedures used to teach reading to hearing-impaired children. *American Annals of the Deaf*, 123, 22–30.
- LaSasso, C. (1987). Survey of reading instruction for hearing-impaired students in the United States. *The Volta Review*, 89(2), 85–98.
- LaSasso, C., & Mobley, R. T. (1997). National Survey of reading instruction for deaf or hard-of-hearing students in the U.S. *The Volta Review*, 99(1), 31–59.
- Leybaert, J. (1993). Reading in the deaf: The roles of phonological codes. In M. Marschark & M. D. Clark (Eds.), *Psychological perspectives on deafness* (pp. 269–309). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Massaro, D.W. (in press). A computer-animated tutor for language learning: Research and applications. In P.E. Spencer & M. Marschark (Eds.), *Advances in the development of spoken language by deaf and hard-of-hearing children*. New York: Oxford University Press.
- Motulsky, H. J. (1999). *Analyzing data with GraphPad Prism*. Retrieved July 13, 2004, from http://www.graphpad.com/articles/interpret/Analyzing_two_groups/wilcoxon_matched_pairs.htm.
- Musselman, C. (2000). How do children who can't hear read an alphabetic script? A review of the literature on reading and deafness. *Journal of Deaf Studies and Deaf Education*, 5, 9–31.
- Myklebust, H. (1960). *The psychology of deafness*. New York: Grune & Stratton.
- National Reading Panel. (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. Retrieved July 13, 2004, from <http://www.nationalreadingpanel.org/Publications/subgroups.htm>.
- Nielsen, D. C., & Luetke-Stahlman, B. (2002). Phonological Awareness: One key to the reading proficiency of deaf children. *American Annals of the Deaf*, 147, 11–19.
- Oregon Center for Applied Sciences. (2001). *Decoding program for deaf and hard of hearing students*. (NICHD grant #40697–01).
- Paul, P. V. (1998). *Literacy and deafness: The development of reading, writing, and literate thought*. Needham Heights, MA: Allyn & Bacon.
- Paul, P. V. (2001). *Language and deafness* (3rd ed.). San Diego, CA: Singular Publishing Group.
- Perfetti, C. A., & Sandak, R. (2000). Reading optimally builds on spoken language. Implications for deaf readers. *Journal of Deaf Studies and Deaf Education*, 5, 32–50.
- Pintner, R., & Patterson, D. (1916). A measure of the language ability of deaf children. *Psychological Review*, 23, 413–436.
- Quigley, S. P., & King, C. M. (1985). *Reading Milestones*. Austin, TX: PRO-ED, Inc.
- Schaper, M., & Reitsma, P. (1993). The use of speech-based recoding in reading by prelingually deaf children. *American Annals of the Deaf*, 138, 46–54.
- Stanovich, K. E. (1988). The right and wrong places to look for the cognitive locus of reading disability. *Annals of Dyslexia*, 38, 154–157.
- Steck-Vaughn Company. (1998). *Pair-it books*. Toronto, CAN: Harcourt Canada Ltd.

- Thompson, B. (1992). A field report. Specific learning disabilities corrective reading pilot study. *Direct Instruction News*, 11(2), 11–13.
- Thorne, M. T. (1978). “Payment for reading”: The use of the “Corrective Reading scheme” with junior maladjusted boys. *Remedial Education*, 13(2), 87–90.
- Traxler, C. B. (2000). The Stanford Achievement Test, 9th edition: National norming and performance standards for deaf and hard-of-hearing students. *Journal of Deaf Studies and Deaf Education*, 5, 337–348.
- Trezek, B. (2000). *New answers to old problems: Deaf children can learn to read*. Unpublished manuscript, University of Wisconsin-Madison.
- Wright Group. (2001). *Wildcat series*. New York: McGraw Hill.

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