Phonological Impairment's Relation to Phonological Awareness, Working Memory, and Literacy

Monica Gordon Pershey
Department of Speech and Hearing, Cleveland State University
Cleveland, OH

Patricia A. Clickner
Lorain County Board of Mental Retardation and Developmental Disabilities
Elyria, OH

A phonological impairment is a disturbance in the speech sound production system that results in systematic speech errors (Bird, Bishop, & Freeman, 1995; Shriberg & Kwiatkowski, 1994). Phonological impairment may arise due to children's inadequate mental representations of speech sounds (Bird et al., 1995) and/or due to difficulty accessing internal representations of speech sounds (Catts, 1991). Phonological impairment affects from 7.5% (Shriberg & Kwiatkowski, 1994) to 10% (National Institute on Deafness and Other Communication Disorders [NIDCD], 2000) of children ages 3 to 11. Of affected children, 80% require speech therapy to facilitate remediation and 50% to 70% experience academic difficulties that may persist through grade 12 (NIDCD, 2000).

The progression from phonological impairment to difficulties with reading and spelling may be due to inadequate development of the internal phonological representations that are needed to facilitate speech sound production and to map sounds to letters in order to read and spell (Frith, Wimmer, & Landerl, 1998; Manis, Seidenberg, & Doi, 1999; Webster & Plante, 1992). Children develop both conscious and unconscious representations of phonemes (Webster & Plante, 1992). Children with phonological impairment may have trouble consciously classifying and analyzing speech sounds (Bird et al., 1995) and/or may unconsciously store imprecise phonological representations of words in memory (Lewis, Freebairn, & Taylor, 2002). Both sorts of inaccuracies may lead to errors in decoding (Shankweiler & Liberman, 1992) and/or spelling (Clark-Klein & Hodson, 1995). Notably, however, speech sound errors do not map directly onto spelling errors (Stackhouse & Wells, 2001).

Bird and colleagues (1995) and Bishop and Adams (1990) indicated that adequate internal representations of speech sounds contribute to phonological awareness, which is the metalinguistic ability to reflect upon and manipulate speech sounds independently from the meanings that sounds convey (Rasinski & Padak, 2001). Phonological awareness is critical for learning to read and spell (Torgesen, 1999). Some children with phonological impairment lack the internal phonological representations that are necessary for developing phonological awareness (Catts, 1991; Torgesen, 1999). Webster and Plante (1995) hypothesized that phonological awareness bootstraps onto the child's phonological system, with instabilities in the phonological system constraining phonological awareness. Strong and accurate internal phonological representations provoke the association of phoneme to grapheme, allowing reading and spelling to develop (Frith et al., 1998). Children with reading disabilities may not perceive distinctions between phonemes as accurately as typical readers (Torgesen, 1999). Accurate word pronunciation stimulates and supports awareness of spelling patterns. Therefore, the presence of phonological impairment may hamper acquisition of several important literacy milestones: first, the accurate manipulation of speech sounds that phonological awareness entails, and, later, grasping that speech sounds in words are represented by certain patterns of letters and developing phonologically based decoding skills.

Apart from phonological awareness, there is a second possible connection between phonological impairment and reading and writing difficulties. Some children with phonological impairment also have deficits in verbal working memory, in either encoding, retrieval, or both processes (Catts, 1991; Shriberg & Kwiatkowski, 1994; Webster, Plante, & Couvillion, 1997). Many types of tasks require verbal working memory, for example, following orally presented directions, repeating spoken words or sentences, or merely answering oral questions. More importantly, verbal working memory allows for short-term storage and manipulation of phonological information. Verbal working memory span must be sufficient for retaining internal representations of speech sounds in "on screen" memory long enough to perform phonological manipulations.

Rapid naming of labels or names for items that have been encountered in the environment demonstrates verbal working memory and is generally assessed by asking children to name colors, letters, or numbers (Wagner, Torgesen, & Rashotte, 1999). Lovett, Steinbach, and Frijters (2000), Schatschneider, Calrson, Francis, Foorman, and Fletcher (2002), and Wolf and colleagues (2002) variously contributed the view that rapid naming of letters reveals additional, separate cognitive-linguistic processes that are critical for learning to read. Children who have trouble rapidly naming letters are evidencing deficiencies related to accessing phonological rep-

resentations (i.e., names or labels for letters) and/or orthographic representations (letter forms). Each time a letter stimulus is encountered it must be matched to letter templates or prototypes stored in memory and then matched to its name. Inefficient or slow naming suggests (a) inadequate iconic storage of orthographic representations, (b) inadequate semantic memory for letter names, and/or (c) deficient connections between letter names and orthographic symbols. Some children with phonological impairment lack speed and accuracy in retrieving names for visual stimuli (Children of the Code, 2004; Wolf et al.). For children with phonological impairment, however, it is important to rule out diminished naming speed that can be attributed to reduced articulatory proficiency (Lewis, Freebairn, & Taylor, 2000).

Lovett and colleagues (2002) confirmed rapid naming deficiency as one of two core processing deficits underlying reading disability, with the other core deficit being undeveloped phonological awareness. Researchers have thus formulated a "double-deficit" hypothesis which contends that some children exhibit a concurrent, additive deficit in phonological awareness and in rapid naming of visual symbols (Wolf et al., 2002). While a deficit in either phonological awareness or rapid naming will interfere with learning to read and spell, coexistence of both deficits is cumulatively injurious to learning to read and spell (Lovett et al., 2000). A phonological awareness deficit compromises meaningful letter-to-sound decoding, while a rapid naming deficit hampers rapid identification of letters and of words as whole units, such that even familiar words may not be recognized consistently and read fluently (Lovett et al.).

We conducted the present study because it appears that there is scant published research on the coexistence of deficits in phonological awareness and rapid naming in children with phonological impairment. There is a lack of documentation of the impact of coexisting deficits in phonological awareness and rapid naming on reading and spelling abilities in children with phonological impairment.

The purpose of this research was to investigate whether phonological impairment coexisted with deficits in phonological awareness and/or verbal working memory in a sample of children. We explored the convergence of the "double deficit" in phonological awareness and rapid naming in children with phonological impairment to observe any combined impact on reading and spelling skills.

Description of the Study

Participants were 23 English speaking children previously diagnosed with phonological impairment (Group 1) and 23 unimpaired peers (Group 2). In each group there were 12 children in 1st grade, 8 in 2nd grade, and 3 in 3rd grade matched for race, gender, age (range 6.4 - 9.1), free lunch status, and IQ (average range). The children were from 10 elementary schools in one Midwest county where median household income is $60,000 (U.S. Census Bureau, 2000). All passed pure tone air conduction hearing screening at 20 db HL for 500, 1000, 2000, and 4000 Hz. Groups 1 and 2 performed significantly differently on a measure of Percentage of Consonants Correct (PCC; obtained by applying results of the Goldman-Fristoe Test of Articulation-2 [GFTA-2; Goldman & Fristoe, 2000] to a procedure adapted from Shriberg, Kwiatkowski, Best, Hengst, & Terselic-Weber, 1986); [ANOVA] $F(1, 44) = 55.16$, $p < .0001$. Children in Group 1, who all had prior diagnoses of phonological impairment, produced fewer consonants correctly. No diagnosed children were in Group 2.

Our research questions involved six comparisons of group performance. We asked whether children with phonological impairment would perform more poorly than typically developing peers on six sets of measures. We measured physiologically based functions associated with speech (i.e., supraseg-mental quality of speech and oral motor control). We presented a variety of cognitive-linguistic tasks that tax verbal working memory and administered rapid naming testing. We also tested phonological awareness, reading, and spelling in an attempt to reveal specific deficits in mentally representing speech sounds and/or accessing representations.

Six additional research questions explored measures of association among variables. We asked whether the presence of phonological impairment could be associated with lesser performance in these same areas: suprasegmental quality of speech and oral motor control, verbal working memory, rapid naming, phonological awareness, reading, and spelling.

Procedures involved administration of standardized tests and observational measures in randomized order over three individual testing sessions per child. To assess suprasegmental quality of speech, we analyzed a conversational sample for adequate quality and scored a "0" for adequate, "1" for quality that deviated 10% or less of the time, or "2" for quality that deviated greater than 10% of the time. To assess oral motor skill, we scored a "1" for adequate diadochokinetic (DDK) rate or "2" for slowed DDK rate (Zelvis, 1986). We tested verbal working memory via the Clinical Evaluation of Language Fundamentals-3 Screening Test (CELF-3; Semel, Wiig, & Secord, 1996) subtests for word forms (holding a stimulus sentence in mind and filling in a blank), following directions, and sentence repetition and the Comprehensive Test of Phonological Processes (CTOPP; Wagner, Torgesen, & Rashotte, 1999) non-word repetition test. We administered the CTOPP rapid naming subtests of visually presented colors, objects, numbers, and letters and computed a composite score. For phonological awareness, we computed a CTOPP composite score for subtests of elision of sounds from words, blending sounds to form

words, and matching initial and final sounds in words. We also administered the reading and spelling subtests from the Kaufman Test of Educational Achievement (K-TEA; Kaufman & Kaufman, 1985). We computed mean scores for each group on all measures.

The children with phonological impairment performed significantly poorer than unimpaired peers on most measures, with Group 1 mean scores often below normative means for the standardized subtests. Given an alpha level of .05, differences between groups were significant for suprasegmental quality ([ANOVA] $F(1, 44) = 7.48$, $p = .009$), oral motor control ([ANOVA] $F(1, 44) = 6.11$, $p = .0170$), two of four cognitive-linguistic tasks that tax verbal working memory (CELF-3 sentence repetition [ANOVA] $F(1, 44) = 5.55$, $p = .023$; CTOPP nonword repetition [ANOVA] $F(1, 44) = 10.39$, $p = .002$); CTOPP rapid naming [ANOVA] $F(1, 44) = 4.72$, $p = .035$), CTOPP phonological awareness [ANOVA] $F(1, 44) = 28.04$, $p \leq .0001$), K-TEA reading [ANOVA] $F(1, 44) = 31.72$, $p \leq .0001$), and K-TEA spelling [ANOVA] $F(1, 44) = 9.84$, $p = .003$).

A Multivariate Analysis of Variance (MANOVA) compared groups based on all variables combined: suprasegmental quality and oral motor control, verbal working memory, rapid naming, phonological awareness, reading, and spelling. The difference between groups was significant ([MANOVA] $F(1, 44) = 14.25$, $p \leq .0001$). Importantly, a MANOVA that compared the groups based on two variables combined, reading and spelling, showed that the difference between groups is significant ([MANOVA] $F(1, 44) = 15.58$, $p \leq .0001$) for these critical academic areas.

Figure 1 confirms that all participants with phonological impairment attained lower phonological awareness and rapid naming composite scores than typically developing peers. This frequency polygon depicts the intersection of performance on the phonological awareness composite and the rapid naming tasks for all participants.

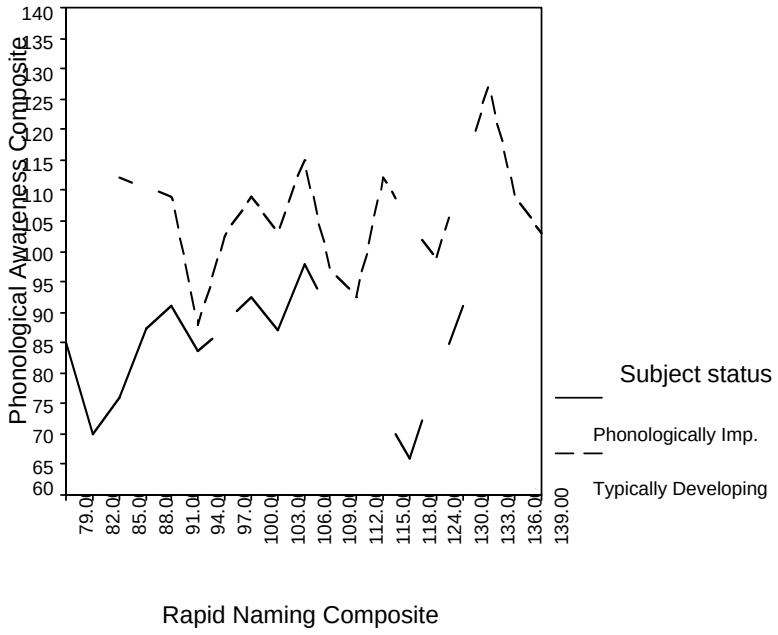
Measures of association among variables were ascertained for the children with phonological impairment. Pearson Product Moment correlations associated children's scores on PCC with all other variables. We found a significant correlation between poor production of consonants and poorer scores on oral motor control ($r = -.597$, $p = .003$), CELF-3 cognitive-linguistic tasks that tax verbal working memory (word forms, $r = .517$, $p = .012$; direction following, $r = .612$, $p = .002$; sentence repetition, $r = .464$, $p = .026$); and CTOPP rapid naming ($r = .405$, $p = .05$). Correlations showed that phonological impairment was associated with diminished performance in oral motor control, verbal working memory, and rapid naming, but not with lower scores on phonological awareness, reading, or spelling.

Because correlational data did not fully describe whether phonological impairment was associated with deficits in phonological awareness, reading, and/or spelling, Stepwise Regression Analyses were run to determine whether performance on the phonological awareness test could account for variance in reading and spelling test scores. Performance on CTOPP phonological awareness tasks accounted for 41% of the variance in K-TEA reading scores ($p \leq .001$) and 64% of the variance in K-TEA spelling scores ($p = .008$) for children in Group 1.

Sixty-nine percent of the variance in K-TEA reading scores obtained by children with phonological impairment could be accounted for by performance on CTOPP phonological awareness and CTOPP rapid naming scores as a combined independent variable ($p \leq .0001$) [coefficient analysis: phonological awareness at $p \leq .0001$; rapid naming at $p = .004$; this indicates adequate stringency for each predictor variable].

To explore the presence of a "double deficit" in this sample, a Stepwise Regression revealed that 66% of the variance in K-TEA reading and spelling scores as a combined dependent variable could be accounted for by performance on CTOPP phonological awareness and CTOPP rapid naming scores as a combined independent variable ($p \leq .0001$) [coefficient analysis: phonological awareness at $p \leq .0001$; rapid naming at $p = .009$; this indicates adequate stringency for each predictor variable]. A significant percentage of variance in

Figure 1. Intersection of Phonological Awareness and Rapid Naming Scores



the reading and spelling performance of children with phonological impairment could be accounted for by the aggregated factor of performance on phonological awareness and rapid naming tasks. A "double deficit" coexisted in this sample of children with phonological impairment.

Conclusions

Children with phonological impairment should be assessed by speech-language pathologists and reading specialists to reveal difficulties in rapid naming, phonological awareness, reading, and spelling. Intensive speech, language, and literacy interventions should be applied for children with coexisting phonological and verbal working memory deficits. Their internal representations of speech sounds must be cultivated.

In addition to the likelihood that internally representing speech sounds was at issue in this sample of children with phonological impairment, the presence of speech motor involvement cannot be ruled out as possibly contributing to their poorer performance on tests of rapid naming and phonological awareness. Additional research is needed to distinguish when deficient rapid naming ability reflects difficulties with verbal working memory and/or with speech motor control. Perhaps future research might establish subtypes of phonological impairment, as in manifestations with verbal working memory impairment, with speech motor impairment, or with both components.

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Addressing 10 Sources of Phonemic and Print Awareness During Storybook Reading

Paul R. Hoffman and Janet A. Norris
Louisiana State University
Baton Rouge, LA

Development of phonemic awareness involves becoming consciously aware of the speech sounds that make up words. This is an important ability in learning to read and write English because of the manner in which print refers to phonemes. Early researchers and interventionists considered phonemic awareness to be a unitary ability whose development enabled a child to start learning about print (Bradley & Bryant, 1983, 1985; Juel, 1988). However, as the study of phonemic awareness progressed, it was found that a variety of tasks could be used to measure phonemic awareness, including providing rhyming words (Goswami & Bryant, 1990); parsing sentences into words, words into syllables, and syllables into sounds (Sawyer, 1987); and counting the number of sounds in a word (Yopp, 1988). These various tasks appear to represent a developmental progression with some being easily performed by preschoolers, while others are challenging to children in grade school. Training in these tasks is interrelated with development of print abilities as seen in a meta-analysis of 52 studies showing that phonemic awareness training that utilizes letter symbols improved the reading and spelling abilities of a variety of populations of children more than training in phonemic awareness without reference to print (Ehri et al., 2001).

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Continuing Education Questions

1. Why might children with phonological impairment have difficulty learning to read and spell?

a. Speech sound errors map directly onto spelling errors.

b. Children with phonological impairment may have trouble consciously classifying and analyzing speech sounds.

c. Children with phonological impairment may unconsciously store imprecise phonological representations of words in memory.

d. b & c.

2. What is the "double deficit" hypothesis?

a. There may be two core processing deficits underlying reading disability, namely, phonological impairment and undeveloped phonological awareness.

b. There may be two core processing deficits underlying reading disability, namely, difficulty with rapid naming, and undeveloped phonological awareness.

c. There may be two core processing deficits underlying reading disability, namely, difficulty with rapid naming and phonological impairment.

d. There may be two core processing deficits underlying reading disability, namely, difficulty with rapid naming and spelling.

3. The present study revealed that

a. Scores for children with phonological impairment were mostly toward the lower range of the distribution of scores for rapid naming and phonological awareness.

b. The children with phonological impairment performed as well as unimpaired peers on most measures.

c. There was no correlation between phonological impairment and oral motor control.

d. No significant percentage of variance in the reading and spelling performance of children with phonological impairment could be accounted for by their performance on phonological awareness and rapid naming tasks.