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David A. Zera
Fairfield University, dzera@fairfield.edu

S. R. Moore

R. M. Seitsinger

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IMPLEMENTING A PHONOLOGICAL PROCESSING SKILL DEVELOPMENT PROGRAM FOR STUDENTS WITH LEARNING DISABILITIES IN A MIDDLE SCHOOL INCLUSIONARY SETTING

David Aloyzy Zera, Ph.D.
Fairfield University, CT

Susan Randolph Moore, Ed.D.
Educational Consultant, FL

Roy Maynard Seitsinger, Ph.D.
North Kingstown, RI

Abstract

This paper describes an intervention designed to improve phonological processing skills of special needs middle school students who were in a traditional, inclusion-based program. Prior to the study, students with special needs who were enrolled in this representative inclusion program did not receive direct, individual or small-group instruction and remediation, nor was there room in the school schedule for such instruction. The intervention developed for the study utilized techniques from proven auditory discrimination programs and incorporated them into abbreviated daily instructional slots of 20 minutes duration. The pilot did significantly improve the phonological processing skills of students with learning and/or language disabilities and an identified deficiency on phoneme awareness and manipulation. Orthographic decoding skills approached, but did not reach, statistical significance, and the intervention did not significantly improve working memory ability. Data from this pilot study indicate that all personnel involved in the study (teachers, students and parents) were pleased with the program.

All too frequently special education students arrive at middle school with severe reading problems. Neither traditional phonics programs nor whole language experiences have given them the word attack skills they need to decode the new and more difficult reading vocabulary they encounter in their content area subjects. Teachers are faced with two dilemmas. One is to find a method to move students beyond their dependence upon memorized and/or context-determined words. The second, if the school operates on an inclusion-based system, is to find time in the schedule to provide the necessary skill development.

Decoding Processes

The skill of decoding, which is the ability to abstract speech sounds at a level that coincides with their alphabetic representation, either impedes or facilitates other higher-level processes necessary for reading (Shaywitz, 1998). Thus it is not surprising that one of the most powerful predictors of reading success is phonemic awareness – the ability to identify, segment and manipulate the constituent sounds or phonemes of words. (Ben-Dror, Bentin,& Frost, 1995; Felton, Wood, & Brown, 1988; Liberman & Shankweiler, 1987; Torgesen, 1996). Accurate reading decoding is predicated upon this skill. A study completed by Schneider, Ennemoser, Roth & Kuspert (1999) indicated "phonological awareness has casual effects, in the sense that it is a prerequisite of the acquisition of literacy" (p.429).

Also necessary for successful decoding is the ability to maintain information (e.g. letter sounds) on-line for processing while scanning the rest of the word. This does not mean that reading is a linear process in which the reader simply needs to understand sounds that individual letters make and then connect them into a word. Rather, the reading of words is a nonsequential process in which the surrounding letters affect each other. For example, the sound of the letter a differs in the words call and bat, and is affected by the letters that come after it (l and t) as well as before (c and b). The articulatory gesture (location of the tongue to create the vowel) is different in each of the previous words.

Furthermore, while a reader is processing the sounds of letters s/he must be able to hold in memory any sounds already discriminated. As words increase in complexity, the difficulty of remembering sounds increases, taxing the phonological portion of working memory tasks. For example, a student who struggles with each of a word's component sounds may perceive the data as unrelated and find it difficult to track and monitor. Unless decoding skills are automatic, the reader will struggle with tracking the individual sound components into a cohesive word.

Baddely (1986) discusses working memory as having a phonological loop that serves "as a system that provides a means for the brief, verbatim storage of verbal material" (Torgesen, 1996, p. 162). It is likely, then, that the coexistence of phonological processing problems with working memory deficits affects one's ability to read (Crain, Shankweiler, Macaruso, & Bar Shalom, 1990; Shankweiler & Crain, 1986) A recursive relationship exists in which the working memory system may be taxed by poor phonological processing and, poor working memory skills may impact phoneme tracking and manipulation (Webster, Plante & Couvillion, 1997). Alexander (1996, personal communication to Torgesen, April 21, 1993) noted his perceptions of the Lindamood program and suggested that "intensive training in phonological awareness can have marked effects on the verbal short term memory performance of children with reading disabilities (Lyon & Krasnegor, 1996, p. 176).

It is then probable that working memory problems and reading difficulties aggravate each other, and that each has its original cause in the phonological processing problems. Therefore, we theorized that improving phoneme awareness and manipulation might also improve verbal working memory. We also theorized that once a student had mastered a program that teaches the phoneme-grapheme (sound-letter) association, decoding skills would also improve.

Numerous studies (Alexander, Anderson, Heilman, & Torgesen, 1991; Howard, 1986; Lindamood, 1985; Truch, 1994) have supported the use of auditory discrimination in-depth procedures (e.g., Auditory Discrimination in Depth (ADD); C.H. Lindamood & P.C. Lindamood, 1975 renamed as Lindamood Phoneme Sequencing Program (LiPS), 1998) as being highly valuable in developing and improving students' foundation for reading. In such programs students learn not only to discriminate sounds by their "feel" or articulatory gestures but also to manipulate them and to make the connection between graphemes and phonemes so necessary for reading. The drawback to these programs for schools using a traditional inclusion-based model is that recommended instruction of 20 hours per week for a minimum of 4 to 6 weeks. School districts utilizing inclusion-based models do not traditionally provide time slots for middle school students with special needs to receive individual or small group instruction in phonological processing skills or, for that matter, other reading-related areas. Thus students who might benefit from instruction in these skills but are enrolled in traditional inclusion-based programs are being deprived of learning skills essential to reading success.

At the request of middle school special educator in an urban school district who were frustrated not only by the intransigent reading problems of their students but also by the restrictive class schedule which limited opportunities to test procedures to remediate these problems, we devised a pilot study which would incorporate many of the concepts from auditory discrimination programs, especially the LiPS program, but would do so within an abbreviated instructional period which could be integrated into the regular school schedule.

A dearth of data exists regarding adolescents with learning disabilities and effective interventions for them that focus on the development of phonological processing skills and their relationship to working memory and decoding. Adolescents and "not blank slates" (Benita, Blachman, personal communication, 1998) and because of this, teachers may be teaching crawling, when they (the students) know how to "run" (Benita, Blachman, personal communication, 1998). Therefore, a pilot study such as the one described here is particularly important because it offers insight into appropriate intervention strategies for early adolescents with phonological processing.

METHOD

Three primary areas of investigation were considered important to explore for this study: (a) the ability to process phonemes, (b) the ability to maintain information online for processing, and (c) the ability to decode pseudowords. Proven assessment instruments appropriate for evaluating the constructs under investigation were utilized in the study. For phonological awareness and manipulation, the Rosner Auditory Elision test and the Lindamood Auditory Conceptualization (LAC) test were used. For working memory, the California Verbal Learning Test, first component internal consistency reliability .85, total test), and the Woodcock-Johnson Psychoeducational Battery - Revised (WJPEB) memory for words test (.870-factor load on short term memory) were used. To test for phonological processing/orthographic decoding, the WJPEB word attack test with a split-half reliability range of .89- .94 was used. Focus groups, individual interviews, and artifact review provided qualitative information regarding the effectiveness of the program and perceptions of both teachers and students.

The researchers posed the following primary research questions:

What would the effect of a phonologically based, 20 minute per-day intervention on levels of phonemic awareness among middle school students with learning and/or language disabilities and an identified deficiency in phonological processing involved in a full-inclusion model?

What would be the effect of this intervention on the working memory capacity of these students?

What would be the effect of this intervention on the decoding skills of students in the intervention?

Although our primary research questions were program-related issues, they were not the only questions we had. We wanted to know how the students and the participating special education teachers as well as the parents of students in the program perceived the intervention. Thus through focus groups and parent communication, we tried to access what, if any, would be the affective impact of the intervention.

Participants and Setting

Subjects were recruited from an urban, middle school (grades 6,7,8) in southwestern Connecticut. The researchers were familiar with the school's inclusion-based model that provided special education services to students with learning disabilities primarily in the mainstream setting. The model also provided for occasional support services in a special education resource room so that students could complete homework assignments, class projects, etc. Remediation and interventions were not provided nor were any compensatory strategies taught during this class time. The students involved in this pilot study did not receive any other reading instruction during the course of the school day.

The investigators scheduled informational meetings with the school's principal and special educators and with appropriate central office personnel to share both the theoretical framework and the rationale for the proposed research study. At this time we agreed to solicit support from the Superintendent of Schools and the Institutional Review Board at Fairfield University where the primary investigation was employed. Permission to continue was granted and follow-up meetings were held to determine the best time for student assessment and for delivery of the intervention.

In future meetings we worked out the logistics of the intervention. After careful scrutiny of the school schedule, we decided each eligible student would receive the intervention daily for 20 minutes. We selected several times during the day when students could be scheduled for these 20-minute time blocks. The principal also agreed to relieve the special education teachers of certain duties in order to evaluate students and implement the program.

The Planning and Placement Team identified all students fitting the classification criteria for learning and/or language disabilities. Significant discrepancies existed between cognitive ability level and academic achievement. All students were receiving special education consultation services in mainstream classes. The special educators helped to modify assignments and provided information regarding the students' disability(ies) to the general educators. Twenty-six students were considered eligible for the first phase of the study: assessment. Notification letters were sent by the principal to the parents/guardians of these children informing them that their child would be assessed for possible phonological processing, working memory and decoding deficiencies. Although the school system mandated that all students eligible for the intervention receive it, parents/guardians had the opportunity to decline testing. None did so.

The investigators trained the three experienced special education teachers in the administration of the assessment instruments. Practice testing sessions were held, and the primary investigator observed the three teachers administering the tests to each other to confirm conformance to testing protocols. The primary researcher also served as a subject of testing to insure appropriate administration prior to subject testing. Testing took place during the school day in a one-to-one setting and the special education teachers anonymously coded the data so that particular students could not be identified. The primary investigator scored tests. The special education teachers performed the post-testing using the same instruction.

Students were considered eligible for phase 2 of the study (intervention) if their results were below 4th grade criterion on the Lindamood Auditory Conceptualization (LAC) test (n=20). Subject characteristics appear in Table 1 and IQ results obtained from a review of students' files appear in Table 2.

Table 1

<u>Summary of Subject Characteristics</u>

Grade	Gender	Race	Handedness	Exceptionality
6^{th} - 5	M - 13	W - 7	R - 17	Learn. Dis. - 16
7^{th} - 6	F - 7	B - 9	L - 3	Lang. Dis. - 1
8^{th} - 9			H - 3	Lang./Learn. - 1
			A - 1	Learn/Lang. - 1
			N.I. -	1

<u>Note.</u> M = male, F = Female, W = White, B = Black, H = Hispanic, A = Asian, R = right, L = left, Learn. Dis. = learning disabled, Lang. Dis. = language disabled, N.I. = neurologically impaired.

Table 2

<u>Summary of Subjects' Mean IQ's and Range Distribution</u>

FSIQ Range	FSIQ Mean	VIQ Range	VIQ Mean	PIQ Range	PIQ Mean
71-114	95.72	73-123	94.67	73-136	98.00

<u>Note.</u> FSIQ = full scale intelligence quotient, VIQ = verbal intelligence quotient, PIQ = performance intelligence quotient.

Students functioning at similar levels (e.g., first grade criterion, third grade criterion) were grouped together and assigned to work with one of three special education teachers. This was done so that students functioning at similar levels would be guided through the program in a step-by-step sequence. Teachers were given the groups that they and the researchers felt would be most appropriate for each of them. Although random group assignments would certainly have yielded more robust statistical data, it was felt that the present design would be of more practical significance because it was more closely aligned with typical school procedures of homogeneous grouping and assigning students to specific teams of personnel.

Once all the students were placed, we saw that we needed only two time blocks. The first twenty-minute grouping met at the beginning of the school day (8:10-8:30) during their homeroom period. This time slot seemed desirable because it did not interfere with any scheduled class time. We were unable to find another time block in which students were not scheduled for class. Thus our second grouping occurred during class time (8:35-8:55), resulting in students missing approximately twenty minutes of a different scheduled class every six days (i.e., math one day, affiliated arts another day). Fortunately, the school's six-day rotating schedule reduced the amount of time lost in any one particular subject. The intervention lasted for 5 months (approximately 80 school days) resulting in approximately 53 hours of direct, small group instruction.

Teacher Training

The investigators trained the three special educators to perform the articulatory gestures associated with phoneme production (e.g. vocal-motor movements associated with sound production) and to use the associated labels (e.g., /t.=tip-tapper, /k/k=scraper, /r/=lifter) and strategies from the LiPS. Teachers were trained to use games that had been developed for skill reinforcement and interest building. Training of the special educators continued throughout the intervention on a regular and as needed basis.

Additionally, each of the three special educators had participated in various workshops the summer prior to implementing the research study; one in the LiPS, another in the Lindamood Visualization and Verbalization (V and V) program. And the other in the Telian Reading Program (similar to LiPS). Therefore, each had prior experience with theoretical framework regarding vocal-motor movements and its relationship to reading. Students were informed that they would be participating in a research project and had the opportunity to decline. None did so.

Intervention Procedure

Students were provided with multi-sensory instruction (visual/auditory/tactile) in various phonological processing tasks. Incorporated into the intervention were techniques for learning to "feel" sounds developed for the LiPS program be Lindamood-Bell (1998) (e.g. feeling the vibrations of the throat). Built into the intervention were original activities such as games to reinforce concepts and heighten student interest, an important consideration for any middle school program. Student engagement was also maintained by adding various role-playing techniques such as having students assume the role of instructor, and by capitalizing on teachable moments. One such moment occurred when a student arrived at the intervention session chewing a piece of gum. Rather then direct her to throw it out, the teacher instructed the student to place the gum on the roof of her mouth. She then showed the student how to use the gum as a way to better recognize the movement associated with the tongue touching the roof of her mouth (as when producing the sound of the letter t).

The intervention sequence included: a.) sound identification and differentiation, b.) phoneme sound comparisons and contrasts, c.) word and syllable rhyming, d.) sound and syllable isolation, e.) sound and syllable segmentation, f.) sound and syllable blending, g.) sound and syllable tracking, h.) sound and syllable manipulation, and i.) the introduction of multisyllable words. The intervention adhered to this sequential presentation of information but reinforced advanced concepts with prior information when needed.

Students performed a variety of activities including: a.) identifying and differentiating between classroom sounds such as paper shuffling and shoes scraping (done to gradually introduce sound discrimination), b.) comparing and contrasting sounds from gross to fine discrimination (e.g., /b/ and /s/ and the more similar /b/ and /d/); c.) identifying rhymes for one and two syllable words, d.) tapping out syllables and sounds within words, e.) separating orally presented words into their constituent sounds and syllables, f.) blending together the constituent sounds and syllable of orally presented words, g.) tracking sounds using manipulative cubes, h.) chaining pseudowords, h.) transforming the order of sounds using manipulative cubes to identify individual sounds, and; i.) manipulating cubes to identify complex syllables and multisyllabic words.

Teachers began by training the students to hear individual phonemes, attach a label to them and then manipulate the order of the sounds. To do so, we used the LiPS sequencing of teaching the consonant sounds from gross to fine articulatory movements (e.g. lip poppers /p/, tip tappers /t/ and ultimate wind sounds /wq/ and lifters, l/r). To clarify, the initial sounds presented (p,b) are known as explosives which, when articulated, have an explosive burst of air that pushes open the lips. These are gross articulatory movements. In contrast are vowels, which are considered fine articulatory movements because they have less easily distinguishable tongue and mouth movement. To present vowels, we used the "vowel circle" developed for the LiPS program. Ultimately the teachers introduced written word parts and complete words. (See LiPS program for further information.)

Reading and spelling were approached concurrently. Students used colored blocks as part of their word reading and sound segmenting activities. This use of manipulative cubes helped them to track and monitor the sounds. Id addition to the skills being developed, an important part of the intervention procedure was error correction. When students erred, the primary remediation used was corrective feedback in which the teacher would guide the students to "feel" the sounds. For example, if a student erred by reading the word blend as bend, s/he was encouraged to align colored manipulative blocks to identify the sounds within the word. This would be followed by questioning whereby students would identify the sound felt, and the appropriate sound label (i.e., lifter for the sound of l). With comparisons being made by the teacher (for example, repeating the words and identifying the number and color of manipulatives) the student was guided to correct the error.

Advancement to the next level of difficulty within the program was determined by student success and informal evaluation by the teachers of each group.

Date Analysis

Post-testing using the same instruments was performed upon completion of the study. To determine if significant differences occurred between pre- and post- test data, paired samples t-tests were run. An a priori significance level of .05 was initially set. However, to account for experiment-wise error caused by multiple tests with the same data and subject, Bonferroni adjustment was made to control the overall alpha level. Therefore, an a priori significance level of .01 was utilized in the study (i.e., .05/5 [the number of t-tests performed] yielded .01) to adjust for Type I error.

Even though the t-test is sufficiently powerful enough to "provide accurate estimates of statistical significance even under conditions of substantial violation of the assumptions" (Borg & Gall, 1989, p. 548) (e.g., homogeneity of variance), analysis of variances (ANOVAS) were performed to see if the issue of homogeneity of variance was of major concern. Separate one-way ANOVAS were performed with the pre-test date from assessment instruments as the dependent variable and VIQ, PIQ, FSIQ, gender, race, grade, and teacher as the independent variables. Results were not significant for any of the ANOVAS at the .05 level.

Qualitative information was obtained via individual teacher interviews and two focus group sessions facilitated by the researchers in this study.

Quantitative Results

The results of the t-test indicated significant pre-post test mean differences in deviation scores on the Rosner (t=-5.524, p.=.0001) (see Table 3) and in raw scores on the LAC (t=-10.739, p.=.0001) (see Table 3). Deviation scores() is at the mean, plus or minus 1 sd) are utilized for scoring purposes on the Rosner. They are calculated by subtracting the student's raw score from the grade 6 mean (929.9) and dividing the result by the standard deviation (6.9). Grade level criterion is used for the LAC as an estimate of achievement. Raw scores were used as a more accurate measurement.

Further analyses were performed to investigate if research results and data interpretation could be further solidified since a control/comparison group was not available for this research study and regression towards the mean is a reasonable expectation. The expected mean growth of a standard yearly raw score increase using the norm tables provided by each of the instruments was calculated as a measure to compare pre-post test growth.

The expected mean yearly raw score growth for the Rosner (grades k through 6) was 4.4. This was calculated by adding the differences between the mean scores in succeeding grade levels (e.g. grade k to grade 1 the difference is 14.1 from grade 1 to 2 the difference is 2.3, etc.) and dividing by 6 (the number of inter-grade differences).

Table 3

Comparisons of Standard Deviation Scores of Pre- and Post-test Results of the Rosner Auditory Elision Test

Test	Sample Size	Standard Deviation	Mean Score	t
Pre	20	1.2187	-1.3305	-5.524**
Post	20	1.2533	-.1055	

Note. Data based on grade 6 norms.

**Significant beyond the 0.01 level.

Table 4

Comparisons of Raw Scores of Pre- and Post-test Results of the Lindamood Auditory Conceptualization Test

Test	Sample Size	Standard Deviation	Mean Score	t
Pre-	20	8.83	62.55	-10.739**
Post	20	9.23	91.25	

Note. Grade 4 minimum raw score = 81; Grade 5 minimum raw score = 86; Grade 6 minimum raw score =93 ; Grade 7/Adult minimum raw score = 99.

**Significant beyond the 0.01 level.

Although 15 students were above the norming population for this test (6 students in grade 7 and 9 students in grade 8), the Rosner still yields important information, particularly for students in grade 7 or 8 who are functioning below the grade 6 performance level. Additionally, the most significant expected raw score gain is made from kindergarten to grade 1 (14.1) and the smallest raw score gain is expected from grade three to four (.6). When kindergarten to grade one difference is removed from the calculation the total mean, expected, raw score increase is 2.4.

The expected mean yearly raw score growth for the LAC (all grades: k-7) was 9.7. This was calculated in the same way as the Rosner. The expected mean, yearly raw score growth for the LAC 0 grades 4 through 7/adult) was 6.0.

Two LACC expected mean yearly raw score growths (all grades and grade 4-7/adult) were calculated due to the observation that greater growth is expected in the very early grades (k-4) than in the upper grade spectrum (5-7), similar to the Rosner. For example, there is a 10 raw score point increase from the beginning of grade k to the beginning of grade one; 20 points from 1st to 2nd; 10 points from 2nd to 3rd; and 10 points from 3rd to 4th. After grade four the raw score growth rates are; 7 points from 5th to 6th; and 6 points from 6th to 7th/adult (considered to be mastery). Since the students involved in this pilot study were in the middle school (grades 6,7, 8), the latter half of the scoring system may be more appropriate and data results are considered in light of this information (see discussion). Although mastery (raw score 99) in considered to be at the grade 7/ adult level (as indicated on the LAC test), students at the end of sixth grade are also expected to achieve mastery as well (raw score 99).

It is assumed that a significant departure from the expected score would be most likely due to the intervention and/or teacher-student interaction as opposed to maturation of the sample or regression towards the mean. Significant, positive differences were observed between the expected and the observed, (pre-post measures) scores on both instruments (Rosner and LAC).

The Rosner result (8.75 vs. 4.4) was almost twice of what was expected when using all grade levels. It is almost four times expected when using grades 5-7 levels, most likely a more accurate estimate of functioning because of students' actual grade placement.

The LAC results (30 vs. 9.7) were slightly more than three times what was expected when using the all grade level expected mean raw score growth. It was five times what was expected (30 vs. 6) when using the grades 4 through 7 expected mean raw score growth, most likely a more accurate estimate of functioning because of students' actual grade placement.

Also, 6 of the 20 students who received the intervention achieved mastery level criterion on the LAC (grade 7- adult) and 2 others were within one-half year of expected achievement level (e.g., functioning in the first half of the 6th grade when they were in the second half of the 6th grade).

The results of the t-test were not significant for verbal working memory as measured by the WJ Memory for Words Test (t=.448, p. =.660). It should be noted, however, that the mean pre-test score of the sample was within the average band of functioning (ss 90.28). A significant mean increase in performance was not observed on the CVLT-C (t=1.350) either.

The results of the t-test for phonological processing/orthographic decoding as measured by the WJWA approached but did not reach statistical significance (t=-2.388, p.=.027).

Student Behavioral Response and Parent Accolade

The special education teachers who implemented the program reported positive student interactions during all phases of the intervention. Although some students seemed to be initially insecure, as manifested by a reluctance to verbalize during instruction, their near-perfect attendance records belie this. Although students were required to attend intervention sessions. It is not uncommon for students to skip add-on activities and remain in their homeroom or with their regularly scheduled class. This was not a problem.

One student commented to another group of students: "It may be boring, but give it more time. It works. When asked, students generally felt that the program was helpful and some of them were observed by the special education teachers using articulatory gestures to help them decode words when they were in mainstream classes. However, all teachers reported the need for continued reinforcement of the concept of "feeling" the sounds as opposed to trying to hear or remember them visually. This was particularly true in the movement from learning consonant sounds to vowel sounds. Teachers found it necessary to encourage students to apply their new-found knowledge in novel situations. Unless reminded, it seemed as though students reverted to using their previous, unproductive ways of decoding.

One parent sent an unsolicited letter (see Appendix A) in which she described how pleased she was with the intervention. In a matter of fact, she stated that her son "has come from a long line of services that improved his learning ability. This program has shown the quickest, rewarding and, most importantly, life long results."

Teacher Response

Prior to the intervention, the participating special educators had found themselves in a demoralizing position. The full inclusion classroom forced them into a role more characteristic of a paraprofessional than a learning disabilities specialist. In the role, even though they could observe that their students were in need of direct instruction in reading, they were unable to determine what form the instruction should take and would not have been able to offer it even if they knew. By participating in the intervention, they had data regarding an underlying cause of their students' reading problems and could direct instruction toward incremental, measurable objectives based on this data. Not only could they deliver the needed instruction, but also they could then observe whether or not students implemented their new skills in a classroom setting and urge them to do so if they were not. Teachers felt confident that they were making a difference in students reading potential.

Negative reactions to the study came from general education teachers, but these reactions were related to scheduling, not the nature of instruction. Although a schedule was devised in collaboration with the principal so that interference with mainstream classes would be kept to a minimum, some teachers felt it occasionally intruded on their class time. In order to garner teacher support, efforts were made through faculty meetings to keep general education teachers informed of the purpose, nature and progress of the intervention.

Discussion

This study was undertaken to explore whether phonological processing skills of learning or language-disabled students enrolled in a full-inclusion classroom could be improved. Being that time is of the essence in such programs and individual and small group special education remediation and/or interventions are kept to a minimum (or even non-existent) in full-inclusion models, this research endeavor was consider to be extremely important. The results obtained are informative and lend credence to the position that public school systems should consider adopting a 20-minute per-day intervention program for students with phonological processing deficits. Almost one-third of the students achieved complete mastery (n=6) and two others were within one-half year of their expected criterion level on the LAC.

Direct instruction in phonology did not seem to improve working memory capacity in the subjects enrolled in our study. However, the pre- and post-test results for the Woodcock-Johnson Memory for Words test, used as a measure of verbal working memory were both within the average band. Lezak (1995) clearly states that WM "may be equated with simple immediate span of attention" (p. 29). This test required the students to maintain a list of unrelated words in mind and to repeat them back to the examiner in the same order. It was selected over the memory for sentences subtest so as not to confound the data due to syntax and semantics that may either distract or aide the student. The single words contain similar sounds and thus may be impacted by phonological processing skills. A more thorough analysis can be made in which individual student errors are explored and may reveal a discernable pattern of functioning.

Although it was theorized, and substantiated by previous research as discussed, that working memory capacity might improve with increased phonological processing skills our results did not substantiate this. A number of possibilities exist to explain this finding (or lack thereof). One is that verbal working memory is not phonologically based, a finding that seems to contradict previous findings and begs further research. A second is that the students did not use their newfound knowledge of phonology during these tests. This raises the question of "why?" Do students need to participate over a greater length of time in order for these new skills to become fully operative? A third possibility is that the measures used did not accurately assess working memory. Lastly, there is the possibility that comorbidities not controlled for may have impacted skill development and/or assessment results.

As we have said, given previous research (Crain et al., 1990; Shankweiler & Crain, 1986) our results regarding the relationship of phonological processing to working memory seem inconsistent with those findings. However, it is possible that in actuality, verbal working memory is based in phonology but that our students did not employ this strategy when working within this assessment dimension. As teachers noted, it may be that students need to be reminded to use their newfound knowledge. It is conceivable that during auditory tasks, our students were not yet able to interpret the different phonemes accurately, a skill that may need further direct instruction. As Adams (1996) states, "the sounds of individual phonemes have no constant or isolable correspondent in the speech stream" (p. 19) and therefore, a purely phonological approach may not be the best method to increase verbal working memory skills. The next phase of the study follows the natural progression of learning to read skill development, and focuses on orthographic decoding skills using the Let's Read program.

Furthermore, various comorbidities such as attention deficit disorder may have impacted the students' ability to perform successfully in this area. For example, some students may have been distracted by other stimuli, disinhibited in their responses or, the lack of results may even be due to a combination of factors. Other assessment instruments such as the Test of Variable Performance (TOVA) or the complete version of the CVLT-C may be necessary to help rule out attention dysfunction or even to provide a more accurate assessment of working memory skills. Additionally, our sample size may not have been large enough to accurately portray results in this dimension, and given this, all of our results need to be viewed as preliminary.

Another finding indicated that although some improvement was noted in decoding skills, phonological interventions did not seem adequate enough to significantly improve pseudoword decoding. This suggests that direct instruction in attaching the phoneme-level sound onto the grapheme to better and more quickly recognize orthographic constructions may be necessary automaticity. However, two important research results were obtained that provide some insight regarding this area of study. First, the pre-post test results of the WJWA approached significance (.027) and were in fact significant at the univariate level. Secondly, the pre- test WJWA mean was more than one standard deviation below the mean (ss 77.10), but the post-test was within the average band (ss 86.20). Although not statistically significant at the .01 level, this data is of practical significant. It suggests that continued instruction in phonological processing and its relationship to graphemes (complex and multisyllable words in particular) may improve pseudoword decoding. Although the students in this study were exposed to this advanced work it was only provided during the last couple of weeks of the program.

Future Studies

Clearly studies of longer duration need to be conducted. Our intervention covered 5 months. Students in our study received direct instruction in pseudo and real work decoding for only a few weeks. Logic suggests this is insufficient. It is highly probable that enduring, behavior-changing results will occur only after a greater length of exposure.

Secondly, the relationship between phonological processing and short-term memory needs to be further investigated. Again duration of the intervention might be a relevant factor, and we need to explore this possibility further. We also need to examine further the role of the other comorbidities such as attentional deficits, socio-emotional concerns, etc. on the effect of the intervention. Does instruction have to be redesigned for some students to compensate for the impact of these comorbidities?

We are convinced this pilot study suggests possibilities for improving both the phonological processing skills and the word attack skills of students enrolled in a full-inclusionary model of scheduling.

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