The Promise Of Thirty Years Of Research

Introduction

The Promise of Thirty Years of Research

Forty years ago, eminent cognitive science experts and psychologists in the field of education recognized that they were:

> ...still a long way from understanding how children learn to read and what has gone wrong when they fail. (Shankweiler and Liberman 1972 293).

Rigorous research in the science of language communication and in learning to read begun in 1965 under the auspices of the National Institute of Health and Human Development (NICHD), resolved many of the mysteries surrounding reading development. A second task, to improve the quality of reading research by conducting long-term, prospective, longitudinal, and multidisciplinary research, added in 1985 with the Health Research Extension Act, had equally impressive results.

The National Institute of Child Health and Human Development is the part of the National Institutes of Health and the United States Department of Health and Human Services. It has among its responsibilities, basic, translational, and clinical research in child health.

Of the "hard" sciences, Max Planck, father of quantum theory and Nobel laureate in physics said in 1918:

> A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it.

But the results of the unparalleled research between 1965 and 2000 that explicated how language systems of the brain complete phonological tasks so that reading is possible and how specific instructional methods support reading reached few members of the new generation of teachers.

To quote G. Reid Lyon, Ph.D., former chief of the Child Development and Behavior Branch within the National Institute of Child Health and Human Development:

Documented and replicated research—discussed below—had demonstrated that the number of children not reaching grade-level expectations could be reduced to fewer than six percent when programs were used that incorporated what had been learned in thirty years of research and training studies.

> ...the world of education policy is like a slinky–it can expand to take new steps, but it ultimately recoils back to its original configuration (Lyon 2008).

Recently, Valerie Strauss of the *Washington Post* observed:

> It's 2014, the year all U.S. public schools were supposed to reach 100% student proficiency, so said No Child Left Behind. No, you didn't miss the fanfare. One hundred percent proficiency didn't happen. Not even close. In fact, our classrooms are making even less progress toward improving overall educational performance and narrowing racial test score gaps than before NCLB became law.

NCLB - The No Child Left Behind Act of 2001 focused on closing student achievement gaps by providing all children with a high-quality education. Its goal was to ensure that children became proficient in reading (and in math as well) over a ten-year period starting in the 2003 – 2004 school year.

In the late 1990s, those of us who had studied the written-language research begun in 1965 under the auspices of NICHD were excited; we expected that programs incorporating what had been learned in the years of research would revolutionize education. More than 10,000 children had been studied in 10 large-scale longitudinal studies and more than 1,500 smaller scale experimental and cross-sectional studies. Some studies began in kindergarten before children started to learn. Some children were followed for 15 years. Most studies included research of

cognitive, linguistic, neurobiological, and genetic aspects of children's learning as well. In the last years of the initiative, research sites were added so that the effects of instructional models could be evaluated.

We imagined that almost all children would learn to read and much more. Quoting Ingvar Lundberg:

> The transition from a non-reading to a reading stage in the life of a child constitutes a remarkable mental revolution with profound consequences. Not only has a door been opened to a world beyond the immediate present....The language, earlier used as an implicit instrument has now become the object for conscious reflection, and this new metalinguistic awareness has also opened up the more general metacognitive capacity to reflect on his/her own thoughts. Thus, becoming literate is far more than the trivial acquisition of a skill" (Lundberg 2).

Ingvar Lundberg 1934 - 2012 Swedish psychologist and world-renowned member of the International Academy of Research in Learning Disability and the Society for Scientific Studies in Reading.

We also quote Uta Frith:

...one might liken the possession of an alphabetic code to a virus. This virus infects all speech processing, as now whole word sounds are automatically broken into sound constituents. Language is never the same again. This is not a cause for regret, since the benefit of this sort of 'brainwashing' is an improvement in memory; by keeping track of phoneme constituents, novel word sounds are remembered more accurately (Frith 1998).

Uta Frith 1941 – German-born psychologist renowned for a neuro-cognitive approach to developmental disorders of dyslexia and autism. She has worked to make research relevant to the education of people with developmental disorders.

Failure to Implement

Sadly, we knew well before 2014 that the promise of the NICHD studies did not materialize in No Child Left Behind. In part, we knew because of the political machinations during its adoption. The legislation failed to meet its fundamental purpose of bringing scientific research to bear on guiding federally-funded education. The intention, that programs qualifying for funding had to demonstrate use of the methods and techniques judged to have been effective and presented in the National Reading Panel (NRP) and National Council on Reading (NCR) reports, was changed by members of Congress and their staff who held the well-intentioned belief that the altered legislation would be more easily implemented than the more restrictive language. It is believed by some that publishers and vendors lobbied to change the original language. Regardless, qualification for funding ultimately required only that such programs were based on the five components deemed essential in reading programs according to the NRP and NCR reports (phonemic awareness, phonics, vocabulary, fluency, and comprehension) rather than the actual methods that resulted in the success of applying those five components.

NRP – The 14-member panel of teachers, administrators, and scientists was authorized in 1997 by Congress to evaluate existing research and evidence to find the best ways of teaching children to read. The panel concluded its work in April 2000.

NRC – The committee established by the National Academy of Sciences at the request of the Department of Education and the U.S. Department of Health and Human Services to conduct a study of the effectiveness of interventions for young children who are at risk of having problems learning to read.

As teachers and as a school board member we saw the dollar cost of NCLB in the necessity to purchase the publishers' reconstitution of previous materials then claimed to be new and "research-based." There was also a cost to students because teachers had to spend time being indoctrinated.

Ten years later in an op-ed in the Washington Post (2011), Bill Gates posited that we "...[needed] to flip the curve....to raise performance without spending a lot more." Mr. Gates was correct that it is necessary to change the way the nation spends money on education. Nevertheless, the nation has embarked on yet another reform that has school districts spending huge amounts of money and teachers spending their time being indoctrinated instead of doing what great teachers do—teach.

"To flip the curve", teachers' efforts to provide the very best education they know how must be supported. Given that the ten years' worth of supposedly "research-based" pedagogy after 2000 did not change the dynamics of teaching and learning, how could anyone expect a great teacher to engage in more of somebody's "good ideas"? Changes can only be made if, instead of indoctrination and re-training, we reaffirm what was learned in the NICHD research from 1965 to 2000 and add to it—as Patricia Kuhl has done. More teachers would be able to do great work instead of leaving a profession with which they have become disillusioned.

Patricia Kuhl, 1947 - Co-director of the Institute for Learning & Brain Sciences at the University of Washington. She has shown how infants' perception of speech sounds predict the development of their language ability, how early exposure alters brain mechanisms, and how young children learn.

In his op-ed piece in the Washington Post, Mr. Gates opined that education could be dramatically improved by simply incentivizing teachers to perform. Great teachers are incentivized, in fact, by being able to develop their craft as teachers, as is done in other professions, rather than being purveyors of programs, many of which are without substance, or by teaching to uniform tests mandated from above. Making it possible for teachers to develop their skills should be the nation's commitment to teachers. In flipping the curve we can also replace fervor and polarization with curricula.

Although NCLB did not fulfill its promise, the excellent quality of the research completed under the auspices of NICHD was unmistakable, and it is still valid in spite of its not becoming the force in education that it was supposed to be.

The Paradox

In addition to politics, there is a paradox that gets in the way of clear thinking and sustained action: what is seemingly simple is, in fact, amazingly complex. According to Keith Rayner, Barbara R. Foorman, Charles A. Perfetti, David Pesetsky, and Mark S. Seidenberg, the essence of the paradox is that the ability to read makes it "...almost impossible to look at a word and not read it." Therefore, it seems to almost everyone who is able to read—even if he or she does not read particularly accurately—that reading is a skill that could not be hard to learn. She or he is apt **not** to understand the nature of learning to read and write. The five scientists unpacked the components of learning to read guided by their understanding of the paradox.

This paradox has been part of the reason that it has been so hard for phonologically-talented people who, if they could wrap their minds around the paradox, could help refashion education and help reshape the rampant fervor caused by belief systems that are not in accordance with valid findings and replication of research. Many who learned to read relatively easily and achieved high levels of success believe that reading is learned with a modicum of instruction, but this happens for relatively few individuals. No matter one's beliefs, there is a science of written and spoken language that needs to be understood in order to teach effectively.

In addition to impedance from politics, paradoxes, and belief systems, there are missing concepts that, if incorporated, would facilitate the teaching of written language skills, namely:

- attention to difficulties with vowel confusion confronted by almost all students who struggle to learn written-language skills;
- incorporation into educational research and practice of relevant scientific research such as that of Patricia Kuhl's in early language development; and
- attention to fluency training underlying the skill of reading connected text.

These issues will be discussed after a brief introduction to the phonological skills that were addressed exceptionally well between 1965 and 2000.

The 1971 conference, "The Relationship between Speech and Learning to Read", focused on the contrast between the ease with which almost all children learn to speak and the effort required in learning to read. At that time, it had been observed that children who knew the alphabet seemed to have an easier time learning to read. Into the bargain,

the need for phonological instruction was recognized as evidenced by the existence of rhyming and alliteration in most curricula, albeit not systematically and not as determined by a structure according to which mastery could be measured (Savin 1972). Otherwise, little was understood about the relationship between learning to read and alphabetic or phonological skills. The conference was recounted in *Language by Ear and by Eye, 1972*. In the Preface, the authors/editors noted, "Our aim is to reveal what is known about this comparison, and by framing questions, to stimulate appropriate and useful research (page x).

Those Pesky Vowels

Over the past twenty years, virtually all students referred to us for remedial written-language work have experienced vowel confusions (knowledge and/or perception). In particular, students for whom English is not a first language or who are diagnosed with dyslexia struggle to establish accurate representations for vowels. Students who have a medical history of middle-ear effusion, low tongue/jaw posture caused by open-mouth breathing, hypotonicity, etc. often also have issues with vowel perception and/or knowledge. Another group experiencing vowel confusion is students who learned to read with little or no explicit reading or spelling instruction. These students have usually mastered all consonant sounds but relatively few vowel sound/spelling correspondences.

Middle-ear effusion may result in a 20 to 30 decibel conductive hearing loss which can be experienced by listening to speech with forefingers occluding one's ear canals. Hypotonicity refers to low muscle tone overall. Low tongue posture may have as a consequence reduced muscle strength.

The most surprising group is high-achieving students with whom, over the years, we have had the luxury of working. These students have been neither identified as having learning problems nor would they have been. When referred to us, they have been described as having "slacked off", as not being "as smart" as originally thought, as being unable to complete college assignments that contain complex text and concepts, or to have "comprehension issues."

While they may have had problems with comprehension, their difficulties have been caused primarily by inefficient reading ability, most notably the inability to apply the alphabetic principle. Not infrequently, well-developed phonemic awareness skill has hindered rather than helped: they have sensed when a mistake has been made but have been unable to fix it. Frequently these students had started school being able to read so had not been given phonics instruction. Usually, consonant knowledge has not been a problem, but vowel knowledge and/or vowel perception consistently have.

Between 2005 and the time of writing, a respected Massachusetts neuropsychologist referred 20 older (grade-6-to-college-level) students to one of us to help understand the phonological difficulties these students were demonstrating. Each student had some degree of difficulty with vowel knowledge and/or vowel perception. After working with three students, the author apologized to the psychologist for finding the same issue troubling every student, believing that there were gaps in the author's knowledge. By the fifth student, however, the pattern of vowel difficulty was clear. The following fifteen students' learning profiles confirmed the hypothesis.

The Alphabetic Principle and Orthography - An orthography is the written form of a language. An orthography's type depends on the unit its symbols represent, the major types being *logographic* (representing morphemes), *syllabic* (representing syllables), and *alphabetic* (representing speech sounds). The ***Alphabetic Principle*** is the attribute of alphabetic languages whereby letters and letter patterns represent the spoken language. In languages such as Finnish and Italian, sounds are represented with correspondences which, while not one-to-one, approximate that regularity. These languages are characterized as having *shallow orthographies*. On the other hand, English has complex and inconsistent representations, making it a language with a *deep orthography*.

Even before 2005 we had searched the NICHD literature for guidance but found no mention of difficulties posed by vowels. Shortly before writing this text, however, in our re-reading of the Shankweiler and Liberman chapter, "Misreading: A Search for Causes" in *By Ear and Eye*, (1972), the difficulty posed by vowels was identified as a concern needing to be researched. Studying linguistic aspects of error patterns in reading and speech for both consonants and vowels, revealed that "...vowels...were seldom misheard but often misread..." (Shankweiler and Liberman 1972 308). One consideration was that errors occurred at least in part because of phonetic confusions,

perhaps related to the continuous nature of categorical perception of vowels. Liberman and Shankweiler discussed vowel errors again in a presentation in May, 1976, (Speech, the Alphabet, and Teaching to Read); nevertheless, at that time, research indicated to them that vowel errors should be attributed to complexity of orthography and no mention was made of possible perceptual issues.

We are forced to conclude that in the NICHD research effort vowels fell through the cracks. As with the older students mentioned above, we have observed vowel-knowledge and/or vowel-perceptual difficulties in work with almost all students, particularly:

- those for whom English is not their native language or their mothers' native language; and
- those for whom there is a medical history of otitus media with middle-ear effusion, low tongue/jaw posture caused by open-mouth breathing, hypotonicity, etc..

We found that by including intensive, explicit instruction in vowel knowledge (and vowel perception if needed), the dynamic of learning and improving both written and oral language skills changed for all of the students described above.

Based on our experience, we have formed the opinion that the lack of study has been enormously detrimental to the development of effective instructional practices for written-language skills. First, because we live in a time when "research" is understood to be essential in every facet of life, the lack of attention to vowel knowledge has resulted in many people's believing that vowels do not play a significant role in learning written-language skills. And, second, teachers end up being blamed for not succeeding when, had the work been done, they would be as successful in teaching as students would be in learning.

The belief that vowels are of little significance in written-language seems to have come from correlational studies in the early 1990s of deficits in speech/language domains and deficits in reading achievement with the result: "Correlational analysis showed no significant relationship between reading achievement and articulation." At the same time the studies did show difficulties in standardized language measures that were statistically significant in predicting reading difficulties. (Catts 151). A 1997 study by Sices et al. replicated the Catts finding. These studies, however, examined articulation of consonants and not articulation of vowels. We believe that this happened because, at the time, it was not certain how vowels could be studied, and as a result, vowels were not studied! The lens that we have to examine a phenomenon determines what we think exists.

Experience in teaching sound/spelling correspondences has demonstrated to us that consonant knowledge develops relatively easily compared to vowel knowledge. Furthermore, vowel sounds that are missing from students' expressive repertoires have detrimental effects on reading and spelling ability. It is the “missingness” that has the effect, not the sounds themselves. In a discussion of the importance of vowel vs. consonant frequency in spoken English in a representative sample in *The Cambridge Encyclopedia of Language*, conversational English vowels constituted 39.21 percent of all sounds (Crystal 1987, Chapter 28, *The linguistic use of sound*)!

The findings of the 1990s, that articulation difficulties were not related to difficulties in learning to read and spell, are in stark contrast with the results of research in early language development conducted by Patricia Kuhl (Kuhl 2004). She has demonstrated that early exposure to language not only alters the physical structure of the brain but affects language learning, including reading readiness. Moreover, what has been measured in the brain itself correlates, strongly, with that which is measured behaviorally. Since the advent of non-invasive brain study, it has been possible to study infants' brains as they acquire language and, in particular, as they learn the sounds and patterns of their languages. Infants listen, analyze, and store what they hear "like a computer being programmed before its printer is hooked up." In research completed by Kuhl, infants' abilities to distinguish speech sounds at 6 months of age correlates with later language abilities. (Early Learning Summit for the Northwest Region: Boise Idaho June 9-10, 2002).

About vowels: the sounds in words do not occur independently, one after the other; rather, they overlap in production (This overlap is termed *coarticulation.*). Consonants overlap so much that in a consonant-vowel-consonant syllable production, the first and last sounds overlap in the middle of the syllable. And vowels sounds are

even more pervasive: their acoustic signals are present from beginning to end. If you say *hat* or read it as a sight word, your tongue is in position for the vowel sound /a/ as you breathe out producing the /h/ sound.

In our practices, we have found that inclusion of intensive and explicit instruction in vowel knowledge and vowel perception changes the trajectory of students' learning to read and spell, challenging assumptions about the relative unimportance of vowel perception and knowledge. We have developed a scope and sequence necessary to teach the vowel system of English and we are able to present empirical evidence to support the efficacy of that system. Unfortunately, we are unable to state that anyone with credentials has conducted systematic, comparative research as has been done with other components of learning to read. It seems likely, however, that others have also become aware of "missing pieces" and have developed systems that do work. It is time for researchers to complete what teachers have started. Research, in our opinion should be linked with that of Patricia Kuhl.

In our experience, students' knowledge of the vowel system and perception of vowel sounds is central to both spoken- and written-language development, so much so, that successful remediation has changed our understanding of how children learn to read and to use the alphabetic principle. We believe that incorporation of explicit and systematic instruction in vowel knowledge and perception would have reduced the number of students who did not make progress in the NICHD studies (Torgesen).

Fluency

In research supported by the National Institutes of Health fluency is defined as the capacity to recognize words easily as well as to read with speed, accuracy, and expression. The research documents the value of building fluency in reading text. We start fluency training below the level of reading connected text in keeping with well-documented research on methods developed by Ogden Lindsley and others that was begun in the 1960s. This body of work, known as Precision Teaching, did not receive any attention in the NICHD studies. We had found that success in fluency training of connected text was jeopardized when more basic foundational skills such as proficiency in naming letters, producing the sounds for spellings, recognizing frequently occurring words, etc. were not fluent. Inclusion of fluency training in foundation skills in our work resulted in our students successfully finishing their intervention programs significantly more quickly than had been previously possible.

Adding a fluency component means that we teach skills that students then practice until those skills are not only accurate but are performed at a rate which ensures that they are retained and maintained even without practice, that they are available even in taxing or distracting learning situations, and, finally, that they are transferred to more complex skills. In other words, students are learning to be proficient and to perform without hesitation in addition to being accurate.

The Phonological Structure of Words and Success in Understanding How Reading is Accomplished

The research begun in 1965 focused on the contrast between the ease with which almost all children learn to speak and the effort required in learning to read. At that time, it had been observed that children who knew the alphabet seemed to have an easier time learning to read. The need for phonological instruction was recognized as evidenced by the existence of rhyming and alliteration in most curricula, albeit not systematically and not as determined by a structure according to which mastery could be measured (Savin 1972). Otherwise, little was understood about the relationship between learning to read and alphabetic or phonological skills.

Examining what was known about the comparison between learning to speak and learning to read resulted in research questions being formulated and subsequent research which confirmed a role for phonological and phonemic awareness in learning to read and an understanding of the alphabetic principle and its function.

The study of phonemic awareness began with Isabelle Liberman's intuition, presented in 1971, that perceiving the phonological structure of written words—its constituent phonemes—is necessary in learning to read. Awareness of phonemes in written words is not a consequence of being able to perceive and produce the words in spoken language

because, in spoken language, the mechanics of perception and production are below the level of conscious awareness. From the conference's focus on the contrast between the ease with which most children learn to speak and the difficulty many have learning to read, Liberman and others formulated questions and directions for research. Consequently, we know that language systems of the brain complete phonological tasks.

In addition to confirming the importance of phonemic awareness, the ensuing research also defined and examined other aspects of phonological skill and use of the phonological structure of language necessary for the development of the ability to read. This research took place not only in the United States but in several other countries having written languages which are alphabetic.

The dedicated research demonstrated a significant correlation between phonological awareness and reading acquisition as well as reading ability. Early research strongly suggested that the relationship between phonological awareness and reading is a causal one. Moreover, and of the utmost importance, was the conclusion that phonological awareness could be taught.

It was deemed most likely that, in order to complete a phonemic task in learning to read, a child must, at a conscious level, understand that a word or syllable consists of individual sounds—phonemes—as well as be able to discern and manipulate those phonemes. That they are abstract—merely units of sound which have no meaning in and of themselves—makes conceptualization difficult (Yopp 1992).

In normal development it appeared that young children discover phonemes in their spoken language when they notice minimally distinctive differences between pairs of words they already know, e.g. *sat* and *fat*. It is thought that they detect the difference as the result of kinesthetic analysis of their own speech production rather than the result of hearing differences in speech, because speech, even their own, is too fast to analyze (Locke 1993).

At this level of development there is little introspective awareness, just as with other forms of maturationally acquired motor and perceptual behavior such as walking or seeing (Mattingly 1972). Lundberg (1991), a Swede, used two analogies to make this point. He related being unable to correctly describe the color of the display or shape of the digits on his watch when asked by his young son, who then calculated that his inability to do so was in spite of having seen it about 300,000 times over ten years. In training teachers, Lundberg asked them to name those persons portrayed on their national currency. He received only a few correct responses, those being of persons on small bank notes, therefore seen most frequently. His point was that a "general principle of economy" is at work for children as well as adults: they pay attention to the meaning of communication rather then to its form.

The classic example of this is offered by Stahl who restructured an intervention when he understood that a young girl he was helping was not able to get to the phonological structure of words: when asked to repeat the word *coat* without the /k/ she thought and replied "Jacket"; when asked to repeat *meat* without the /m/ she again thought and replied "Chicken" (Stahl 621).

Needing to attend to phonological structure is further complicated by the fact that individual speech sounds in words are coarticulated, that is, produced together rather than separately. Coarticulation is the mechanism by which the brain precisely overlaps, merges, and spreads out phonologically-significant, acoustic information so that speech is rapidly produced. (It may be helpful to understanding to think about muscular movement of the body; the same principle is at work in movements of the organs of speech.)

The automaticity of coarticulation means that the speaker need only think of the word; the phonological component of his grammar "spells" it for him. Indeed, the automaticity of this specialization makes it that much harder to be aware of how the word is spelled, or even to know that such a thing as spelling exists (Liberman 4).

Perception of speech is no less complex and just as automatic. Listeners have only to rely on their phonological specialization to automatically process the speech signal and recover the coarticulated gestures that caused it (Liberman & Mattingly 1989).

The general difficulty in getting to the phonological structures of words led Liberman to suppose that young students would not possess the necessary knowledge and skill to get to phonological structures. She set out to test and understand children's ability to segment words into phonemes and syllables.

Early reading research mostly focused on determining the puzzling nature of the correlation between phonological awareness and reading ability. A study by Bradley and Bryant in 1984 was the first that demonstrated a possible causal link, a finding replicated in other studies.

Several possibilities were considered and explored; phonological awareness might have been: 1) a prerequisite to learning to read and spell; 2) a facilitator but not a prerequisite; 3) a consequence of learning to read and spell; or 4) a skill independent of reading and spelling but related to a third unknown factor. Furthermore, it might have been that the first four possibilities, or some of them, functioned together. There was also evidence that in early reading and spelling, causation is unidirectional and that later, as the child progresses in school, causation becomes reciprocal (Lie 1991; Perfetti 1998). It may also be that the relationship is influenced by how phonetically regular the language is, Norwegian, for example being more regular than English (Lie 1991).

We point out that, while those engaged in research did not agree on all aspects of the role of phonemic and phonological awareness, most thought it to be of critical importance to reading and spelling acquisition. Most also thought it could be taught. For instance, Charles Temple and others (1993) stated that in order to spell, one must know that written symbols represent phonemes, which are "peculiar, knowable, but peculiar." (The Beginnings of Writing, Needham Heights, MA: Allyn and Bacon, 1992).Temple insists that teachers need to understand how speech sounds are made and that words are "bundles of phonemes" (Ibid). He believes, furthermore, that children can deal with "exceptions and irregularities in the match of letters and spellings if they have a working sense of sound units" (Ibid).

"The evidence is compelling: toward the goal of efficient and effective reading instruction, explicit training in phonemic awareness is invaluable. The reason that they agree is that, no matter how phonological awareness has been tested, it has been related to success in learning to read (Blachman 1991).

Finding and incorporating new techniques was most relevant to our work; therefore, we focused on the training studies. The following are a sampling of the many studies conducted after 1971 which examined the relationship of phonological awareness and reading. We have chosen these studies, in particular, because they illustrate how the results of one study generated many more research questions which were addressed in subsequent studies, accounting for the rapid expansion of knowledge about reading and factors related to reading instruction, and because they have helped us develop our frame of reference for the interventions that we provide to our students.

Bradley and Bryant (1984), in trying to determine if specific training in phonemic awareness would significantly improve the reading achievement test scores of children, pre-tested approximately 400 four- and five-year olds who initially could not read. They then compared performances on tasks requiring sound categorization (segmentation) to their progress in reading and spelling over the next four years. This research methodology was typical of research up to that time.

In addition to this research piece, Bradley and Bryant selected 65 children who had low scores on the sound categorization task and placed them in four groups matched for age, verbal intelligence, and categorization scores. The first group received training in attending to initial, medial, and final phonemes in simple (consonant-vowel-consonant) syllables; the second group was instructed in sound/symbol correspondences in addition to receiving the training of the first group; the third group received instruction in semantic classification, i.e., that words can be classified in different ways, using the same words studied by the first two groups; and the fourth group received no training.

The group trained in sound categorization outperformed the groups which received no training or training in semantic classification, albeit not significantly. The group trained in sound/symbol correspondences in addition to sound categorization, however, showed significant evidence of an advantage as a result of the training.

Ball and Blachman (1988) conducted a study to research a question left unanswered by Bradly and Bryant's study, i.e., whether training in sound/symbol correspondences without training in phonemic awareness would produce equally impressive results. Children were assigned to three groups: one received phoneme segmentation and sound/symbol correspondence training; one received instruction in sound/symbol correspondences using the same sound stimuli, but not in segmentation; and 3) one received no such instruction. All children were taught in small

groups; training lasted seven weeks and consisted of 15- to 20-minute sessions four times a week. Those who had received both sound/symbol and segmentation training outperformed the others in phoneme segmentation, reading, and spelling. Those who received sound/symbol correspondence training only had equivalent sound/symbol knowledge, thus the effective ingredient in reading gains was the segmentation training.

Ball and Blachman chose to have children taught in small groups to examine the efficacy of group instruction. They recognized that small group instruction is more feasible than individualized instruction, and that such training ought to occur before children have experienced failure, which would then warrant individualized attention.

Based on the results of this study, Blachman (et. al. 1991) proceeded to determine the practicality of providing such instruction in regular classrooms. They trained teachers and assistants who worked with 84 children in small groups in regular classrooms, using the same procedures as in the previous study. Those children received both segmentation and sound/symbol instruction. In addition, seventy-five control children were instructed in sound/symbol correspondences as part of the regular curriculum, but were not instructed in segmentation. After an 11-week period of 15- to 20-minute sessions four times a week, children receiving both segmentation and sound/symbol instruction out-performed the control children. Thus Blachman demonstrated that phonemic awareness training could be integrated into the regular education curriculum. It is important to note, as Blachman does (1991), that these training sessions lasted no longer than 20 minutes and were but a small part of the children's educational program. She has implemented the findings of her research in programs in inner city schools in New Haven, Connecticut.

In a different approach to looking at phonemic awareness in Norway, Skjelfjord (1987), beginning in 1970, set out to determine how children decide the position of a phoneme in a particular word, His purpose was to gather information which would help in constructing a program for teaching phonemic analysis. This study was to be followed by several similar studies.

Kindergarten children received instruction in phonemic awareness by way of: 1) listening to short stories in which a particular phoneme was found several times; 2) seeing an illustration of the story; and 3) being introduced to pictures in which the phoneme being studied was found in initial, medial, or final position in illustrated words. To assess the efficacy of the training, children were tested on phonemes not previously taught but related by phonetic features. The results suggested that there was transfer of the analytical skill.

He also observed that children seemed to analyze their own pronunciation of the words on which they were being tested, rather than the speech they were hearing. Furthermore, two of the children who were not benefiting from training, i.e., they were not developing analytical ability at all, were able to catch up with other children in the training group once directed to attend to articulatory features of the sounds.

Finally, Skjelfjord observed that the children in the study acquired analytical skills gradually. In identifying the correct position of phonemes, initial, medial, or final (positional analysis), it appeared that the children needed to segment the whole target word before reporting the initial phoneme. As their skill developed, however, they were able to report the phoneme without first segmenting, but continued to segment before reporting medial and final sounds. Again, as their ability developed, children had only to sound out the first two phonemes before reporting the one in medial position. In teaching the color-encoding exercise of the Lindamood Phoneme Sequencing (LiPS) program, we saw the same gradual, analytical skill acquisition.

As a result of his observations, Skjelfjord recommended that children be taught to attend to their articulation, and that they receive training in identifying and blending the sequence of sounds in a word (sequential analysis) rather than training in positional analysis.

Another Norwegian study, conducted by Lie (1991), examined the issue of sequential and positional analysis with first-grade children, i.e., children beginning to learn to read, instead of kindergartners. Reading and spelling assessments at the end of grades one and two showed that both types of instruction were effective with indefinite statistical variation. In addition to indicating that either method worked, correlations with general intelligence scores suggested that children with low general intelligence scores made greater gains than those with average or high general intelligence scores. Lie concluded: "The finding of an interaction with intelligence suggests that instruction in word analysis should be provided according to the pupil's need for systematic instruction in this area." As had

Skjelfjord, Lie recommended that research be directed toward examining the importance of directing children's attention to the articulatory features of phonemes.

Olofsson and Lundberg (1983) demonstrated that improving phonemic awareness of pre-school children placed them in good stead when beginning to learn to read. Their study provided evidence of the effectiveness of training in phonemic awareness skills prior to learning to read (Lundberg 1991). The hypothesis of the study was that tasks requiring phonemic analysis and synthesis would be most affected by the training. The study was conducted in Denmark because Danish children did not begin school until the age of seven and few had received any informal literacy training when they began. The study, beginning in 1985, consisted of 400 children in two groups, carefully matched for socio-economic background. The first group received training meant to help children discover and attend to the phonological structure of words. Children began with listening and rhyming games, moved to looking at sentences and words as concepts, and then focused on segmenting sentences into word units. Following those tasks, they segmented words into syllables. In the third month, they segmented syllables into phonemes, beginning with the phoneme in initial position. It was not until the fifth month that syllables with more than two sounds were added.

Results were published in 1987. The treatment group significantly outperformed the control group on measures of phonological awareness, reading, and spelling, and persistence of the training effect of phoneme segmentation was demonstrated. Thus Lundberg showed that phonological skills can be trained before formal reading and spelling instruction begins. He also concluded that handling phonemic segments is the most difficult task that children face, and perhaps the most crucial to their academic survival.

Another question generated by earlier studies was whether there would be an advantage in training children in analysis (segmentation) skills rather than training them in synthesis (blending) skills. This question was addressed by Fox and Routh in 1984, who concluded that only if children could segment syllables into phonemes, could they benefit from training in blending phonemes. Perfetti, Beck, Bell, and Hughes (1987) conducted a study to determine the nature of the reciprocity between beginning reading instruction and phonemic awareness. They concluded that synthesizing taps early segmentation ability necessary for beginning reading and that deleting phonemes, which requires manipulation, requires a more sophisticated segmentation ability. They concluded that this ability develops because of learning to read.

Torgesen, Morgan and Davis (1992) also conducted studies aimed at determining the relative efficacy of training both analysis and synthesis skills together compared to training synthesis skills alone. They concluded that children trained in both were better able to transfer skills to new tasks, and that although synthesis skills were easier to teach than analysis skills, both ought to be taught.

Torgesen also noted that a third of the group in their study did not respond to analysis training, i.e., identifying the initial, medial, and final sounds of two and three phoneme words. He suggested that a more intensive approach, which included learning the specific motor features of the speech sounds (reminiscent of Skjelfjord's and Lie's observations), was needed to teach children with severe phonological disability.

There was limited research on the effects of phonemic, or phonological, awareness training in remedial settings, although several programs, such as those of Williams, Blackman, Wallach and Wallach, and Venezky, have been successful in remediating deficits. A problem in analyzing the success of such programs is that awareness training is included within a larger framework of reading instruction and is therefore difficult to evaluate in isolation.

One such study, however, a remediation-training study of children from seven to 12 years old (Alexander, Anderson, Heilman, Voeller, and Torgesen, 1992) proceeded on the assumption that, while acquiring the alphabetic principle might be difficult for children with severe phonological difficulty, it is essential. The Lindamood Phoneme Sequencing (LiPS) program (at the time named Auditory Discrimination in Depth) focuses on: 1) developing explicit awareness of the articulatory features of speech sounds so that each sound has identity based on either its relationship--or contrast--to other sounds; 2) sound/symbol correspondence training; and 3) phonemic awareness training in the form of a problem-solving activity of tracking speech sounds which are represented by blocks. At the conclusion of the training, which varied in duration according to the need of individual children, phonological awareness skills not only improved, but on word attack post-testing, children advanced to a range normal for their ages. It was noted, however, that not all word recognition problems disappeared, i.e., children still had difficulty

with complex words. Furthermore, the study did not have a control group, and given the complexity of the LiPS program, it was not possible to assess the effectiveness of its particular components, or to determine if such a complex program was necessary for, or beneficial to, children with minor difficulties.

In 1994, Torgesen began both developmental and remedial training studies, both with control groups. The purpose of the developmental study was to determine which techniques might be successful in preventing reading disabilities for children who are deemed to be at risk for them. Training, using two instructional conditions began when the children were in kindergarten and continued through their second-grade year. Their progress in both reading and intellectual development was followed for an additional two-year period.

The same instructional conditions were used in the remedial study. Even when significantly more time was spent providing explicit instruction, the difference in results from the prevention studies was remarkable. Whereas in both studies, regardless of the length of time of the intervention, decoding accuracy (word attack) rose to the average range for most students, only in the prevention study did students reach the average range in text-reading accuracy, reading comprehension, and fluency as well as in word-attack.

Use of Relevant Research

Irony abounds! What we have done is effective and inexpensive to implement—in training, materials, time, and effort. We are sure that others have also used the research to develop effective programs. Unfortunately those programs have not come into wide circulation.

We cite and describe early training studies because they have informed the work that we have done since the 1990s. The correspondence between our experiences and research results led us to believe we were on the "right track", first, in using the Lindamood Phoneme Sequencing (LiPS) program to teach phonemic awareness skills and eventually in developing a conceptual framework for our instructional programs.

In addition to phonemic awareness skills, we studied research on other aspects of phonological awareness. Liberman, Liberman, Shankweiler, and others posited that problems with the phonological component of students' spoken language would not only result in difficulty in learning to read, but would cause difficulties in memory for verbal information, in discerning words when there is background noise, in word play, in rhyming, in word finding, and in producing complex speech patterns (Liberman, Shankweiler, Liberman 1990.) The connection between these difficulties has been evident to us in performance of many students.

The research of these scientists demonstrated that there are three components of phonological processing: phonological awareness, phonological recoding in lexical access (rapid naming), and phonological recoding in working memory (holding in mind phonological segments and/or manipulating them). By using phonological tasks developed by Elizabeth Haughton and using the fluency techniques of Precision Teaching, we have been able to strengthen those skills. We are able to provide preliminary evidence of student progress.

Both a significant number of theorists (of varied philosophical principles) and a significant number of thoroughly researched studies have concluded that phonological awareness can and must be taught. We have found methods suggested by that research to be effective. In our practices, we have sought to extend these teaching methods by focusing on the unanswered questions presented in *Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research and Literature on Reading and its Implications for Reading Instruction* commissioned by the United States Congress, supported in development by NICHD and Office of Education (National Reading Panel), published in 2000, and *Preventing Reading Difficulties in Young Children* commissioned by the National Research Council published by the National Academy of Sciences in 1998,

In particular, we focused on "...what teachers need to know and be able to do to teach phonemic awareness effectively and to integrate this instruction with other elements of beginning reading instruction or instruction directed at older disabled readers" (NRP) and "What factors govern children's induction and generalization of spelling-sound knowledge and how can they be fostered" (NRC). We found that by constructing exercises in which students developed both phonemic awareness and phonics skills for words they **had not yet learned to recognize**,

we could move students along into reading, especially those children who would have been judged to have intractable problems and referred to as "treatment resisters" in the '90s.

For some students "sounding out" and blending sounds to form words, even with only three letters and three sounds, was not possible because of weak auditory memory. For example, the /p/ in *pot* was not held in mind long enough to get to the /t/; the /o/ and /t/ did not make a known word, but if our student looked back at the *p*, they might produce the word *top* (a word in their mental lexicon). It was for these students that we created our phonetic analysis exercise. Students were able to work on a word until the whole word could be held in memory and turned into a "sight-word". These students, in the process of acquiring a sight-word vocabulary, also developed the ability to apply the alphabetic principle. As these students progressed, we found that the same method worked for turning words of more than one syllable into sight words. Furthermore, the use of the technique with students not as phonologically challenged resulted in their making significant gains in learning new high-frequency words. The evidence that they were learning to apply the alphabetic principle came from the fact that once they had learned 50 words from the high-frequency list using phonetic analysis, they could read more new words by analogy. This was true whether they began knowing virtually no words, 40 words, or 150 words as “sight” words.

We were likewise thrilled to think that by targeting high-frequency words apt to be confused with similarly spelled words, we could use the phonetic analysis technique to develop use of the alphabetic principle for students who "knew" most of the 600 high-frequency words but did not apply the alphabetic principle. We immediately understood the significance of Ingvar Lundberg's "general principle of economy"—children as well as adults pay attention to the meaning of communication rather then to its form. Encourage as we might, students were loathe to complete such exercises because they "knew" the words.

On the other hand, when we introduced those same students to spelling, initially using a subset of the 600 most commonly used words, they were motivated to complete the phonetic analysis exercise on words they had difficulty spelling as well as on less-frequently-occurring words students at their grade-levels would be expected to know.

Not counting those who are just learning to read or who would be considered learning disabled, there are, in our experience, three categories of learners in need of help:

- young learners who have mastered reading many but not all of the first 600 commonly used words;
- more advanced learners who read relatively accurately, but without fluency and who spell without accuracy;
- older learners—high-school, college, or even graduate school, who, despite well-developed cognitive skills, have difficulty in spelling, written composition, reading, or analyzing complex texts.

As for our older, relatively high-achieving students, we did not find that they had the vocabulary skills that would be expected had they read independently. Many of these students stated that they "hated to read." We also noticed that when asked to define words, many students could not—sometimes to the point of wondering why we asked as they understood the word and its meaning to be one. Others derived words’ meanings from context, but failed being able to define those words in isolation—sometimes knowing full well that they had understood a particular word in the text but did not remember its meaning.

We assert that countless students who are not identified as requiring specific instruction in reading do not learn to apply the alphabetic principle and are not able to read efficiently. Lack of application of the alphabetic principle can be seen in their spelling, vocabulary learning, and reading of polysyllabic words. By adding vocabulary to spelling and by devoting instructional time to how word parts combine in English, these students make significant gains in vocabulary.

Between *Essential Word-Knowledge Skills* and *The Spell of Language*, teachers are provided with curricular materials for not just beginning readers, but readers of all ages. To develop effective spelling instruction, we had extrapolated from what we had come to understand in teaching reading based on research studies conducted starting in the 1970s. The conclusions of those studies are presented in *Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research and Literature on Reading and its Implications for Reading Instruction*,

commissioned by the United States Congress, supported in development by NICHD and Office of Education and published in 2000. We also studied *Preventing Reading Difficulties in Young Children*, Snow, Burns, and Griffin, commissioned by the National Research Council and published by the National Academy of Sciences in 1998.

The charge to both groups was to examine the research that had been conducted for findings that were supported by consistent study. The degree of convergence of the conclusions of the two reports was remarkable.

The NRP report concluded that there should be incorporation of "explicit instruction in phonemic awareness" whereas the NRC report stated that there should be a focus on "the sublexical structure of spoken words." The focus on "systematic phonics instruction" in the NRP conclusions corresponded to the alphabet representation of sounds and "specifics of frequent, regular spelling-sound relationships" in the NRC report conclusions. The NRP's "methods to improve fluency practice in reading" corresponded to the NRC's "to achieve fluency with different purposes."

Recommendations for continued study were convergent as well:

Questions in need of answers developed by members of the NRC:

- How can decoding automaticity be hastened?
- The factors that govern knowledge and generalization of spelling-sound knowledge and how can they be fostered?
- Syntactic and semantic factors in beginning readers: how do they influence the growth of decoding and fluency?
- Through what means can word recognition and comprehension development be coordinated so that they develop most efficiently and synergistically?
- What kinds of reading and writing activities and instruction serve to maximize the leverage of each on the other?
- How do syntactic competence and awareness influence growth? What aspects of syntax warrant instruction?
- What kinds of instructional practices and activities serve best to develop children's habits of self-monitoring for coherence and comprehension?
- What is the impact of early childhood and primary-grade instructional practices on reading and literacy growth in the middle and upper grades of school? How should the curriculum be changed to maximize such benefit?
- What is the actual incidence and nature of the "fourth-grade slump"? Its prevalence and presenting symptoms should be documented, and if so indicated, research on its underlying causes and best prevention should follow.
- What kinds of curriculum materials (including basal readers) are useful for what purpose, and how can published materials and the reading/writing curriculum be integrated?
- What kinds of knowledge and material support do classroom teachers need for greatest effectiveness?
- How can in-service opportunities be used most effectively?
- What are the best strategies for monitoring and managing the range of student progress and difficulties in any given classroom or building?
- What kinds of classroom, grouping, and staffing options would significantly improve instructional delivery in the primary grades?
- What are the best strategies for maintaining constructive communication and collaboration between parents and teachers in support of children's reading development?

Questions in need of answers developed by members of the NRP:

- How best can the development of decoding automaticity be hastened?
- What factors govern children's induction and generalization of spelling-sound knowledge and how can they be fostered?

- What are the roles and dynamics of syntactic and semantic factors in beginning readers? How do they influence the growth of decoding and fluency?
- Through what means can word recognition and comprehension development be coordinated so that they develop most efficiently and synergistically? (Within *The Spell of Language* vocabulary is joined with spelling and morphology)
- What kinds of reading and writing activities and instruction serve to maximize the leverage of each on the other?
- How do syntactic competence and awareness influence growth? What aspects of syntax warrant instruction?
- What kinds of instructional practices and activities serve best to develop children's habits of self-monitoring for coherence and comprehension?
- What is the impact of early childhood and primary-grade instructional practices on reading and literacy growth in the middle and upper grades of school? How should the curriculum be changed to maximize such benefit?

Topics Deserving Further Investigation

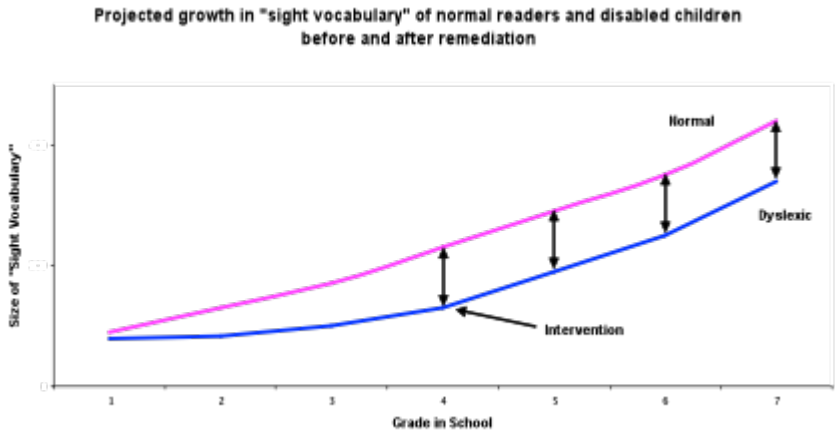
From our experience, we have qualitatively answered many, if not most, of the questions regarding teaching basic written language skills posited by the NRC and NRP. Were we able to direct research, our first question would be: what effect does improvement of vowel knowledge and perception have on written- and spoken-language skills of students, including those diagnosed with specific language impairment?

We would then ask: how does fluency skill development below the level of connected text, such as sounds, words, and phrases, support comprehension and other higher level skills? (There are studies in Precision Teaching that show gains in reading comprehension by virtue of gains in foundation skills without directly attending to comprehension skills.)

We would also ask:

- What would students' trajectories of learning look like after learning to apply the alphabetic principle in addition to developing vowel knowledge and vowel perception?
- What is the relationship between a student's development of vowel perception and the ability to perceive the rhyming of words?
- How can vowel knowledge development be assessed so that teachers can be sure that students maintain knowledge and perception?
- How can spelling instruction be developed as a component of written-language learning rather than as an isolated school subject?
- How might generic programs be developed, lowering the cost of curricular materials and making it possible for teachers to integrate appropriate materials as needed?
- How might a syllabus be designed for teaching the nature of learning written language to those adults who, because they are phonologically gifted, may not understand what it takes to become competent in applying the alphabetic principle and therefore find the topic to be of little consequence?

Finally, we believe that for the purpose of developing effective instruction, research should examine the ease, or lack of ease, with which students add new words to their mental lexicons. The following figure, presented by Joseph Torgesen, was instrumental in our attending to word learning as it pertains to being able to read grade-level text: while students do learn to read when remediation is provided, without specific intervention, they remain behind in being able to understand the words in grade-level text.



Conclusions

We conclude by restating the principles that have informed our practices: phonemic awareness, phonics, vocabulary, fluency and comprehension. Implementation has been guided by the work of those such as Dr. Torgesen, a leader in reading research:

> Instructional adaptations for individual children will be made primarily in terms of varying amounts and intensity of instruction and practice on the five components—based on good diagnosis.
>
> Children who experience reading difficulties must be helped to acquire adequate skills in all five components. If any one of these does not develop properly, the child is unlikely to attain grade-level reading skills. (Torgesen presentation, Portsmouth, NH October 2002)

Of the five components, obtaining meaning from print is the paramount skill for which the other four components are necessary but not sufficient. Along with fundamental skills, we teach comprehension skills and strategies to our students as are appropriate. Comprehension skills and strategies are not included in *The Spell of Language* program because, to quote Dr. Charles Perfetti, "...there is nothing gained by lumping all conceivable strategies that become learned in specific contexts into the problem of basic reading acquisition." What is lost is "conceptual clarity", and making "practical recommendations" becomes near to impossible (Perfetti 22).

Recommendations for Teachers

We recommend careful study of the NICHD-sponsored research pertaining to reading comprehension. Before that research was completed, many thought that comprehension skill was wholly dependent on basic reading ability alone. The NICHD research led to the understanding and recognition that direct teaching of comprehension strategies is a necessary and integral part of effective reading instruction. Since 2000, the amount of literature outlining the many ways of teaching comprehension strategies has increased.

Working Memory

We also recommend that teachers study what is known about the functioning of working memory. Research has demonstrated an even larger role of working memory in reading than first presented in the early work of Liberman and others (presented in “Phonological Structure of Words…”.) Our experience has been consistent with this research extension. In *Working Memory and Academic Learning*, published in 2008, Milton J. Dehn presents the relationship between working memory and language development in addition to the relationship between reading skills and working memory. Rather than language production being an automatic process as was thought by many, studies have shown that oral language production as well as listening comprehension require working memory skills

even for so-called "normal" speakers. Moreover, "...children with language impairments have a limited capacity for processing and remembering verbal information (Dehn 100)."

Dehn categorizes reading skills into reading decoding (basic reading skills) and reading comprehension. As described earlier in this text, basic reading skill depends first and foremost on phonological-skill development.

Reading decoding is primarily dependent on phonological processing—the ability to detect and manipulate the sound units (phonemes) of spoken language. Reading comprehension is more complex and involves several higher level cognitive processes (Ibid).

The importance of memory in developing comprehension skill is clear: studies have found working memory capacity to be surpassed only by reading decoding skills and vocabulary level in predicting reading comprehension in all groups of learners (Dehn 104).

As described by Dehn, we have observed students for whom skill development has positively "influenced working memory development and capacity..." (Dehn 123). We have also observed the salutary effects of automatized learning on working memory functioning.

We have observed that, as basic skills develop to the point of full automaticity, working memory capacity becomes less of a factor in skill performance, thereby allowing students with working memory deficiencies to progress academically (Dehn 122).

We know that there must be ranges of instructional intensity readily available to ensure the growth in students' abilities so that they function at levels that match their cognitive potentials. We have learned from experience that automatized learning (fluency) is the bridge between phonemic awareness/phonics and vocabulary/comprehension.

In closing we would share a few of the important concepts we have learned.

First, to paraphrase Liberman, Shankweiler, and Liberman: meanings cannot be communicated in language independently of words.

From Patricia Kuhl we learned: "language and reading require getting the sounds sorted out correctly"; "learning itself, not merely time, affects one’s future ability to learn"; and, moreover, that

> Social interaction may be essential for learning in complex natural language-learning situations—the neurobiological mechanisms underlying the evolution of language likely utilized the kinds of interactional cues available in a social setting (Kuhl 518).

We have learned from Reuven Feuerstein, a psychologist renowned for his work in developing the theories of mediated learning experience and providing teachers with skills and tools to develop students cognitive skills that learning occurs most assuredly when an intentioned person (the mediator/teacher) organizes stimuli according to clearly identified goals so that students' thinking skills are enhanced and that intrinsic motivation comes from being successful in learning.

We have learned that students should learn what is possible rather than what is "hard". To quote Virginia Spencer, a written-language tutor, learning should occur in "achievable" chunks. Our goal, and wish for all teachers, is to be able to say, as Patricia Lindamood was able say to each of her students, "All I need to know is where your brain meets my question."

References

Adams, Marilyn J. *Beginning to Read: Thinking and Learning about Print.* Cambridge, MA: M.I.T. Press, 1990.

Alexander, Ann W., et al. "Phonological Awareness Training and Remediation of Analytic Decoding Deficits in a Group of Severe Dyslexics." Annals of Dyslexia. 41 (1991) 192-206.

Ball, E. W. and B. A. Blachman. "Phoneme Segmentation Training: Effect on Reading Readiness." Annals of Dyslexia 38 (1998) 208-225.

Binder, Carl. "Behavioral fluency: Evolution of a new paradigm. The Behavior Analyst, 19:2 (1996) 163-197.

Binder, Carl, et al. "Fluency: Achieving True Mastery in the Learning Process. special.edschool.virginia.edu/papers/Binder-et-al_Fluency.pdf, 2002.

Blachman, Benita A. "Early Intervention for Children's Reading Problems: Clinical Applications." *Topics in Language Disorders*. 12(1) New York, NY: Aspen Publishers, 1991.

Bloom, B. S. "The Hands and Feet of Genius: Automaticity." *Educational Leadership:* (1986) 70-77.

Bradley, L. and P. E. Bryant. "Categorizing Sounds and Learning to Read—A Causal Connection." *Nature* 301 (1983) 419-421.

Catts, Hugh, et al. "Early Identification of Reading Disabilities in Children with Speech-Language Impairments." *Specific Language Impairments in Children,* eds., Ruth V. Watkins and Mabel L. Rice. Baltimore, MD: Brookes Publishing Company, 1994.

Crystal, David. *Cambridge Encyclopedia of Language*. Cambridge: Cambridge University Press, UK, 1987.

Dehn, Milton. *Working Memory and Academic Learning: Assessment and Intervention*. Hoboken, NJ: John Wiley & Sons. 2008.

Ehri, Linnea C. "Learning to Read and Spell Words." *Journal of Reading Behavior* 19: 1 (1987) 5-28.

Fox B. and D. K. Routh. Phonemic Analysis and Synthesis as Word Attack Skills: Revisited. *Journal of Educational. Psychology 76* (1984) 1059-1064.

Frith, Uta, ed. *Cognitive Processes in Spellin*g. 1980.

Fromkin, Victoria and Robert Rodman. *An Introduction to Language*, fifth edition. Fort Worth, TX: Harcourt Brace Jovanovich, 1993

Haughton, E. C. (1972). "Aims: Growing and sharing." In J. B. Jordan & L. S. Robbins (Eds.), *Let's Try Doing Something Else Kind of Thing* (pp. 20-39). Arlington, VA: Council on Exceptional Children.

Johnson, Kent & Elizabeth M. Street. *The Morningside Model of Generative Instruction: What It Means to Leave No Child Behind.* Concord, MA, Cambridge Center for Behavioral Studies, 2004

Johnson, K.R., and T. V. K. Layng. "Breaking the Structuralist Barrier: Literacy and Numeracy with Fluency." *American Psychologist*, 47 (1992) 1475-1490.

Kuhl, Patricia and Maritza Rivera-Gaxiola. *Substrates of Language Acquisition.* http://ilabs.washington.edu/kuhl/pdf/Kuhl&Rivera-Gaxiola2008.pdf

Kubina, Richard M, Jr. “Fluency in Education.” *Behavior and Social Issues, 10 (2000) 83-99.* Concord, MA, Cambridge Center for Behavioral Studies

Lewkowicz, Nancy. “Phonemic Awareness Training: What to Teach and How to Teach It.” *Journal of Education Psychology.* 72 (1980) 686-700.

Liberman, Isabelle Y. “Language and Literacy: The Obligation of the Schools of Education.” *Intimacy with Language: A Forgotten Basic in Teacher Education,* edited by W. Ellis, 1-9. Baltimore: Orton Dyslexia Society, 1987.

Liberman, Isabelle Y., Shankweiler, Donald, and Liberman, Alvin M. “The Alphabetic Principle and Learning to Read.” *Haskins Laboratories Status Report on Speech Research* 101/102, (1990) 1-13.

Lie, Alfred. “Effects of a Training Program for Stimulating Skills in. Word Analysis in First--grade Children.” *Reading Research Quarterly. 26 (1991) 234-250.*

Lindamood, Charles and Patricia Lindamood. The *A.D.D.Program: Auditory Discrimination* in *Depth. 2d* ed. Allen, TX: DLM, Inc. 1075.

Lindsley, Ogden R. “Precision Teaching: By Teachers for Children.” *Teaching Exceptional Children,* 23:3 (1990) 10-15.

Locke, John L. *The Child's Path to Spoken Language.* Cambridge, MA: Harvard University Press, 1993.

Lundberg, Ingvar. “Phonological Awareness Facilitates Reading and Spelling Acquisition.” *Intimacy with Language: A Forgotten Basic in Teacher Education.* Baltimore: Orton Dyslexia Society, 1987.

Lyon, G. Reid. “Ask Reid Lyon – Reading First Implementation.” Guest web blog post. *Jay P. Greene’s Blog: With Help from Some Friends.* 19 May 2008.

Mann, Virginia. “Why Some Children Encounter Reading Problems: The Contribution of Difficulties with Language Processing and Phonological. Sophistication to Early Reading Disability." *Psychological and Educational Perspectives on Learning Disabilities, J. K.* Torgesen and B. Y. Wong eds. New York, NY, Academic Press. 1985.

Marzano, Robert J., et al. *Appendix: A List of Essential Words by Grade Level.* http://www.scribd.com/doc/40871206/Vocabulary-Project-Word-List

Mattingly, Ignatius. “Reading, the Linguistic Process, and Linguistic Awareness.” *Relationships between Speech and Reading,* eds. J. F. Kavanagh and I. G. Mattingly, Cambridge, MA: MIT Press, 1972.

Moats, Louisa C. “Linguistics: An Essential for Multisensory Language Teaching.” Presentation at the Orton Society Dyslexia Conference, November, (1993), St. Petersburg, FL: Convention Recordings International Inc.

“The Missing Foundation in Teacher Education: Knowledge of the Structure of Spoken and Written Language." *Annals of Dyslexia* 44 (1994) 81-101.

Olofsson, A. and Ingvar Lundberg. “Can Phonemic Awareness be Trained in Kindergarten?” *Scandinavian Journal of Psychology* 24 (1983) 35-44.

Perfetti, C. A., et al. “Phonemic Knowledge and Learning to Read are Reciprocal: A Longitudinal Study of First-grade Children.” *Merrill-Palmer Quarterly* 33 (1987) 283-319.

Perfetti, C. A., Laurence Rieben and Michel Fayol, eds. *Learning to Spell: Research, Theory, and Practice Across Languages.* Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 1997.

Perfetti, C. A., et al. “The Acquisition of Reading Comprehension Skill.” *The Science of Reading: A Handbook xiv* (2005) 227-247.

Paul, Rhea “Assessing Advanced Language.” In *Language Disorders from Infancy through Adolescence*. St. Louis, MO: Mosby-Year Book, Inc., 1995.

Pickett, J. M. *The Sounds of Speech Communication*. Needham Heights, MA: Allyn and Bacon, 1980.

Rayner, Keith, et al. “How Psychological Science Informs the Teaching of Reading.” *Psychological Science in the Public Interest 2* (2001) 31-74.

Savin, H. B. “What the Child Knows about Speech When He Starts to Learn.” *Language by Ear and by Eye: The Relationships* between *Speech and Reading,* eds. J. F. Kavanagh and I. G. Mattingly. Cambridge, MA: MIT Press, 1972.

Shankweiler, D. and T. Liberman. “Misreading: a Search for Causes. *Language by Ear and by Eye: The Relationships between Speech and Reading,* eds. J. F. Kavanagh and I. G. Mattingly. Cambridge, MA: MIT Press, 1972.

Starlin, C. “Evaluating Progress Toward Reading Proficiency”. B Bateman, (Ed.), *Learning Disorders Vol. 4,* (1971) Seattle, WA: Special Child Publication, 389-465.

Skjelfjord, Verbjorn J. “Phonemic Segmentation. An Important Subskill.” Learning to Read.” *Scandinavian Journal of Educational Research* 31 (1987) 41-57.

Snow, Catherine E., Burns, M. S., and Griffin, P. (Eds.) *Preventing Reading Difficulties in Young Children/Committee on the Prevention of Reading Difficulties in Young Children.* Washington, DC: National Academy Press, 1998.

Stanovich, Keith E. *Progress in Understanding Reading*. New York, NY: The Guilford Press, 2000.

Strauss, Valerie, “NCLB crashed and burned. When will we ever learn?” *Washington Post* [Washington] 3 Feb. 2014. Website.

Teaching Children to Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and its Implications for Reading Instruction: Reports of the Subgroups (Report of the National Reading Panel, NIH Publication No. 00-4754). National Institute of Child Health and Human Development. Washington, DC: U.S. Government Printing Office, 2000.

Temple, Charles, R., et al. *The Beginnings of Writing*. Needham Heights, MA Allyn and Bacon, 1993.

Torgesen, Joseph K, et al. “Effects of Two Types of Phonological Awareness Training on Word Learning in Kindergarten Children.” *Journal of Educational Psychology*. 84, No.3 (1992) 364-370.

“Longitudinal Studies of Phonological Processing and Reading.” *Journal of Learning Disabilities. 27 No. 5* (1994) 276-286.

Torgesen, Joseph K. and P. G. Mathes. *A Basic Guide to Understanding, Assessing, and Teaching Phonological Awareness*. Austin TX: PRO-ED, 2000.

Torneus, Margit. “Phonological Awareness and Reading: a Chicken and Egg Problem?” *Journal of Educational Psychology.* 76, No.6 (1984) 1346-1358.