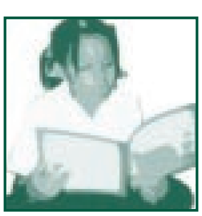
CIERA REPORT

Building an Integrated Model of Early Reading Acquisition

Timothy R. Konold, Connie Juel, and Marlie McKinnon
University of Virginia



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Center for the Improvement of Early Reading Achievement

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CIERA Inquiry 1: Readers and Texts
What are the characteristics of readers and texts that have the greatest influence on early success in reading? Can one cohesive model be developed to integrate models of word-level processes of decoding and spelling with text-level processes of learning to read and write text?

This study investigated children's profiles on four constructs fundamental to areas of childrens' early literacy acquisition: auditory processing, crystallized ability, processing speed, and short-term memory. These areas were measured using six tests: Memory for Sentences, Visual Matching, Incomplete Words, Sound Blending, Oral Vocabulary, and Listening Comprehension. Results were used to establish the most common reading profiles. Children within profiles were then compared to children in other profiles on various reading outcomes to determine which profiles were likely to be associated with reading success.

Konold et al. wanted to identify the most common profiles, those associated with success in reading, and the patterns likely to result in reading difficulty. Their analyses led to six profiles, three of which were relatively flat (had equivalent scores across the different areas). They labeled these profiles Above, Slightly Below, and Below Average Reading Ability. The remaining three profiles demonstrated average overall reading ability with strengths in one or more areas. Children with flat average profiles performed significantly worse overall than their average peers who had secondary strengths in one or more areas. The comparison suggests that there is more than one route to successful reading performance.

CIERA

Center for the Improvement of Early Reading Achievement
University of Michigan – Ann Arbor

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CIERA
Center for the Improvement of
Early Reading Achievement

University of Michigan School of Education

610 E University Ave., Rm 1600 SEB
Ann Arbor, MI 48109-1259

734.647.6940 voice
734.763.1229 fax
ciera@umich.edu

www.ciera.org

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Cognitive models of literacy acquisition generally define early acquisition as dependent upon factors considered core to developing (a) word recognition and (b) reading comprehension. Much is known about specific processes involved in reading acquisition, as well as more global stages in reading development. Phonemic awareness has been found to be associated with the early development of word recognition and reading, and factors strongly associated with comprehension include oral vocabulary and listening comprehension (Adams, 1990; Juel, 1994; Snow, Burns, & Griffin, 1998; Wagner, Torgesen, & Rashotte, 1994). Models have also been proposed delineating developmental stages of oral language and phonological awareness (Berko-Gleason, 1951; Brown, 1973; Yopp, 1995). While an understanding of how these causative agents function is important, learning to read is a multivariate phenomenon that requires joint consideration of these processes. In other words, it is likely that these processes operate in combination rather than in isolation (i.e., children may have strengths or weaknesses in more than one area). As a result, it is important to develop models that integrate the full network of relationships that exist among these abilities in order to investigate their joint influence on reading outcomes. Understanding the complex network of these abilities and their influence on emergent readers will increase our theoretical understanding and provide for instructional utility.

Many theories of human abilities have been proposed over the years in an attempt to explain individual differences. The most promising theory seems to be based on the Horn-Cattell Gf-Gc model (Ysseldyke, 1990). This model is said to "offer the most well-founded and reasonable approach to an acceptable theory of the structure of cognitive abilities" (Carroll, 1993, p. 62). The Gf-Gc model currently comprises nine broad abilities (Horn, 1991). Fluid (Gf) and crystallized (Gc) factors are supported by subfactors that include visual organization, perceptual speed, auditory organization, and several memory capacities, as well as specific sensory reception components (Greggory, 1996). This study investigated children's profiles on four of the Gf-Gc constructs (i.e., auditory processing [Ga], crystallized ability [Gc], processing speed [Gs], and short-term memory [Gsm]) that appear to be of particular importance to children's reading acquisition and writing skills.

Auditory processing (Ga) involves the understanding of auditory patterns and is particularly important for language development (Woodcock, 1990). In a series of structural models designed to investigate the relationships between the Gf-Gc factors and various reading and writing outcomes, auditory processing was found to yield a greater relationship with basic reading skills than any of the other Gf-Gc abilities. It was also found to influence reading comprehension and written expression, but to a somewhat lesser degree than basic reading skills (McGrew, Werder, & Woodcock, 1991). These relationships were stronger in the early years (i.e., age 5), and appeared to decline with age to about 40 years (McGrew, 1994).

Children need to be able to recognize printed words. The sheer volume of words that children are expected to read quickly and accurately is daunting. They will be expected to recognize, and know, more than 80,000 different words by the end of third grade (Adams, 1990; Carroll, Davies, & Richman, 1971). The overwhelmingly central task in early reading is learning to recognize words. The clearest difference between what is required in reading a language, but not in speaking or listening to it, is learning to recognize printed words. This means a child must learn a lot about the English spelling system (i.e., orthography). To speak a word one need not know how it is spelled. However, such learning is at the core of spelling and word recognition. In reading, the child is faced with an orthographic avalanche of printed words. Letters must be learned, and these letters must be associated with consonant and vowel sounds. This requires an awareness of the internal phonological structure of the words of the language—an awareness that is more explicit than is ever demanded in listening and responding to speech.

Crystallized ability (Gc), or what some refer to as comprehension knowledge (McGrew, Werder, & Woodcock, 1991), consists of knowledge and experience. It also includes knowledge-based reasoning and judgment (Woodcock, 1990). Structural model studies demonstrated that this factor had a greater influence on reading comprehension and basic writing skills than other Gf-Gc factors. It was also found to influence basic reading skills and written expression (McGrew, Werder, & Woodcock, 1991). Unlike other Gf-Gc factors, these relationships are weaker for younger children (i.e., age 5) and rapidly increase with age (McGrew, 1994).

Text comprehension requires children to have knowledge of the concepts and world described by words, and the ability to draw inferences from their existing knowledge. Knowledge of concepts and the world are especially critical when the texts children read are informational in nature. As Juel's (1994) longitudinal study demonstrated, even successful decoders started to fail in fourth grade because they lacked the world knowledge to understand texts. It is important to remember that grade 4 represents a transition in literacy, a point at which informational text begins to assume an ever-increasing role in reading. Authors of informational text generally assume a good deal of background knowledge.

In comparison to ordinary conversations, less common words are employed in both informational and narrative texts. In narrative text, the unexpected word or event may actually be one of the devices authors use to keep the reader interested. As a field, we have increased children's exposure to interesting, but difficult, literate vocabulary by increasing the use of children's literature in primary classrooms. In everyday conversation, a child may tell her friend that her folks were "fighting." In a narrative text, however, the child might encounter "bickering" (Cleary, 1985).

Reasoning and inference (i.e., putting things together) based on existing knowledge is also required for successful reading of grade-appropriate text. Text comprehension is an interaction between what the reader knows about a topic and what information the text provides (Kintsch, 1988). Writers of both narrative and informational texts normally make assumptions about the reader's knowledge base. These assumptions can be wrong. A reader may not have the background knowledge, may not know how to finesse it, and may withdraw from engagement with the text. To read both informational and narrative texts, the reader must activate background knowledge, supply inferences to fill what the author doesn't say, and simply reflect upon what is being read.

Text is normally nonredundant, or at least highly parsimonious. Inferences are continually required to make sense of texts. Even a brief note, such as "Clean up your room," requires the inference by the reader that the note is addressed to her, that the writer probably wants a quick response, and that the writer assumes the reader knows what is to be picked up. In fact, if a speaker or a writer fills in too many details, we are likely to accuse her of being ponderous and boring. Inferences require a strong knowledge base, as well as attention, motivation to make sense of a text, and active reasoning about what one is reading.

Lastly, *processing speed* (Gs) and *short-term memory* (Gsm) appear important to basic reading skills and reading comprehension (McGrew, 1994). Processing speed involves the ability to maintain focus and work quickly through automatic cognitive tasks. Processing speed was found to have more influence on written expression than other Gf-Gc factors and to yield a notable influence on basic writing skills, reading comprehension, and basic reading skills (McGrew, 1994; McGrew, Werder, & Woodcock, 1991). These relationships were strongest in the primary and elementary school years and declined with age (McGrew, 1994).

Due to the many tasks required of the successful reader, some processes must become automatic. For example, when children have letters, syllables and word recognition at a level of automaticity, it allows them to place greater attention on comprehending what is being read.

Short-term memory, or working memory, involves the ability to maintain a limited amount of information in immediate awareness for use within a short period of time. It demonstrated moderate relationships with basic reading skills that increased with age from 5 years to about 40 years. Its relationship with reading comprehension was slightly weaker in the early years but increased with age to about 24 years (McGrew, 1994).

Short-term memory is involved in remembering word links between letters and sounds as well as the spelling of "irregular" words (e.g., come, of). Individuals with short-term memory deficits have greater difficulty recalling information, which in turn causes greater difficulty when attempting to comprehend sentences. This difficulty is particularly problematic with complex sentence structures (Mather, 1991).

Given this complex array of factors involved in successful reading, children face a formidable learning task. They must learn to associate consonant and vowel sounds with letters (Ga/phonological awareness). They must recall specific orthographic patters (e.g., green is spelled with "ee" not "ea" or "grene"). They must gain sufficient world knowledge in order to understand what is being read, and must be active readers who bring everything they know to bear upon what they read and then expand upon it to accommodate new information (Gc/oral comprehension). Children with processing (Gs) and/or short-term memory (Gsm) deficits will likely experience even greater challenges as a result of needing to concentrate on basic skills that are not yet automatic and difficulties recalling and manipulating previously learned information, respectively.

Because many beginning readers have difficulty in more than one area of reading, it is important to develop models that explain how the aforementioned processes operate in combination to explain reading acquisition difficulties in order to improve diagnosis and instruction. This study examined children's profiles on measures of Ga, Gc, Gs, and Gsm as they relate to literacy outcomes. A model was developed through cluster analysis to provide a unified framework of how these constructs operate in concert by accounting for the multivariate aspects of children's abilities. This procedure allowed us to account for the heterogeneous nature of children's reading abilities and identify homogeneous subgroups of children who displayed similar patterns of strengths and weaknesses.

The four constructs were measured with six tests that were treated as profiles. Profiles are integrated sets of test scores that are defined by three elements: level, shape, and scatter (Cronbach & Gleser, 1953). Treating test scores as integrated profiles provides many benefits. Most notable is that multivariate methods of evaluating profiles account for the full network of relationships among abilities (Sternberg, 1984) and provide greater insight into the nature and complexity of human ability, thereby providing greater diagnostic precision (Glutting, McDermott, & Konold, 1997).

The design combines cross-sectional and longitudinal procedures and involves two major phases of analysis. In the first phase, a large nationally standardized sample was used to identify the most common reading profiles of children on measures of Ga, Gc, Gs, & Gsm. Cross-validation was incorporated into the analysis, and the internal and external validity of the resulting profiles was also investigated. Children within profiles were then compared to children in other profiles on various reading outcomes, to determine which profiles were most likely to be associated with successful readers. Phase I was important because it established stable profiles on a large demographically representative sample of children that could be used for normative comparisons with the longitudinal sample.

Profiles from Phase I served as benchmarks of typical performance and allowed us to link children from our longitudinal sample (Phase II) to one of the identified score configurations. Because we want our analysis to model different patterns of growth among children who are developing their literacy skills at different rates, we will continue to follow these four- and five–year-old children throughout the remaining years of the study. This will allow us to investigate profile changes and establish links between profiles and successful readers. These links are important because they can provide educators with necessary information to address the instructional need of children with similar profiles.

Several questions were of particular interest:

1. What are the most common profiles of important reading abilities?
2. Which profile(s) are associated with success in reading, and what patterns are likely to result in reading acquisition difficulty?
3. Are the same profiles that are associated with success in one aspect of reading (e.g., word recognition) also associated with success in other reading areas (e.g., comprehension)?
4. What is it that actually develops in students over time? Do the same abilities continue to develop (i.e., do they continue to display similar profile configurations) or do they acquire different strategies for dealing with words and text (i.e., do their profiles change)?
5. What type of instruction contributes to this development?

The first three questions were addressed in the current study (Phase I). Questions two and three were investigated by between-profile comparisons on several reading outcomes. Questions four and five will begin to be addressed in the upcoming year as we continue to follow several cohorts of children over time and examine within-cluster behavior (Phase II). Details concerning the two phases of this study are provided below.

Phase I

Methods

Subjects.

Sixteen hundred and four children, ranging in age from 5 to 10 years (M = 7.8; SD = 1.6), were selected from the *Woodcock Diagnostic Reading Battery* (WDRB; Woodcock, 1997) standardization sample. The sample was stratified in accordance with 1980 (and later) U.S. census reports on the variables of race (Anglo 81.2%, African-American 15%, Indian .9%, and Asian 2.8%), gender (male 50.8%, female 49.2%), and origin (Hispanic 9.7%, non-Hispanic 90.3%).

Instrumentation.

The *Woodcock-Johnson Tests of Cognitive Ability* (WJ-R COG; Woodcock & Johnson, 1989) are operational representations of the Horn-Cattell Gf-Gc theory (Woodcock, 1990; Ysseldyke, 1990). Some of the same tests on the WJ-R COG are also located on the WDRB (Woodcock, 1997) for convenience to those whose primary interest is in reading. The WDRB is comprised of ten tests (M = 100, SD = 10), six of which can be combined to measure the four Gf-Gc abilities currently under investigation (i.e., Ga, Gc, Gs, Gsm; Woodcock, 1990). The remaining four tests on WDRB provide measures of basic reading skills (Letter-Word Identification, Word Attack) and reading comprehension (Reading Vocabulary, Passage Comprehension; McGrew, Werder, & Woodcock, 1991). These achievement-oriented tests served as dependent variables for determining which profiles were most likely to be associated with reading problems in these areas. A brief description of these measures is provided below. These descriptions were adopted in part from the WDRB Examiner's Manual; reliabilities were obtained from McGrew, Werder, and Woodcock (1991); and factor loadings can be found in Woodcock (1990). The reported factor loadings represent the median value obtained across nine data sets.

Ga: Auditory Processing. Ga was assessed by two subtests, *Incomplete Words* and *Sound Blending*. Incomplete Words requires children to identify words with one or more missing phonemes. Children are asked to respond with the complete word when orally presented with phoneme-deleted words. This test yielded a median factor loading of .55 on Ga. Internal consistency reliability = .79, and test-retest reliability = .63. Sound Blending provides a measure of phonological synthesis by asking children to consider words presented to them in parts and to respond with the whole word. Sound Blending provides a slightly better measure of Ga than Incomplete Words, with a median factor loading of .69. This test can also be combined with Incomplete Words to provide a measure of phonological awareness. Internal consistency reliability = .87 and test-retest reliability = .72.

Gc: Crystallized Ability/Comprehension Knowledge. Gc was also assessed by two subtests, *Oral Vocabulary* and *Listening Comprehension.* Oral Vocabulary measures knowledge of word meaning and has a median factor loading of .61 on Gc. Oral Vocabulary is comprised of two parts. In the first part, children are orally presented with a word and asked to respond with a word that is similar in meaning (i.e., a synonym). In the second part, children are asked to provide a word that is opposite in meaning to the one they are presented (i.e., antonym). This test taps children's ability to recall appropriate words in context, and provides information pertaining to receptive and expressive vocabulary. Internal consistency reliability = .85 and test-retest reliability = .89.

Listening Comprehension evaluates children's prior knowledge with simple verbal analogies and associations and progresses to higher level comprehension involving reasoning. Children are required to comprehend an orally presented passage and provide the single missing word at the end of the passage. The median factor loading of this test on Gs was .66. Internal consistency reliability = .78 and test-retest reliability = .75.

Gs: Processing Speed. *Visual Matching* measures visual processing by requiring children to identify and mark two identical numbers in a row that contain six numbers. The test ranges in difficulty from single-digit numbers to triple-digit numbers. Visual Matching provides an exceptionally good measure of Gs with a median factor loading of .84. Internal consistency reliability is not available, and test-retest reliability = .84.

Gsm: Short-Term Memory. *Memory for Sentences* loads on Gsm with a median factor loading of .55. Children are orally presented with a sentence or phrase and asked to recite it back. In this task, the child makes use of sentence meaning to aid retrieval. Median factor loading = .93, internal consistency reliability = .92, and test-retest reliability = .76.

Basic Reading Skills. Two measures of basic reading skills are available. *Letter-Word Identification* requires children to identify symbols, letters, and words. The test progresses from matching a picture of an object with a rebus to identifying isolated letters and words. The test progresses in difficulty to words that are less frequently used in the English language and are irregular in spelling. Median factor loading = .93. *Word Attack* measures the ability to pronounce printed, unfamiliar letter strings by applying phonic and structural analysis skills. Children are asked to read pseudo words that are linguistically logical. Median factor loading = .79.

Reading Comprehension. Two aspects of reading comprehension were assessed, vocabulary and passage comprehension. *Reading Vocabulary* evaluates children's ability to read words and provide appropriate meaning to them. This test is divided into two sections: synonyms and antonyms. The first section requires children to respond to a written word with another word that is similar in meaning. In the second section, children are asked to respond with a word that is opposite in meaning to the word read by the child. Median factor loading = .93. *Passage Comprehension* requires children to respond with an appropriate word for the context of the passage they are reading. Children begin by matching a phrase with the appropriate picture, and progress to passages that require the child to identify an omitted word. These items require the use of a variety of vocabulary and comprehension skills to respond. Median factor loading = .78.

Data Analyses and Results

Means and standard deviations for the six tests comprising the constructs of phonological awareness, oral comprehension, and reading aptitude used to identify normative profiles through cluster analysis are presented in Table 1. The clustering strategy we adopted was similar to the one used elsewhere for identifying normative profiles (Glutting & McDermott, 1990; Glutting, McDermott, & Konold, 1997; Konold, Glutting, & McDermott, 1997; Konold, Glutting, McDermott, Kush, & Watkins, in press; McDermott, Glutting, Jones, & Noonan, 1989). This procedure involves three steps. In the first step, the total sample (N=1,604) was randomly divided into four equal samples (N=401), and Ward's (1963) hierarchical-agglomerative procedure was performed on a Euclidean distance matrix that is sensitive to level, shape, and scatter. Decisions regarding the number of clusters to retain within each of the four samples were based on a number of indices: Pseudo-F (Calinski & Harabasz, 1985), pseudo t2 (Duda & Hart, 1973), and R2. This step also utilized a "trim" procedure that removed a maximum of 2% of the outlier cases from consideration in the analysis (McDermott, 1998).

Results from step 1 were pooled to form an overall similarity matrix that was used for step 2. Ward's method was employed on the resulting similarity matrix from step 1 to assess the extent to which cluster profiles from subsamples of the data matched those found for the total sample (i.e., replication). Each of the aforementioned statistical indices was again considered when determining the number of clusters to retain at step 2. Steps 1 and 2

Table 1: Descriptive Statistics for WDRB Clustered Variables and Reading Achievement Outcome Measures*

	M	*SD*
Clustered Variables		
Memory for Sentences	101	16
Visual Matching	100	16
Incomplete Words	101	15
Sound Blending	101	16
Oral Vocabulary	102	16
Listening Comprehension	102	16
Achievement Measures		
Letter-Word Identification	101	16
Word Attack	100	17
Reading Vocabulary	102	15
Passage Comprehension	102	15

* *N*=1,604.

led to the identification of six clusters, each of which yielded a 100% replication rate. This replication rate indicates that each of the profiles identified in the four subsamples also emerged when the entire sample was utilized.

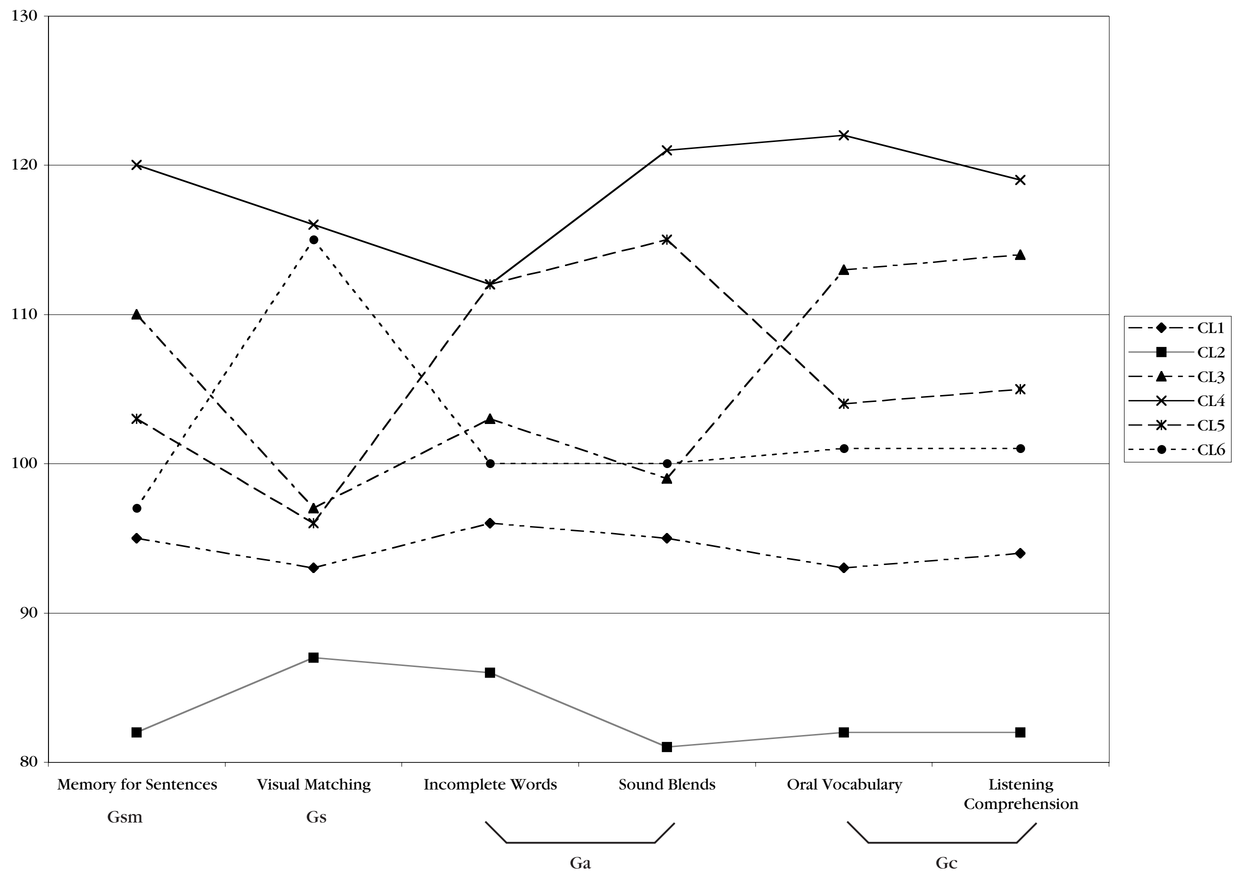
The six clusters identified from step 2 served as initial starting seeds for the step 3 K-means iterative partitioning procedure. This third stage was necessary because hierarchical-agglomerative procedures (steps 1 and 2) do not allow subjects to shift clusters after their original assignment, despite the fact that they may fit better in a different profile later in the solution. By contrast, iterative partitioning procedures allow subjects to migrate to neighboring clusters, following identification of the number of suspected clusters (steps 1 and 2), and generally result in tighter solutions.

Table 2: Mean Standard Scores for the WDRB Core Profile Types

Profile Type	Memory for Sentences	Visual Matching	Incomplete Words	Sound Blends	Oral Vocabulary	Listening Comprehension
1. Slightly Below Average Reading Ability	95	93	96	95	93	94
2. Below Average Reading Ability	82	87	86	81	82	82
3. Average Reading Ability With Strengths in Gc and Gsm	110	97	103	99	113	114
4. Above Average Reading Ability	120	116	112	121	122	119
5. Average Reading Ability With Strengths in Ga	103	96	112	115	104	105
6. Average Reading Ability With Elevated Gs	97	115	100	100	101	101

Mean profile configurations are presented in Table 2 and illustrated in Figure 1. Each of the six profiles represents natural variation of reading abilities and is typical of what we would expect among children between the ages of 5 to 10 years. Profiles 1, 2, and 4 appeared primarily defined by general reading ability; that is, they are flat, revealing little indication of relative strengths and weaknesses among subtests in the WJ-R COG. Profile 1 was defined by slightly below average reading ability, profile 2 by low reading ability, and profile 4 by above average ability. The remaining three profiles (3, 5, and 6) demonstrated noteworthy patterns of dips and rises. Each of these three profiles was approximately centered on average ability. However, they also reflected different strengths that set them apart. Profile 3 reflected strengths in Oral Vocabulary, Listening Comprehension (measures of crystallized ability), and Memory for Sentences (short-term memory); profile 5 demonstrated elevated scores in Incomplete Words and Sound Blending (measures of auditory processing); and children in profile 6 demonstrated strengths in processing speed.

Figure 1: Mean Profile Configurations for the Six Profiles



Prevalence rates, internal cohesion, external isolation, and profile replication rates are presented in Table 3 for each of the six clusters. The average H coefficient (Tryon & Bailey, 1970) of .71 provides evidence in support of homogeneous within-cluster representation. External isolation refers to the extent to which clusters differ from one another in multivariate space. An examination of Table 3 provides evidence in support of the six-cluster solution through external isolation. That is, the average Rp value of .32 only slightly exceeds the a priori criterion of Rp < .30, indicating good separation between clusters.

An overview of the six cluster profiles is provided below. This summary includes consideration of demographic representation of gender and age within each cluster. Observed demographic proportions within each cluster were compared to what would be expected if children comprising different demographic groups were proportionately distributed across the six profiles according to their representation in the total sample (N = 1,604). For example, the total sample (N = 1,604) was comprised of 50.8% males and 49.2% females. Profile 1 contained 25% of the total sample (N = 401). Thus, we would expect 50.8% of this number to be males and 49.2% to be females. This procedure tested for violations of this hypothesis within each profile. Two-tailed standard error of proportional difference tests were made for all possible pair-wise comparisons within each profile. Type I error rates were controlled through the use of Bonferroni adjustments. Results demonstrated that children's age was not statistically different from population expectancy within any of the six clusters. The prevailing composition of each profile type described below considers only those demographic variables where significant differences were obtained ($p < .05$).

Table 3: Psychometric Properties of the WDRB Core Profiles

Cluster Number	% Population Prevalence	Internal Profile Cohesion (H)	External Isolation (Rp)	% Independent Replications Across Four Blocks
1	25	.77	.31	100
2	11	.68	.01	100
3	15	.73	.46	100
4	13	.58	.37	100
5	16	.75	.32	100
6	17	.74	.42	100
Averages		.71	.32	100

Profile Types

1. Slightly Below Average Reading Ability (Prevalence = 25%).

Children in this cluster demonstrated a relatively flat profile with scores slightly below average on most measures. This type demonstrated the highest rate of prevalence.

2. Below Average Reading Ability (Prevalence = 11%).

This profile demonstrated the lowest rate of prevalence. Similar to profile 1, it was relatively flat with no remarkable patterns of dips or rises across subtests.

3. Average Reading Ability w/ Strengths in Crystalized Ability (Prevalence = 15%).

Elevations were observed on three of the six tests used to form clusters, two of which were measures of Gc (comprehension) and one of which measured Gsm (sentence memory). There were more males than expected and fewer females than expected in this cluster.

4. Above Average Reading Ability (Prevalence = 13%).

Similar to profiles 1 and 2, profile 4 failed to demonstrate any noteworthy dips or rises. This profile was the highest in terms of elevation (i.e., general ability). Profile 4 demonstrated no unusual demographic representation.

5. Average Reading Ability w/ Strengths in Auditory Processing (Prevalence =16%).

These were students, both male and female in equal proportion, who achieved average scores on most tests with definitely elevated scores on phonological awareness measures, Ga.

6. Average Reading Ability w/ Elevated Processing Speed (Prevalence = 17%).

Of the three profiles demonstrating patterns of dips and rises, profile 6 yielded a strength on the measure of Gs. There were fewer males and more females than expected.

Children within profiles were compared on four literacy outcome measures. This procedure served two purposes. First, it allowed us to further substantiate the external validity of the six clusters by demonstrating that children within profiles scored differently on reading outcome measures when compared to children in other profiles. Second, it provided preliminary evidence regarding which profiles were most likely to be associated with success in reading.

A multivariate analysis of variance (MANOVA) was conducted to assess whether scores from the four achievement measures of Letter-Word Identification, Word Attack, Reading Vocabulary, and Passage Comprehension varied across the final six profiles. Means and standard deviations for these four measures are provided in Table 1. Wilks' criterion indicated that scores on the four achievement measures varied significantly across the six profile types, $p < .001$. Follow-up comparisons were completed using four one-way analyses of variance. Each achievement measure served as a dependent variable. These results also add to the external validity of the six clusters by yielding significant differences across profiles on Letter-Word Identification, $F(5, 1561) = 173.34$, $p < .001$; Word Attack $F(5, 1561) = 140.02$, $p < .001$; Reading Vocabulary, $F(5, 1561) = 230.23$, $p < .001$; and Passage Comprehension, $F(5, 1561) = 161.11$, $p < .001$.

Table 4: Reading Achievement Means by Cluster & Post-Hoc Comparisons*

Letter-Word Identification					
Cluster 4 >	[Cluster 5	Cluster 6	Cluster 3] >	Cluster 1 >	Cluster 2
117.6	104.61	104.17	103.67	94.67	84.46
Word Attack					
Cluster 4 >	Cluster 5 >	[Cluster 6	Cluster 3] >	Cluster 1 >	Cluster 2
116.13	106.76	101.50	100.56	93.11	83.37
Reading Vocabulary					
Cluster 4 >	[Cluster 3	Cluster 5] >	Cluster 6 >	Cluster 1 >	Cluster 2
118.85	107.42	105.38	102.43	94.56	85.75
Passage Completion					
Cluster 4 >	[Cluster 3	Cluster 5	Cluster 6] >	Cluster 1 >	Cluster 2
119.18	106.82	105.82	104.47	95.81	87.57

* All > indicate statistical significance, $p < .05$.

Post-hoc comparisons were also made between profile means on each of the four achievement measures. Due to the unequal sample sizes of the clusters, Tukey's harmonic mean procedure was used to facilitate these comparisons. Cluster means are presented in Table 4 for each of the reading outcome measures under consideration. Reading the table from left to right, these means are arranged in descending order. Clusters that were not statistically different from one another are enclosed in parentheses. As expected, children in cluster 4 demonstrated the highest proficiency in reading across all four outcome measures. Conversely, children in cluster 2 demonstrated the lowest levels of reading proficiency across all reading outcomes.

The most interesting results of these comparisons pertained to clusters 1, 3, 5, and 6. These profiles were previously defined primarily by approximate average reading ability, with profiles 3, 5, and 6 demonstrating different secondary strengths. Children comprising cluster 1, those with a "flat" average profile, were found to perform significantly worse than children in other average ability profiles that had at least one secondary strength (i.e., clusters 3, 5, and 6) on all four reading achievement measures ($p < .05$). No significant differences were observed between clusters 3, 5, and 6 on Letter Word Identification or Passage Comprehension. However, when Word Attack was considered, children in cluster 5 (demonstrating average reading ability with secondary strengths in auditory processing) outperformed children in clusters 3 and 6, suggesting that for students with average reading ability, auditory processing plays a larger role in Word Attack than do strengths in cystallized ability, processing speed, or short-term memory. When Reading Vocabulary was considered, children in cluster 3 appeared to merge with those in cluster 5 to outperform children in cluster 6. This last comparison suggests that children with approximately average reading ability who have strengths in either crystallized ability and short-term memory or auditory processing perform better on Reading Vocabulary tasks than do children who do not possess strengths in these areas, even though they may possess processing speed strengths (i.e., cluster 6).

Discussion

Phase I addressed the first three questions that were of interest to us. Six core profiles were identified in a nationally representative group of children. These profiles are typical of the patterns we would expect to observe and represent the most common score configurations among children between the ages of 5 and 10 years. The internal and external validity of these profiles was very favorable, suggesting homogeneous within- cluster membership and clear separation between the six core profiles. In addition, the six cluster solution was supported through cross-validation.

These profiles can be described in terms of patterns of strengths and weaknesses as well as demographic prevalence rates. Three of the profiles (i.e., profiles 1, 2 and 4) were relatively flat. These flat profiles were unremarkable in terms of strengths or weaknesses and appeared to be predominately defined by varying degrees of general reading ability. The remaining three profiles (i.e., 3, 5, and 6) were defined primarily by average reading ability with various secondary strengths. This procedure allowed us to capture the heterogeneous nature of children's reading abilities and identify homogeneous groups of children based on patterns of strengths and weaknesses. The educational utility of these groupings comes by way of identifying profiles that are predictive of successful readers. In other words, what strength(s) are most important to reading acquisition? As we expand and deepen this work and gather more longitudinal data, our results will have the potential to assist teachers as they address the instructional needs of children with similar patterns of reading ability.

The second and third questions were addressed by comparing children with different profiles on four measures of basic reading skills and reading comprehension. Results of these analyses suggested that certain profiles were associated with greater success on external measures of reading achievement than others, and that the importance of certain reading abilities varied in accordance with the achievement being considered. Children with strengths in all areas of crystallized ability, auditory processing, processing speed, and short-term memory (i.e., profile 4) performed better on all four reading outcomes than children composing any other profile. On the other hand, children with weaknesses in all four reading ability constructs (i.e., profile 2) performed the worst on all four reading outcomes. When the focus turns to children composing profiles defined primarily by general ability (i.e., profiles 1, 3, 5, and 6), successful readers appear to need a strength in at least one area. Children in profile 1 (i.e., defined entirely by slightly below average ability) performed worse than children in any of the other profiles, defined primarily by average ability that had at least one secondary strength, on all four reading outcomes. These initial results are suggestive of a compensatory hypothesis, one that acknowledges that there is more than one route to successful, or at least to adequate, reading performance.

But each route carries with it some costs and benefits. Teasing out the most important abilities among children with average reading abilities depends, in part, on the reading outcome being considered. Children with strengths in either auditory processing (profile 5), processing speed (profile 6), or crystallized ability and short-term memory (profile 3) appear to do equally well on some measures of basic reading skills (e.g., Letter-Word Identification) and reading comprehension (e.g., Passage Comprehension). These findings suggest that children with average reading ability and one or more secondary strengths perform better than children of approximate average ability without such secondary strengths (profile 1). The particular secondary strength, however, does not seem to be of much importance on these reading outcomes. On the other hand, when different measures of basic reading skills and reading comprehension are considered, the particular secondary strength does appear to influence reading achievement. Namely, elevated auditory processing scores produce better performance on Word Attack, whereas elevated processing speed scores do not influence reading vocabulary as much as elevations on either crystallized ability and short-term memory or auditory processing.

Future Directions

The results described above provide much needed information regarding the multivariate nature of children's reading ability patterns and their influence on various reading outcome measures. The findings provide insight into the difficulties children are likely to face in learning to read when they do not possess the necessary foundation. Several questions remain unresolved and will be addressed over the next two years. The first concerns the stability of children's profile placement over time. That is, are children able to migrate to neighboring profiles and thereby increase their chances of becoming successful readers? What types of instruction might be responsible for such movement? Second, it is important to determine which profiles are likely to continue to be associated with reading success over time. In other words, are certain profiles more important to success at a given age? To address these concerns, profiles identified in Phase I will serve as benchmarks against which children in our longitudinal sample will be linked, in a normative sense (Phase II).

To illustrate what we will be able to do in Phase II, we have conducted a sample analysis with some data from year one. The preliminary framework for Phase II is described below. Our specific interest concerns children that appear most at risk of failing to read. As a result, the sample described below is composed primarily of lower achieving children.

This part of the analysis involved linking a new sample of children to the profiles identified in Phase I. It established a baseline for this sample so that profile changes and future success in external contexts of reading acquisition could be assessed over the remaining four years of the study.

Children's profiles from our first year (1997–98) of data collection were matched to the normative profiles identified in Phase I. Data from year two (1998–99) has also been collected, and we are currently in the process of scoring their responses. As a result, the information provided below pertains only to our first year of data collection. Matching of children was accomplished through a procedure based on generalized distance theory (D2) (Osgood & Suci, 1952). This procedure also allows for the identification of profiles that do not closely fit the core types. This latter procedure is prevalence-based so that any desired number of students with poor matches can be identified. Thus, rare profiles (i.e., those less common than the core profiles identified in Phase I) occur with a low prevalence rate. For example, we could link every child in our longitudinal sample to one of the core profiles, that provide the best match, if we set the prevalence rate to 0%. Alternatively, we could link only those children that match reasonably well (e.g., 90% or 95% of the children) to the core types, leaving children that have more unique profiles for further consideration by setting the prevalence rate to 10% or 5%, respectively.

To date, children composing our longitudinal sample (year one) were matched to the core profiles. Both procedures described above were followed here for future consideration. The first procedure matched each child to one of the core types by assuming all children could be reasonably matched to one of the core profiles identified in Phase I (i.e., prevalence rate = 0%). The second utilized a 5% prevalence rate identified from the normative sample in Phase I to identify 5% of the children with the worst-fitting profiles. The first procedure will allow us to determine whether certain profiles are associated with success or failure. The latter procedure is based on the hypothesis that there may be a small segment of the population that have more unique profiles than those identified in the normative sample (Phase I). Identifying this group will allow us to determine whether children with these unique profiles are any more or less likely to perform differently on various reading outcomes.

One hundred fifty parent permission forms were sent to parents of children from six feeder preschools that indicated they would allow us to observe and test their children. One hundred six parents agreed to allow their child to participate. Children ranged in age from four to five (M = 4.49; SD = .50) years of age. The sample contained both African-Americans (72.6%) and Anglos (22.6%). There were approximately equal numbers of males (49%) and females (51%). Eighty-four percent of the sample qualified for free lunch, 2.8% for reduced lunch, and 11.3% for neither. All children were evaluated with the WRDB (Woodcock, 1997) by one of four graduate students who had received training in the administration of this instrument.

One hundred ninety-two children were also evaluated in year two of our study (1998–99). Many of these children were previously tested in year one, as described above. Children from year two were drawn from one of three elementary schools ($N_{school\ 1}$ = 68, $N_{school\ 2}$ = 65, and $N_{school\ 3}$ = 59). As previously indicated, we are currently in the process of scoring and analyzing these data. Thus, the results described below pertain only to children in the first wave of data collection.

Prior to matching students from this sample to the normative profiles identified in Phase I, the accuracy of the D2 classifications was first investigated with the standardization sample. High agreement ratings were obtained between children's actual cluster membership and that predicted on the basis of the D2 decision rule when the entire standardization sample was considered (Kappa = .980). Accuracy of the D2 rule was also investigated with a 5% prevalence rate. Children with D2 values of 1,488 or greater yielded the poorest match with any of the six normative clusters. When these children were removed from consideration, the agreement rate between children's initial classification and that predicted from D2 increased slightly (Kappa = .981).

Children's score configurations from the Phase II longitudinal sample (N = 106) were investigated by assigning everyone to one of the core profiles (prevalence = 0%), and also by utilizing the aforementioned 5% prevalence rate to identify children with more unique profiles. When all children were assigned to one of the existing core profiles identified in Phase I, the majority of the children were matched with cluster 2 (64.2%: below average reading ability). The remaining children were matched with clusters 1 (28.3%: slightly below average reading ability), 3 (2.8%: average reading ability with strengths in Gc and Gsm), 5 (2.8%: average reading ability with strengths in Ga), and cluster 6 (1.9%: average reading ability with strengths in Gs). When a 5% prevalence rate for aberrant profiles was considered, only 37 of the 106 children obtained D2 cut scores less than 1,488. Of these children, most were again assigned to cluster 2 (45.9%), with the remaining children falling into clusters 1 (35.1%), 3 (5.4%), 5 (8.1%), and 6 (5.4%).

These are the types of analyses we will be able to do once we have more definitive longitudinal data. These children's profiles will be evaluated in subsequent years to assess their stability and identify which profiles are most likely to be associated with reading problems. It will also be interesting to investigate whether children with initially "flat" profiles develop strengths or weaknesses as a result of increasing age and/or specific school instruction. Progressive reading skills will be measured with both standardized instruments and qualitative observations. The standardized measures will include tests from both the WDRB and Wide Range Achievement Test-Third Edition (Wilkinson, 1993).

We believe that we are on the verge of discovering and validating a new tool for evaluating growth patterns of young readers. This tool, in contrast to earlier ones, allows us, as researchers, and if validated would allow teachers, to get inside "achievement" and "growth" to learn more about the particular pathways, as indexed by profiles of skill strengths and weaknesses, that distinct groups of readers follow in arriving at particular levels of overall achievement or performance. The hope is that what we learn about the course of development of these profiles over the primary years will offer us guidance for providing more appropriate and more individually tailored instruction. This approach has the additional virtue of teaching us, as scholars and theorists, something about the nature of reading development in these critical early years.

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About CIERA

The Center for the Improvement of Early Reading Achievement (CIERA) is the national center for research on early reading and represents a consortium of educators in five universities (University of Michigan, University of Virginia, and Michigan State University with University of Southern California and University of Minnesota), teacher educators, teachers, publishers of texts, tests, and technology, professional organizations, and schools and school districts across the United States. CIERA is supported under the Educational Research and Development Centers Program, PR/Award Number R305R70004, as administered by the Office of Educational Research and Improvement, U.S. Department of Education.

Mission. CIERA's mission is to improve the reading achievement of America's children by generating and disseminating theoretical, empirical, and practical solutions to persistent problems in the learning and teaching of beginning reading.

CIERA Research Model

The model that underlies CIERA's efforts acknowledges many influences on children's reading acquisition. The multiple influences on children's early reading acquisition can be represented in three successive layers, each yielding an area of inquiry of the CIERA scope of work. These three areas of inquiry each present a set of persistent problems in the learning and teaching of beginning reading:

CIERA INQUIRY 1
Readers and Texts

Characteristics of readers and texts and their relationship to early reading achievement. What are the characteristics of readers and texts that have the greatest influence on early success in reading? How can children's existing knowledge and classroom environments enhance the factors that make for success?

CIERA INQUIRY 2
Home and School

Home and school effects on early reading achievevment. How do the contexts of homes, communities, classrooms, and schools support high levels of reading achievement among primary-level children? How can these contexts be enhanced to ensure high levels of reading achievement for all children?

CIERA INQUIRY 3
Policy and Profession

Policy and professional effects on early reading achievement. How can new teachers be initiated into the profession and experienced teachers be provided with the knowledge and dispositions to teach young children to read well? How do policies at all levels support or detract from providing all children with access to high levels of reading instruction?

CIERA

Center for the Improvement of Early Reading Achievement

CIERA is a collaboration of
University of Michigan
University of Virginia
Michigan State University
with
University of Minnesota
University of Southern California

University of Michigan School of Education

610 E University Av, Rm 1600 SEB
Ann Arbor, MI 48109-1259

734.647.6940 voice
734.763.1229 fax
ciera@umich.edu

www.ciera.org