

THE RELATIONSHIPS BETWEEN ACHIEVEMENT IN  
BASIC READING AND LANGUAGE AND ACHIEVEMENT IN  
READING COMPREHENSION ACROSS THE SCHOOL YEARS

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## CHAPTER I

### INTRODUCTION AND REVIEW OF LITERATURE

#### Introduction

Twenty years ago Perfetti (1985) stated, “the central processes of reading are essentially mental operations on linguistic structures,” and that “differences in reading ability turn out to depend on its linguistic components” (p. 5). This language-reading relationship continues to be explored and is important from at least two perspectives: (a) understanding the nature of language-reading interaction, and (b) understanding how these processes are potentially disrupted in disordered populations. Aside from reading difficulties related to sensory disruption of the visual pathway, reading problems are typically considered to be language-based (Catts, 1989, 1991; Liberman & Liberman, 1990; Mann & Brady, 1988; Perfetti, 1985). However, there are disagreements regarding the relative importance of specific language skills for reading comprehension.

The purpose of this study was to examine the relationship between achievement in basic reading, sound awareness, and oral language and achievement in reading comprehension during the school years. The goal was to identify particular aspects of oral language and basic reading skills that are important for reading comprehension, and to examine patterns of these relationships across age and grade levels for potential differences across time.

## *Definitions*

Both language and reading have been extensively examined in the literature. This wide coverage has resulted in disparity in terms and definitions, warranting clarification in the context of this review and study. Herein, *language* is defined as a shared, rule-based system of symbolic representation of concepts (Owens, 1988). It consists of conventions for *phonology*, which is the system of sounds in a language. *Morphology* refers to word structure and units of meaning, and *syntax* refers to the rules for combining words. Together, these conventions for morphology and syntax comprise the *grammar* of a language (Bloomfield, 1933). Language also includes vocabulary, often referred to as *semantics* (Camarata, 1991).

Language can be used in both oral and written forms. When oral language is heard and interpreted, the process is defined as *listening comprehension*; when written language is decoded and interpreted, it is defined as *reading comprehension*. Both are ultimately processes of linguistic comprehension, the application of linguistic knowledge to determine meaning. Reading comprehension is contingent upon sufficient visual decoding of the written form of language, just as one must hear and interpret speech in order to engage in listening comprehension. In both instances, reception of input, either through listening or visual decoding, is necessary but not sufficient for comprehension. In this paper, *reading* will refer to the processes of successfully decoding and comprehending written text. Components of reading, such as letter identification and reading comprehension, will be specified as such.

## Review of Literature

The following literature review offers a summary of models and research regarding the relationship between language and reading, and is organized into three sections. The first reviews general models of the shared bases of language and reading and the differences between the tasks of listening comprehension and reading comprehension. The second section reviews studies that have examined the relationship between language and reading at the linguistic levels identified in models of this relationship. Although the proposed study is not focused on individuals with disorders of language or reading, these clinical studies highlight aspects of language that are important for reading proficiency through analysis of disruptions in the typical course of literacy acquisition. Finally, the third section considers these findings in the context of proposed models and their implications for concurrent assessment of language and reading.

### *Models of Language and Reading*

The association between language skills and reading skills has been described through both general models and processing models. General models offer a broad overview of the linkage between language and reading, whereas processing models are more specific regarding the linguistic processes involved in reading comprehension. Examples of both types will be discussed.

#### *General Reading Models*

General reading models have sought to provide a core description of the overall relationship between reading and broader language knowledge. They are characterized

by use of broadly defined terminology, and do not attempt to provide specific details regarding the actual decoding and comprehension process.

*Gough and Tunmer's model.* The most cited general reading model is the work of Gough and Tunmer (1986). Their "Simple View of Reading," postulates that reading (R) is the product of decoding (D) and linguistic comprehension (L) in the equation " $R = D \times L$ ". This equation illustrates that insufficient decoding or linguistic comprehension (or both), yielding a zero in the equation, will produce a reading product with a value of zero. The authors note that reading is a skill that is overlaid onto oral language, with the additional demand of decoding the visual stimulus. For the purposes of this review, this model illustrates the central nature of linguistic ability for reading competence.

*Konold et al.'s model.* Another general model was described recently by Konold, Juel, McKinnon, & Deffes (2003). In this model, listening comprehension is viewed as the foundation for reading comprehension. Onto this foundation, decoding is built through exposure to language (facilitating development of phonological awareness) and explicit instruction in the nature of sound-symbol relationships. After decoding skills are mastered, word identification can ensue, initially through the sounding out of words, and eventually through automatic word recognition. Word meanings are then accessible from the individual's existing vocabulary, which heretofore had been utilized exclusively for listening comprehension. This model expands upon the Simple View of Reading by describing the prerequisites and general process for acquisition of decoding and comprehension skills.

*Summary of general models.* Each of these general models makes two claims. First, each considers an individual's linguistic knowledge to be required for both listening

comprehension and reading comprehension. Each model also notes that decoding is necessary but not sufficient for reading comprehension. In contrast, comprehension processing models elaborate upon these views to explain the relationship between reading and language in more depth.

### *Comprehension Processing Models*

In contrast to general models, processing models attempt to describe the sequence of cognitive events (referred to as “processing”) that occur during decoding and comprehension (Just & Carpenter, 1987; Kamhi & Catts, 2002). Processing models offer illustrations of the sequence in which the mind receives input and applies it to stored linguistic knowledge in order to derive meaning. They are characterized by the ways in which linguistic information is organized, and by the flow of processing in the model.

*Kamhi and Catts’ model.* Kamhi and Catts (2002) present a linguistic processing model for both listening comprehension and reading comprehension. In this model, both listening comprehension and reading comprehension involve three stages: perceptual analysis, word recognition, and higher-order processing. Within this interactive, parallel processing model, information from one stage can be shared with any of the other stages in order to support analysis of the input. This dual-modality approach illustrates the shared correlates of language and reading.

At the level of perceptual analysis the two modalities are inherently different; listening relies on auditory input, whereas reading relies on visual input. Beyond this stage, however, this model does not differentiate between listening comprehension and reading comprehension. At the stage of word recognition, the lexicon is characterized as the product of interaction among knowledge in the areas of phonological representation,

word meaning, and visual representation. This level also includes the grammatical and syntactic aspects of word meaning. Successful processing relies upon the individual having sufficient knowledge of the words to be analyzed, or at the very least, enough knowledge to infer word meaning. The higher-order processing stage is also identical for both modalities, involving processing of words strung together in an utterance or text. This level operates on the basis of two types of information: (1) grammatical and syntactic knowledge at the multi-word utterance level and (2) knowledge of semantic relations. Additionally, this level incorporates world knowledge to aid in comprehension. In listening comprehension and reading comprehension, the end product of this processing model is understanding meaning.

Discussing this linguistic processing model, Kamhi and Catts point out two distinct differences between listening and reading. First, they note that oral language is typically learned without direct instruction, whereas reading usually must be taught explicitly. For these reasons, discrepancies between language proficiency and reading proficiency may be the result of lack of exposure to reading materials or inadequate instruction. Secondly, they acknowledge that literacy acquisition, because it is not a developmental accomplishment like listening comprehension, requires conscious practice, attention, and motivation. Disruption in these factors may interfere with reading competence, as noted by other authors who emphasized the importance of attention (Shaywitz, Fletcher, & Shaywitz, 1996), motivation (Scarborough & Dobrich, 1994), and quality of instruction (Foorman, Francis, Fletcher, & Lynn, 1996) for reading success.

*Just and Carpenter's model.* A computational processing model was proposed by Just and Carpenter (1987), based on a cognitive approach to reading theory. Within this

approach, reading is considered to be a coordinated execution of four types of processes: perceptual, lexical, semantic/syntactic, and representational, with an end product of comprehension. Perceptual processes handle visual input. Lexical processes address word meaning, and semantic/syntactic processes organize meaning into larger units (such as phrases). Representational processes support interpretation of meaning with respect to type of text, also referred to as schema knowledge.

This approach is based on spreading activation modeling as described by Rumelhart and McClelland (1981). In that view, linguistic knowledge is stored in semantic networks in which knowledge of individual words and phonemes are stored as interconnected nodes. Within this framework, neural nodes are organized into “neighborhoods” on the basis of phonology and meaning. For instance, nodes for the words “cat” and “dog” would be relatively close together in the neighborhood because they represent four-legged, furry, domesticated animals, but the nodes for “lamp” and “shrub” would be relatively distant because of their perceptual, semantic, and phonological differences. Likewise, nodes for “cat” and “cap” would be relatively close due to their phonemic similarities, whereas “dog” and “kitchen” would be relatively distant in a phonemic neighborhood. In this model, nodes are excited or inhibited by input and its context, with an end result of comprehension. As applied in Just and Carpenter’s theory, this spreading activation is not strictly sequential. Rather, processing occurs in parallel within and between levels in the model, and increasingly so as reading proficiency increases and becomes more automatic. The end result of parallel processing via spreading activation across the four levels of processes is comprehension. This model emphasizes the interconnected nature of language and reading by highlighting the

interactive processes among aspects of linguistic knowledge that facilitate reading comprehension success.

*Summary of processing models.* These processing models expanded upon the earlier general models of the relationship between language and reading. Like the general models, the recognition of input differences is acknowledged. However, these processing models offer further descriptions of the associations among levels of linguistic knowledge in listening and reading comprehension. Extensive critical review of these models is beyond the scope of the present investigation; they are presented here to illustrate two important aspects of the relationship between language and reading. First, these two modalities of comprehension differ in input but are otherwise similar. Secondly, processing models differentiate linguistic knowledge utilized in both listening comprehension and reading comprehension into phonological, lexical, and morphosyntactic components. As such, exploration of the relative influence of these specific aspects of language on reading comprehension could further quantify the relationship between language and reading.

Furthermore, these models provide a rationale for examining developmental data in reading and language to explore potential associations among these domains. Because reading acquisition is a learning process overlaid on the ongoing yet relatively more developed process of language acquisition, the relationships between specific language abilities and reading comprehension proficiency may differ over time. Such relationships could be systematically examined to determine whether such shifts exist.



### *Studies of the Relationship between Language and Reading Skills*

A number of studies have examined the relationship between language and reading in children using two primary approaches: (a) general, prospective studies following the progression of language and reading acquisition in samples of typically-developing children and with those considered at-risk for language disorder, and (b) clinical studies of the communication and literacy skills of children with disorders in language and/or reading. Each type of research has contributed to the understanding of the language-reading association. Prospective, population-based studies support a language-reading association, while detailed studies of individuals with disorders have sought to clarify these relationships by examining phonological awareness, vocabulary, grammar, and receptive language competencies associated with language difficulties and reading difficulties.

#### *Prospective Studies*

Early prospective studies followed the progress of groups of children through the school years to determine if baseline characteristics, including language skills observed in preschool or kindergarten, could predict later reading performance (Badian, 1988; Forell & Hood, 1985; de Hirsch & Jansky, 1967). Each of these studies followed the progress of students enrolled in general education settings through the period of reading acquisition, with sizable numbers of students identified with reading difficulties during the course of the investigations. Two consistent findings emerged from these studies: (a) children with lower levels of language performance were at a higher risk for difficulties learning to read, and (b) children who were poor readers were at risk for further academic failure in the later school years.

Language-based difficulties were noted in children who went on to have difficulty learning to read in these studies. Weakness in the areas of oral vocabulary (de Hirsch & Jansky, 1967) and complex syntax (Rutter & Yule, 1975) were predictive of future reading problems. With respect to persistence of difficulty, the vast majority of children with reading problems identified by third grade continued to have reading and other academic problems into adolescence, despite intervention efforts to mitigate these difficulties (Badian, 1988). These early studies are frequently cited as the rationale for subsequent studies that have more carefully examined the relationship between language and reading.

### *Clinical Studies*

The relationship between language and reading has also been explored in studies of clinical populations. As noted by Vellutino (1979), “deficiencies in any aspect of linguistic functioning will presumably result in difficulty reading” (p. 1040). These studies have examined the effect of selective problems in language on reading, and vice versa, in an attempt to illuminate specific skills that are important for both language and reading proficiency. Disruption in phonological awareness (Juel, 1988; Kamhi & Catts, 1986; Lencher, Gerber & Routh, 1990; Scarborough, 1990), lexical knowledge (Rescorla, 2005; Snow, Tabors, Nicholson, & Kurland, 1995), grammar (Catts, Fey, Tomblin, & Zhang, 2002), syntactic skills (Scarborough, 1990, 1991), and general receptive language (Catts et al., 2002; Rissman, Curtiss, & Tallal, 1990; Hoover & Gough, 1990) have been strongly associated with reading comprehension difficulties. Severity of these difficulties, and the impact of difficulty in more than one of these areas, has also been explored (Aram & Nation, 1980; Bishop & Adams, 1990; Catts, 1991; Hall & Tomblin,

1978; Haines & Naidoo, 1991; Levi, Capozzi, Fabrizi & Sechi, 1982; Tomblin, Zhang, Buckwalter, & O'Brien, 2003). The following sections will review studies of the influence of disruptions in each of these linguistic areas on literacy acquisition.

*Phonological awareness.* Phonological awareness is defined as “awareness or sensitivity to the sound structure of language” (Swank & Catts, 1994, p. 9). Such awareness is critical for decoding written text. As a construct, phonological awareness encompasses the ability to manipulate sounds in a variety of ways. In Juel’s (1988) longitudinal study of children from first through fourth grade, first graders with low scores on a broad test of phonological awareness were more likely to be diagnosed with reading difficulties in fourth grade. Several specific phonological awareness tasks have been identified as predictors of decoding skills. In particular, rhyming, sound deletion, and sound substitution have emerged as tasks that are significantly associated with decoding for reading (Kamhi & Catts, 1986; Lencher et al., 1990; Scarborough, 1990).

The ability to state whether two words rhyme, or to produce a rhyming word for a target word, has been associated with decoding. In Scarborough’s (1990) longitudinal study of the relationship between preschool development and later academic performance, identification of rhyme and providing rhyming words at 42 months was highly predictive of basic decoding proficiency at age 5. Early difficulties with these tasks were associated with diagnosis of dyslexia in second grade. Rhyming ability was also identified by McDougall, Hulme, Ellis, and Monk (1994) as an independent predictor of reading ability in their study of 69 children between the ages of 7 and 9 years with low, average, or high reading abilities. For all three reading ability groups, performance on rhyming tasks was significantly different.

Another finding of McDougal et al. was that syllable deletion varied according to reading level group. This supports previous studies that have claimed a strong relationship between syllable deletion and reading. Kamhi and Catts (1986) reported that performance on phoneme elision tasks was different for children between the ages of 6 to 8 years with reading difficulties and age-matched, typically-developing peers. Likewise, Lencher et al. (1990) reported that deletion tasks were more highly correlated with decoding than other phonological awareness tasks for third and fourth grade boys with and without reading difficulties. Their study also indicated that phonological tasks involving sound substitution were strongly associated with decoding performance.

The appropriateness of various phonological awareness tasks for assessment across the early school years was explored by Schatschneider et al. (1999) in a study based on item response theory. The authors concluded that a variety of phonological awareness tasks assesses the broader construct of phonological awareness, but that the usefulness of particular approaches varies according to a child's skill level. For example, this study indicated that blending tasks were most appropriate for discriminating the abilities of very young children, whereas elision tasks are most appropriate for children in first and second grade. But, both blending and elision are considered phonological awareness tasks.

*Lexical knowledge.* The end product of decoding is word recognition and determination of meaning. As such, knowledge of word meanings is important for accuracy and sufficient speed in the reading comprehension process (Yang & Kuo, 2003). The importance of lexical knowledge for reading comprehension has been examined by Nation and Snowling (1998) and in the longitudinal work of Rescorla (2005).

Nation and Snowling (1998) compared the reading skills of 16 nine-year-olds with age-appropriate reading achievement and 16 nine-year-olds with poor reading comprehension but age-appropriate non-word decoding skills. The performance of children with poor comprehension was significantly slower and less accurate than the comparison group on three tasks: providing synonyms, generating words associated with a topic (such as generating a list of types of animals), and oral reading of low-frequency words. These results were interpreted as evidence that word knowledge influences both decoding and comprehension, and implicated semantic deficits in poor reading comprehension.

In a longitudinal study, Rescorla (2005) followed the progress of 28 children identified as having difficulty with language at age two (referred to as “late talkers”), and compared their language skills with a matched group of typically-developing peers at various intervals. At age 13, late talkers’ performance on tests of vocabulary (both comprehension and production), though not in the clinical range, was significantly poorer than the comparison group. They were also significantly poorer in reading comprehension despite similar performance on basic reading (decoding) tasks. Furthermore, vocabulary at age two was identified as a significant predictor of vocabulary, grammar, and reading comprehension at age 13. Rescorla concluded that there is an association between early vocabulary size and later language and reading skills, indicating that variation within the typical range of language achievement is associated with variation in reading achievement.

*Influences of grammar.* The processing models discussed above each specify a component encompassing knowledge of grammar, which includes morphology and

syntax. Disruption in these areas has been associated with reading comprehension difficulties. The following studies consider the relationships between these skills and reading proficiency.

Lyytinen and Lyytinen (2004) reported that children with a familial history of dyslexia were more likely to exhibit deficits in inflectional morphology than their age-matched peers at the age of 3.5 years, and that the extent of these deficits was predictive of later diagnosis of dyslexia for this at-risk group. This supports previous findings of a longitudinal study by Catts et al. (2002). In this study of 208 children identified with language difficulties in kindergarten and a matched group of typically-developing peers, scores on tests of grammar were predictive of both future and concurrent language proficiency, as well as reading proficiency at grades two and four.

Considering this relationship from a different perspective, a recent study examined the linguistic skills of a group of 25 eight-year-old children diagnosed with reading comprehension difficulties who had not previously been diagnosed with language difficulties, in comparison with a matched group of 23 same-age peers without reading difficulties (Nation et al., 2004). For the group with reading comprehension difficulties, scores for the Recalling Sentences test of the *Clinical Evaluation of Language Fundamentals, Third Edition, United Kingdom version* (Semel, Wiig, & Secord, 2000) and a past-tense elicitation procedure were significantly lower than for the comparison group. Based on these measures of grammar, 26% of the poor readers were eligible for diagnosis of language difficulties.

Other studies have reported that general receptive language deficit across semantics, grammar, and syntax has a negative impact on future reading comprehension

(Bishop & Adams, 1990; Rissman et al., Tallal, 1990). In a five-year longitudinal study of the annual progress of 89 4-year-old children diagnosed with language difficulties, receptive language at age 4 was most predictive of academic placement at age 8 (Rissman et al., 1990). Similarly, longitudinal assessment of children identified with receptive and expressive language difficulties at age 4 revealed that their reading comprehension scores at age 8 were “disproportionately poor relative to their reading accuracy” (Bishop & Adams, 1990, p. 1033).

### *Shifts in the Relationship between Language and Reading over Time*

Each of the aforementioned studies has examined the relationship between particular linguistic skills and reading. Taking this approach a step further, researchers have attempted to examine this relationship over time, with mixed results.

An early study by Curtis (1980) examined the concurrent performance of students in grades 2, 3, 4, and 5, some of whom had reading difficulties, on tests of language and reading, reaction time, memory span, matching speed, and vocalization speed. For younger children with appropriate reading skills and older children with reading difficulties, decoding was the strongest predictor of reading comprehension. In older, skilled readers, listening comprehension was a stronger predictor of reading comprehension. The author concluded that listening comprehension becomes more important as decoding becomes more automatic.

A related study by Fletcher, Satz, and Scholes (1981) assessed the language skills of 5, 8, and 11-year-olds with and without reading difficulties. Their results indicated that later-developing language skills differentiated the reading performance of older children, but did not prove that earlier-developing language skills differentiated early

reading. The authors concluded that the inability to prove this latter relationship may lie in their choice of tests. They encouraged further investigation of this relationship with measures that are more sensitive to differences in early language skills, such as tests of phonological awareness.

Age range constraints, as opposed to assessment constraints, were faced in Butler, Marsh, Sheppard, and Sheppard's (1986) follow-up of 392 kindergarten students through grade 6. Their results revealed that reading achievement was reliably predicted in grades 3 and 6 but not in grades 1 and 2, and that reading achievement itself is a better predictor of future reading achievement than language or other psycholinguistic abilities. They advised that future studies of these relationships should include even older children for optimal prediction, and characterized developmental change in reading as a fan-spread effect in which the differences among students increases over time.

These findings were elaborated by Vellutino, Scanlon, Small, and Tanzman (1991) in their study of children at grades 2 to 3 and grades 6 to 7 whose reading skills ranged from impaired to good. For the younger group, tests of word identification and decoding were most strongly associated with reading comprehension, whereas reading comprehension for the older group was more strongly associated with listening comprehension. For children with impaired reading skills, performance on measures of reading sub-skills and language were lower than those of the other participants.

Collectively, these studies make two important points regarding the relationship between language and reading over time. First, they highlight the importance of considering both decoding and listening comprehension when examining reading comprehension. They also provide a rationale for examining these relationships across



the school years, as opposed to limiting analysis to participants in the elementary school years.

#### Concurrent Assessment of Language and Reading with the Woodcock-Johnson III

The models of language and reading comprehension and the studies of specific linguistic influences present a strong argument for an interrelated nature. These studies demonstrate that examination of these relationships should include assessment of phonological awareness, letter-sound association and decoding, vocabulary, grammar, listening comprehension, and reading comprehension. They also indicate that relationships of basic reading skills and language with reading comprehension change over time, and that consideration of a broad age-range is necessary to explore these relationships more fully.

One approach for directly examining the extent of specific interrelationships is concurrent assessment. This approach was difficult in previous studies of language and reading because a single, co-normed instrument was not available to address both language and reading. Thus, previous work required concurrent assessment with multiple tests to compare achievement in these areas. This issue can be addressed with the *Woodcock-Johnson III* (WJ III; Woodcock, McGrew & Mather, 2001). This battery consists of measures that address phonological awareness, vocabulary, and receptive and expressive language, as well as measures of basic reading skills (such as decoding) and reading comprehension. It is the only single instrument currently available that evaluates each of these areas and has been designed to allow direct comparison of scores between and among tests.

### *Theoretical Basis*

WJ III, which includes the *Tests of Achievement* and the *Tests of Cognitive Abilities*, is based on the Cattell-Horn-Carroll Theory of Cognitive Abilities. This theory was derived from two primary theories: the Cattell-Horn Gf-Gc Model and Carroll's Three Stratum Model.

The Cattell-Horn Gf-Gc Model began as Cattell's (1941) conceptualization of two forms of intelligence that explain individual differences: fluid intelligence (Gf) and crystallized intelligence (Gc). This dichotomous representation of intelligence was in response to the prevailing trend at that time of considering intelligence as a singular, unitary concept, referred to as Spearman's "g," general intelligence (1927). Cattell's model was later elaborated by Horn to include Gf, Gc, and seven additional types of intellectual abilities: Short-Term Acquisition and Retrieval, Long-Term Storage and Retrieval, Visual Intelligence, Auditory Intelligence, Cognitive Processing Speed, Correct Decision Speed, and Quantitative Knowledge (Horn 1991, 1994). With these additions, the model emerged as a multidimensional representation of cognitive ability.

Working from this model, Carroll (1993) undertook the task of factor analysis of data from more than 60 years of research on human cognitive abilities to further clarify the abilities that comprise intelligence, resulting in Carroll's Three-Stratum Model of intelligence. Based on these analyses, he proposed that intelligence can be examined at three levels: Stratum I, Stratum II, and Stratum III. At the most basic level, Carroll identified 69 factorially distinct narrow abilities which he considered to be Stratum I. These narrow abilities were grouped into broader categories of intelligence at Stratum II, which consisted of Fluid Intelligence, Crystallized Intelligence, General Memory and

Learning, Broad Visual Perception, Broad Auditory Perception, Broad Retrieval Ability, Broad Cognitive Speediness, and Processing Speed. At the highest level, Stratum III, Carroll recognized a general factor, General Intelligence, as a confirmation of abilities in Strata I and II. This work differs from that of Cattell and Horn in its emphasis on the importance of the general factor, which is not part of Cattell and Horn's theory.

Today, this collection of research is referred to as Cattell-Horn-Carroll (CHC) theory (McGrew & Woodcock, 2001), and also as Gf-Gc theory (McGrew & Flanagan, 1998). According to the *WJ III Technical Manual*, "WJ III is a measurement model of CHC theory" (McGrew & Woodcock, 2001, p. 11). It was designed to provide data on individual performance with respect to general intelligence and achievement (analogous to Carroll's Stratum III), broad abilities (analogous to the areas identified by Cattell and Horn, and in Carroll's Stratum II) and narrow abilities (Carroll's Stratum I). As such, it is serving to bridge the gap between theory and practice in psychological assessment. Although no single test or battery can provide a complete evaluation of the entire breadth and depth of intelligence as conceptualized by CHC theory, the WJ III is specifically designed to assess the CHC model.

### *Test Structure*

The *Woodcock-Johnson III Tests of Achievement* battery (WJ III ACH) is an application of CHC theory to broad educational curricular areas. Figure 1 presents the general hierarchical structure of the WJ III ACH; Table 1 presents the curricular areas, clusters, and tests that comprise WJ III ACH.

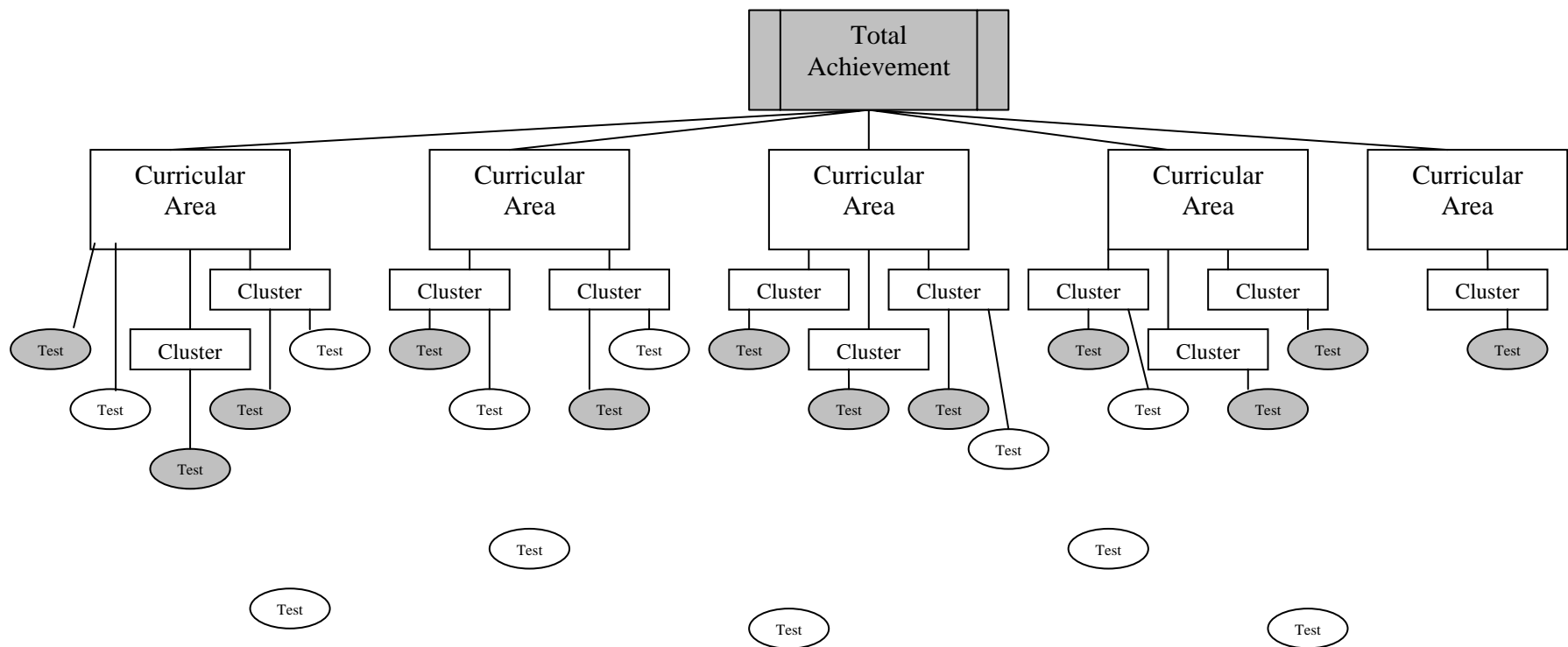


Figure 1. Organization of *Woodcock-Johnson III Tests of Achievement*. This graphic shows the levels of test organization and scoring. Shaded ovals represent Standard Battery tests that comprise Total Achievement score; white ovals represent Extended Battery tests. Detached ovals represent Extended Battery supplemental tests not associated with a particular curricular area.

Table 1. Curricular areas, clusters, and tests of *Woodcock-Johnson III Tests of Achievement* (McGrew & Woodcock, 2001, p. 2).

<b>Curricular areas</b>	<b>Clusters</b>	<b>Tests</b>
<b>Reading</b>	Basic Reading	Letter-Word Identification* Word Attack
	Reading Fluency	Reading Fluency*
	Reading Comprehension	Passage Comprehension* Reading Vocabulary
<b>Oral Language</b>	Oral Expression	Story Recall* Picture Vocabulary
	Listening Comprehension	Understanding Directions* Oral Comprehension
<b>Mathematics</b>	Math Calculation	Calculation*
	Math Fluency	Math Fluency*
	Math Reasoning	Applied Problems* Quantitative Concepts
<b>Written Language</b>	Basic Writing	Spelling* Editing
	Writing Fluency	Writing Fluency*
	Written Expression	Writing Samples*
<b>Knowledge</b>	Knowledge	Academic Knowledge*
<b>Supplemental</b>		Story Recall-Delayed Handwriting Legibility Spelling of Sounds Sound Awareness Punctuation & Capitalization

Tests marked with (\*) comprise the Standard Battery.

WJ III ACH consists of the Standard Battery of 12 tests and an Extended Battery of 10 additional tests. It is organized into four levels: Total Achievement, curricular areas, clusters, and tests. This structure allows comparison of scores within and across curricular areas for the purpose of identifying patterns of strengths, weaknesses, and discrepancies, as well as yielding Total Achievement.

Total Achievement is calculated on the basis of Standard Battery tests. These tests represent achievement across five curricular areas: Reading, Oral Language, Written Language, Mathematics, and Knowledge. Figure 2 presents the structure of Reading and Oral Language curricular areas, utilized in this study. The curricular areas are further broken down into clusters, which allows for assessment of component skills within the curricular areas. For example, Reading clusters are Basic Reading, Reading Fluency, and Reading Comprehension; Oral Language clusters are Oral Expression and Listening Comprehension. Each cluster consists of one test from the Standard Battery, and in most cases also includes one test from the Extended Battery. Listening Comprehension, for instance, consists of the tests Understanding Directions (from the Standard Battery) and Oral Comprehension (from the Extended Battery). Each of the tests is designed to assess one or more specific CHC narrow abilities. For example, the Understanding Directions test was designed to capture listening ability and language development.

One aspect of the Supplemental Battery that is worth noting is the inclusion of several tests that do not neatly fit into the five curricular areas and corresponding clusters thus far discussed. These tests are Handwriting, Delayed Story Recall, Spelling of Sounds, Punctuation and Capitalization, and Sound Awareness. Although Sound

**Woodcock-Johnson III Tests of Achievement: Curricular Areas**



**Reading and Oral Language Clusters (in ellipses) and Tests (in boxes, bolded; tested CHC narrow abilities listed in italics)**

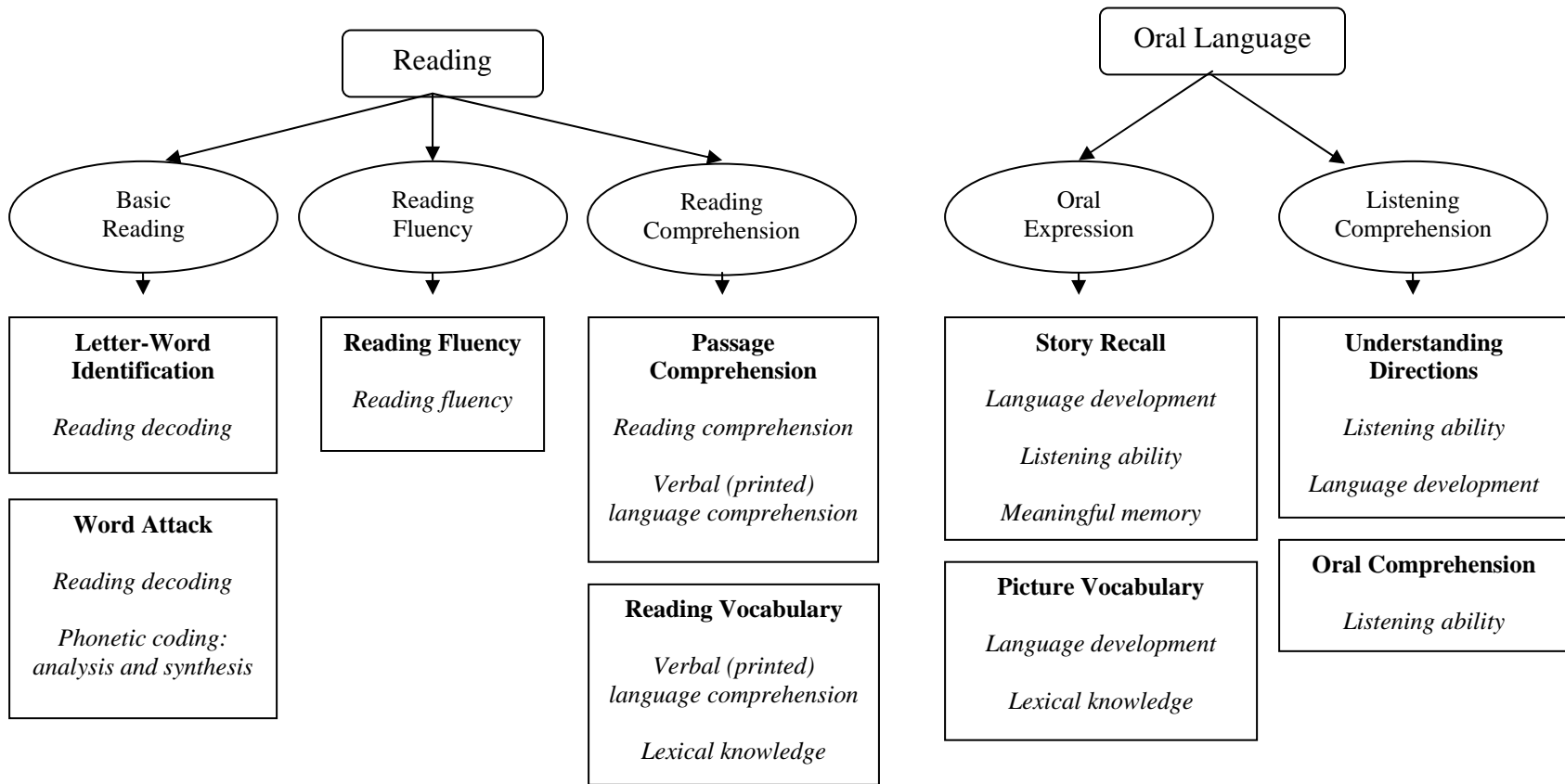


Figure 2. Curricular areas, clusters, and tests.

Awareness is not formally designated as a component of any of the three reading clusters, it is designated as a measure of the CHC narrow ability phonetic coding, as is the Basic Reading cluster test Word Attack.

### *Test Descriptions*

The tests that comprise the Reading and Oral Language curricular areas of WJ III ACH are well-suited for analysis of the relationship between language and reading. Specific pertinent tasks and areas of knowledge, identified in research summarized above, dovetail with the tests and clusters included in WJ III ACH. The following sections will describe the tests in detail and highlight their importance with respect to language and reading. Sample test items are presented in Appendix A.

#### *Oral Language*

The Oral Language curricular area of WJ III ACH consists of two clusters: Oral Expression and Listening Comprehension. Oral Expression cluster is based on scores for the tests Story Recall and Picture Vocabulary. Picture Vocabulary involves naming pictures and serves as a measure of vocabulary. Story Recall involves listening to and recalling details of stories. The emphasis in this test is on providing specific words that were used in the story, so it is an additional measure of vocabulary as well as a test of listening ability and memory. Together, scores on these tests yield Oral Expression cluster, serving primarily as an indicator of expressive vocabulary.

Listening Comprehension cluster is based on scores for the tests Understanding Directions and Oral Comprehension. Understanding Directions is a listening task in which a sequence of instructions is provided and the individual is asked to point to a



picture in a set of pictures in response. This test assesses knowledge of semantic relations, grammar, and syntax, and also working memory processes. Oral Comprehension also assesses these areas. In this test, a sentence is read with a missing word which the test taker is asked to provide. Successful completion of this task requires recruitment of knowledge of semantics, grammar, and syntax to determine the appropriate word. Thus, the combined scores from these tests serve as an indicator of comprehension of semantics, grammar, and syntax.

### *Reading*

The Reading curricular area of WJ III ACH consists of three clusters: Basic Reading, Reading Comprehension, and Reading Fluency. Basic Reading cluster is based on scores from Letter-Word Identification and Word Attack tests. Letter-Word Identification, as the name implies, requires the test taker to verbally label letters and words. Word Attack is a decoding task in which phonologically-regular non-words must be read aloud, serving as an index of decoding in the absence of support from meaning. Both of these tests, which together yield the Basic Reading cluster score, assess decoding performance.

Reading Comprehension cluster score is based on the tests Passage Comprehension and Reading Vocabulary. The structure of the Passage Comprehension test parallels that of the Oral Comprehension test described above. In Passage Comprehension, a passage is provided in which there is a missing word. The test taker must read the passage and determine what the missing word is. As in Oral Comprehension, knowledge of semantics, grammar, and syntax is involved in task completion, but this task carries the added demand of reading the passage (as opposed to

listening to the passage). Likewise, the Reading Vocabulary test parallels the Picture Vocabulary test. In Reading Vocabulary, the test taker must decode words and provide their meanings. Consequently, this task goes beyond identification and taps lexical knowledge.

Reading Fluency cluster is comprised of only one test, Reading Fluency. In this timed test, sentences are read and the test-taker must determine whether they are true or false, circling “yes” or “no” on the test record. Scoring for this test is based on both accuracy and number of items completed. This test is unique because it brings together all of the skills necessary for competent reading: decoding, comprehension, and speed. It differs from other measures of “reading fluency,” such as *Dynamic Indicators of Basic Learning Skills* (DIBELS; Good & Kaminski, 2002) which only require the test-taker to read aloud in a timed setting. In contrast, Reading Fluency in the WJ III includes comprehension and truth value of the stimulus items.

#### *Supplemental testing*

As noted in the general description of WJ III ACH, there are several tests in the battery that do not neatly fit into specific curricular areas. One such test pertinent to both Oral Language and Reading is Sound Awareness test. This test serves as a measure of phonological awareness, and consists of two different types of test items. The first set of items requires the test taker to provide rhyming words. The subsequent sections involve deleting, substituting, and reversing parts of words. As in all WJ III ACH tests, the test items are presented in an order of increasing difficulty. Thus, the simpler rhyming items are at the beginning of the test, while deletion, substitution, and reversal items appear

later in the test. This allows for inclusion of items that represent phonological awareness tasks that are associated with decoding and reading proficiency across a range of ages.

### *Summary*

The tests in the Oral Language and Reading curricular areas of WJ III ACH are especially useful for consideration of the relationship between language and reading. They assess phonological awareness, decoding, vocabulary, grammar, and syntax, which are the aspects of language and basic reading that have been identified as significant correlates of reading comprehension. Furthermore, the structure of the test battery allows for comparison within and across clusters and curricular areas, enabling examination of the relationship between language and reading at both a broad level and at a more detailed level of analysis. For these reasons, WJ III ACH is well-suited for study of these relationships.

### *Relationships of Cognitive Abilities with Reading Achievement over Time*

Several studies by McGrew and colleagues (Evans, Floyd, McGrew, & Leforgee, 2001; McGrew, 1993; Vanderwood, McGrew, Flanagan, & Keith, 2002) have utilized the normative samples of the *Woodcock-Johnson Psycho-Educational Battery Revised* (WJ-R; Woodcock & Johnson, 1989) and WJ III to examine the relationship between scores on tests from the Cognitive Batteries with Reading Achievement. The purpose of these studies was to determine the relative strength of the relationships between specific Cognitive battery tests and Reading Achievement across age groups.

The first of these studies (McGrew, 1993) analyzed the relationship between the seven WJ-R Cognitive battery clusters (Fluid Reasoning, Comprehension-Knowledge,

Visual Processing, Auditory Processing, Processing Speed, Short-Term Memory, and Long-Term Retrieval) and Basic Reading and Reading Comprehension. These relationships were analyzed through computation of multiple regression equations in which the seven Cognitive battery clusters were regressed onto Basic Reading, and in equations in which the seven clusters were regressed onto Reading Comprehension. These analyses were calculated separately for each of 21 age groups. This approach allows for comparison among the standardized regression coefficients, defined as the “portion of standard deviation units that a criterion measure changes as a function of one standard deviation change in a predictor” (McGrew, 1993, p. 41).

All regression models in this study yielded significant F-statistics. The number of significant coefficients for each Cognitive cluster across age groups was tallied to indicate which Cognitive clusters were more strongly related to Basic Reading and Reading Comprehension. Comprehension-Knowledge, Auditory Processing, Processing Speed, and Short-Term Memory were most consistently associated with Basic Reading; Comprehension-Knowledge, and Short-Term Memory were most consistently associated with Reading Comprehension.

In order to examine differences in standardized regression coefficients for these tests across age groups, scatterplots were constructed. To reduce sampling error, these plots were smoothed with the distance-weighted least squares (DWLS) approach (Wilkinson, 1990). Visual inspection of these curves revealed shifts in the relationships between the various Cognitive clusters and Basic Reading and Reading Comprehension over time. Most notably, the strength of the relationship between Comprehension-Knowledge and the reading tests increased over time.

In a follow-up study, these same regression analyses were conducted with the normative sample of WJ III (Evans, Floyd, McGrew, & Leforgee, 2001). This replication confirmed that Comprehension-Knowledge is the Cognitive battery cluster most strongly associated with Basic Reading and Reading Comprehension. This study also examined the relationship of new clusters in the WJ III, Auditory Processing and Phonological Awareness, and revealed moderate relations with Basic Reading.

Each of these studies demonstrates the usefulness of the normative samples of Woodcock-Johnson batteries for examination of shifts in relationships across ages. The methodology of these studies has successfully identified the relative strength of these relationships, offering a better understanding of the association between broad cognitive abilities and reading achievement. One question in these studies is whether age level is the most appropriate grouping metric for studies of reading. Because reading achievement is associated with school experience, examination across grade level may provide a better representation of shifts across time.

### Rationale for Study

The models and studies reviewed herein have each examined aspects of the relationship between language and reading, and represent the depth and breadth of research already conducted in this area. However, none of these studies has taken the perspective of examining concurrent language achievement and reading achievement across the school years in a large sample. The need for more research was specifically stated by McCardle, Scarborough, and Catts (2001), who remarked, “Research must also

consider changes in language development over time, and the association of these changes with current and subsequent reading achievement” (p. 236).

One reason for the lack of such studies may be that no single comprehensive co-normed measure of language and reading has been available for use with the entire range of the school-age population. This issue can be addressed with WJ III ACH, which includes both language and reading achievement batteries and has been normed for use with individuals between the ages of 2 and 95 years. One other obstacle may have been the practical difficulties associated with assessing a large, representative sample of individuals across the school years to examine these relationships across age and grade. This difficulty has been addressed through the generosity of the Woodcock-Munoz Foundation, the organization responsible for collection, analysis, and dissemination of normative data acquired during the extensive process of standardization of the WJ III. The foundation has provided demographic and test score data from more than 2,000 students for the purpose of addressing the following research questions:

- (1) What is the relationship between achievement in Language, Sound Awareness, and Basic Reading and achievement in Reading Comprehension and Reading Fluency, as measured by the *Woodcock-Johnson III Tests of Achievement*, across the age range of 6 to 18 years?
- (2) What is the relationship between achievement in Language, Sound Awareness, and Basic Reading and achievement in Reading Comprehension and Reading Fluency, as measured by the *Woodcock-Johnson III Tests of Achievement*, across the grade range 1 through 12?

## CHAPTER II

### METHOD

#### Instrumentation

*Woodcock-Johnson III Tests of Achievement* (WJ III ACH; Woodcock, McGrew, & Mather, 2001) is an individually administered, norm-referenced measure of academic achievement. It is an updated and expanded version of the *Woodcock Johnson-Revised Tests of Achievement*, which is part of the *Woodcock Johnson Psycho-Educational Battery-Revised* (Woodcock & Johnson, 1989). This battery, as in the 1979 version, offered co-normed but separate cognitive and achievement batteries. It has been favorably reviewed for its technical characteristics and theory-based construction (Kamphaus, 1993; Lee & Stefany, 1995; McGhee & Buckhalt, 1993; Reschly, 1990; Ysseldyke, 1990). These qualities are also inherent in WJ III ACH, which has received similar positive reviews (Ford, 2002). Table 2 presents a description of each of the tests pertinent to the proposed study. These tests will hereafter be abbreviated in tables and figures as follows:

- Letter-Word Identification (LWI)
- Word Attack (WA)
- Understanding Directions (UD)
- Story Recall (SR)
- Picture Vocabulary (PV)
- Oral Comprehension (OC)
- Sound Awareness (SA)
- Reading Fluency (RF)
- Passage Comprehension (PC)
- Reading Vocabulary (RV).

Table 2. Description of pertinent *Woodcock-Johnson III Tests of Achievement* tests (McGrew and Woodcock, 2003, p. 53-54).

Test	Description	Narrow CHC abilities assessed
Letter-Word Identification	Identifying printed letters and words; oral response	Reading decoding
Word Attack	Reading phonically regular nonwords; oral response	Reading decoding Phonetic coding: Analysis and synthesis
Reading Fluency	Reading printed sentences rapidly and responding true or false; motoric response (circling)	Reading speed
Passage Comprehension	Identify a missing key word that makes sense in the context of a written passage; oral response	Reading comprehension Verbal (printed) language comprehension
Reading Vocabulary	Reading words and supplying appropriate meanings; oral response	Verbal (printed) language comprehension Lexical knowledge
Story Recall	Listening to and recalling details of stories; oral response	Language development Listening ability Meaningful memory
Picture Vocabulary	Identifying objects; oral response	Language development Lexical knowledge
Understanding Directions	Listening to a sequence of instructions and then following the directions; motoric response (pointing)	Listening ability Language development



Oral Comprehension	Identifying a missing key word that makes sense in an oral passage; oral response	Listening ability
Sound Awareness	Providing rhyming words; Removing, substituting, and reversing parts of words to make new words; oral response	Phonetic coding

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### *WJ III ACH Scoring*

One advantage of WJ III ACH is the use of W-scores. W-scores are derived through application of a special transformation of the Rasch ability scale (Rasch, 1980; Woodcock, 1978; Woodcock & Dahl, 1971). As such, W-scores are similar to raw scores in that they are not adjusted for age or grade in school, but different from raw scores because they are scaled to reference achievement rather than the specific number of items correct. That is, a raw score provides the number of correct items on a test whereas a W-score provides the relative developmental level on the test. Because the purpose of this study was to examine the relationships between level of achievement in Sound Awareness, Basic Reading, Oral Expression, and Listening Comprehension and level of achievement in Reading Comprehension and Reading Fluency, W-scores are most appropriate.

For example, a child age 6 with a raw score of 15 on Letter-Word Identification test of WJ III ACH would have a standard score of 100, percentile rank of 51, and W-score of 369. In contrast, a child age 13 with the same raw score on the same test would have a standard score of 23 and percentile rank of less than one, but an identical W-score of 369. This indicates that both children performed similarly in terms of number correct (raw score) and in terms of developmental level (less than would be expected in a 10 year old or a beginning fifth grader). The W-scores are the same in both cases because the levels of achievement are equivalent, despite the differences in age.

For WJ III ACH, the mean W-score of 500 is set to approximate the performance of a child age 10 years, 0 months, in the beginning of grade 5. Consequently, the raw scores which yield particular W-scores vary across tests. In the above example, a raw

score of 15 by a 6-year-old on Letter-Word Identification was equal to a W-score of 369. For the same 6-year-old with a raw score of 3 on Passage Comprehension, the W-score would be 368. This W-score is commensurate with the above score for Letter-Word Identification, yet the raw scores for the two tests are 12 points apart. W-scores offer an opportunity to compare scores across tests without the scaling difficulties inherent in raw scores.

The tiered design of WJ III ACH allows for scoring at the levels of test, cluster, curricular area, and Total Achievement. Raw scores on individual tests are transformed into standard scores on the basis of either age or grade. Cluster standard scores are based on the average of W-scores from the tests that comprise the cluster. Likewise, curricular area scores are the average of scores from the component clusters. Total Achievement is based on the average of W-scores from the 12 tests of the Standard Battery; it does not require scores from the Extended Battery.

### *Reliability*

WJ III ACH has been deemed by its authors to “meet or exceed basic standards for both individual placement and programming decisions” (McGrew & Woodcock, 2001, p. 48) with respect to reliability. For most WJ III ACH tests (8 of the 9 tests included in this study), reliability was calculated using the split-half procedure based on data for even and odd numbered items. This procedure is inappropriate for timed tests (including Reading Fluency), for which reliability was calculated with Rasch error analysis procedures (McGrew & Woodcock, 2001).

Reliability coefficients and standard error of measurement (SEM) for the tests and age ranges involved in this study are presented in Table 3. Of the reliability coefficients for the 130 tests pertinent to this study (10 tests across the 13 years within the age range 6 to 18 years), 97 are .80 or higher. Mean reliability (averaged across the age range 6 to 18 years) for the ten tests in this study ranges from .77 to .92. Standard error of measurement is cited by *Standards for Educational and Psychological Testing* (American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 1999) as the best single indicator of test reliability. Mean SEM for W-scores (averaged across the age range 6 to 18 years) for the ten tests in this study ranges from 2.20 to 12.11.

Table 3. Reliability coefficients (r) and standard error of measure (SEM) for pertinent WJ III ACH tests for ages 6 to 18 years.

Age	LWI		WA		UD		SR		PV		OC		SA		RF		PC		RV	
	r	SEM	r	SEM	R	SEM	r	SEM	r	SEM	r	SEM	r	SEM	R	SEM	r	SEM	R	SEM
6	0.98	5.79	0.94	8.60	0.85	5.93	0.81	2.66	0.70	8.43	0.82	6.81	0.93	4.69	0.89	7.46	0.96	5.84	0.92	5.06
7	0.97	6.54	0.92	8.40	0.85	5.98	0.83	2.71	0.71	8.11	0.78	7.59	0.93	4.41	0.89	7.86	0.96	5.70	0.93	5.20
8	0.96	6.53	0.92	7.50	0.88	5.32	0.79	3.19	0.73	8.41	0.83	7.34	0.86	4.46	0.89	7.92	0.92	6.38	0.90	5.43
9	0.94	7.47	0.89	7.87	0.80	5.24	0.87	2.06	0.77	7.95	0.80	8.02	0.86	4.76	0.89	7.38	0.91	5.25	0.88	5.47
10	0.93	7.69	0.88	8.04	0.82	5.50	0.88	1.83	0.80	8.15	0.78	8.12	0.84	5.23	0.90	9.38	0.89	5.55	0.84	6.07
11	0.90	7.63	0.86	8.47	0.73	5.23	0.88	2.07	0.79	8.49	0.76	8.41	0.82	4.84	0.87	11.27	0.83	5.97	0.82	6.32
12	0.90	8.00	0.85	8.63	0.77	5.07	0.87	1.95	0.77	8.81	0.66	9.86	0.81	5.83	0.90	12.12	0.80	6.46	0.84	6.13
13	0.89	8.24	0.81	9.01	0.74	5.69	0.89	2.05	0.74	9.30	0.86	7.54	0.80	6.04	0.90	13.55	0.83	6.46	0.85	6.32
14	0.95	6.14	0.90	7.48	0.85	6.34	0.86	1.95	0.81	9.09	0.86	8.02	0.77	6.30	0.94	12.51	0.86	6.16	0.88	5.99
15	0.90	7.67	0.80	9.08	0.73	6.27	0.88	2.00	0.85	8.38	0.78	8.27	0.69	6.04	0.90	16.04	0.79	7.20	0.89	6.11
16	0.88	8.12	0.78	8.30	0.62	6.07	0.88	2.12	0.76	9.22	0.81	8.46	0.73	6.43	0.90	17.37	0.73	7.95	0.84	7.06
17	0.91	7.53	0.79	8.90	0.62	6.93	0.87	2.13	0.80	8.28	0.69	9.55	0.71	6.70	0.94	14.94	0.78	6.70	0.88	5.99
18	0.89	8.57	0.82	7.92	0.72	7.23	0.88	1.91	0.81	8.31	0.81	8.21	0.76	7.35	0.90	19.58	0.78	7.44	0.87	6.86
Mean	0.92	7.38	0.86	8.32	0.77	5.91	0.86	2.20	0.77	8.53	0.79	8.17	0.81	5.62	0.90	12.11	0.85	6.39	0.87	6.00
SD	0.03	0.86	0.05	0.53	0.08	0.67	0.03	0.40	0.04	0.44	0.06	0.83	0.08	0.95	0.02	4.05	0.07	0.78	0.03	0.59

## *Validity*

Validity of the WJ III ACH has been demonstrated with respect to content validity, criterion-related validity, and construct validity.

### *Content validity*

Content validity refers to the appropriateness of test items and organization. With respect to WJ III ACH, this applies both to the organization of tests that comprise the battery as well as the items within each of the tests. The tests themselves were chosen to represent both curricular areas and oral language competence as specified in federal education legislation, guided by the principles of CHC theory. Test clusters were devised to combine appropriate tests to ascertain achievement in areas in which more than one narrow ability is represented. Likewise, curricular areas reflect performance across a combination of tests and narrow abilities to determine broader curricular area achievement.

Item selection was conducted by experienced teachers and psychologists, with the goal of identifying items that would capture both the construct being assessed and a wide range of difficulty. Rasch model fit criteria were used to ensure that items were appropriate for the particular test and were not influenced by unrelated constructs. Individual items were also subject to bias and discrimination review; items identified as potentially biased or discriminatory were revised or retracted.

The Examiner's Manual presents graphics reflecting the growth and decline of broad abilities and narrow abilities across the life span, reproduced in Figure 3. These graphs reveal important relationships among test scores that support content validity.

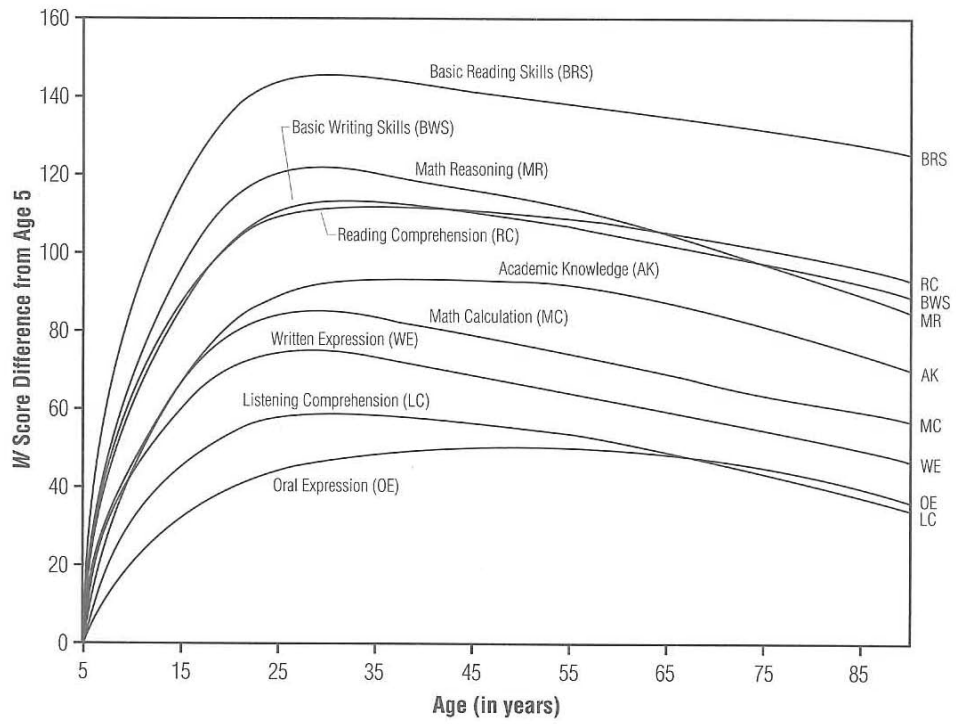


Figure 3. Growth curves for *Woodcock-Johnson III Tests of Achievement* clusters (McGrew & Woodcock, 2003, p. 56)

First, it is clear that scores represent rapid growth in curricular areas from age 5 to 25 years, followed by a slight, gradual decline. This pattern is logical, given that academic achievement increases during the period of school enrollment and may gradually decline with lack of practice and the aging process. Narrow ability growth curves also support content validity, as tests of related areas demonstrate similar slope.

#### *Criterion-related validity*

Criterion-related validity refers to the extent to which an individual's test score predicts the person's performance on a criterion measure. One of the strongest arguments for the criterion-related validity of WJ III ACH, as well the previous edition of the test, is the frequent usage of Woodcock-Johnson tests as criterion measures in evaluations of other tests. Jenkins (2003) declared that WJ-R reading subtests were the "gold standard" for criterion-related validity for comparison with other measures of reading. In fact, numerous other test makers have used correlations with WJ-R and WJ III tests as evidence of criterion related validity. Language tests, which are new in WJ III, have not yet been widely utilized for this purpose. One weakness of WJ III ACH is that there is no description in the Examiner's Manual of comparison of WJ III ACH scores with other measures of academic achievement, such as grade point average or teacher ratings. Nonetheless, this appears to be a valid measuring instrument.

#### *Construct validity*

Construct validity refers to the extent to which a test measures a theoretical trait or characteristic. With respect to WJ III ACH, the traits measured are achievement in academic areas. Numerous studies of concurrent validity with other measures of academic achievement are presented in the Examiner's Manual, with favorable findings.



For instance, correlation coefficients for tests of basic reading, reading comprehension, and overall reading range from .62 to .76 for *Kaufman Test of Educational Achievement* (Kaufman & Kaufman, 1985), and from .51 to .82 for *Wechsler Individual Achievement Test* (Wechsler, 1992). Pertinent correlations from tables in the Examiner's Manual are presented in Table 4.

Intercorrelation analysis within the battery also reveals appropriate patterns of association. Representative inter-score correlations reported for 9 to 13 year-olds are presented in Figure 4. Correlations between tests in the same cluster vary from 0.44 to 0.47 for the clusters in the Oral Language curricular area, and from 0.63 to 0.73 for clusters in the Reading curricular area. Correlations between clusters and their associated curricular area are 0.87 and 0.92 in Oral Language, and 0.78 and 0.81 in Reading.

Table 4. Correlations between *Woodcock-Johnson III Tests of Achievement* clusters and related tests

WJ III ACH Measure	<i>Kaufman Test of Educational Achievement</i>	<i>Wechsler Individual Achievement Test</i>
Broad Reading	.76 (Reading Composite)	.67 (Reading Composite)
Basic Reading	.66 (Reading Decoding)	.82 (Basic Reading)
Reading Comprehension	.62 (Reading Comprehension)	.79 (Reading Comprehension)
Oral Language		.51 (Oral Expression)
Listening Comprehension		.55 (Listening Comprehension)

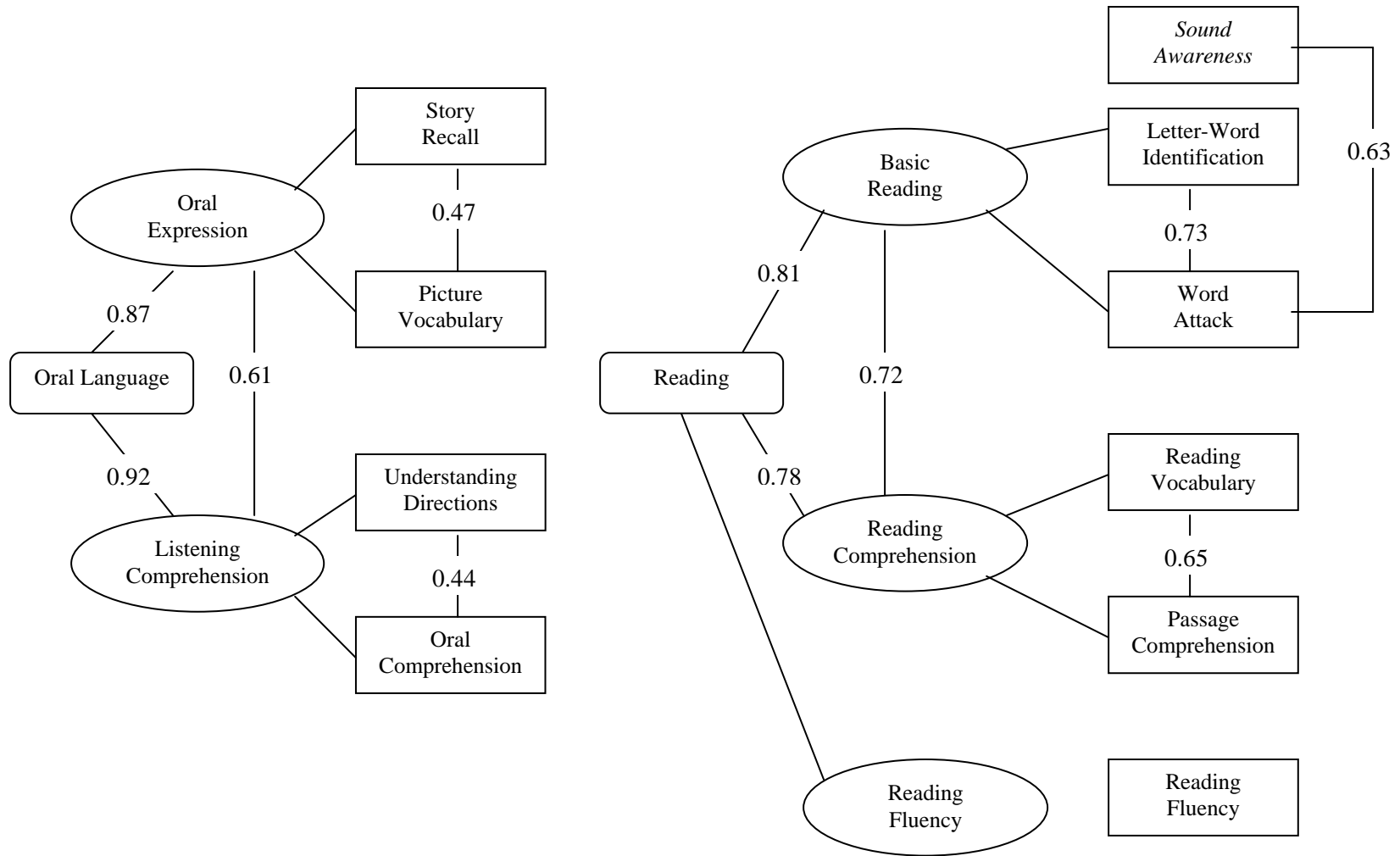


Figure 4. Within-battery correlations for 9-13 year olds.

## Participants

The data for the proposed study included scores from participants between the ages of 6 and 18 years in the age sample ( $n = 2,885$ ) and in grades 1 through 12 in the grade sample ( $n = 2,748$ ) drawn from the WJ III standardization sample. Inclusion in this study was limited to individuals who spoke English as a first language, and who were administered both the Reading Fluency cluster and the Reading Comprehension cluster during normative testing.

This study included children from 13 age levels and 12 grade levels. The subsetting of age and grade was based on mean W-scores for Reading Comprehension cluster. Each subset, which could include more than one age or grade level, was constructed using a 10-point W-score bandwidth. For example, there were more than 10 W-score points separating the mean score on Reading Comprehension cluster of age 6 and age 7, so each of these age levels formed separate subsets. But, ages 10, 11, and 12 all performed within a 10-point band, so they were collapsed into a subset. Difference in these levels were collapsed to form 6 age groups and 6 grade groups. Because growth in W-scores for Reading Comprehension cluster is greater in the earlier school years, earlier groups consist of single levels but older groups consist of multiple levels. For age, the groups were as follows: 6 years, 7 years, 8-9 years, 10-12 years, 13-16 years, and 17-18 years. For grade, the groups were as follows: grade 1, grade 2, grade 3, grades 4-6, grades 7-9, and grades 10-12. A summary of the distribution and characteristics of participants is presented by age in Table 5 and by grade in Table 6.

Table 5. Participant distribution and characteristics by age group.

Age group	Total n	Male	Female	White/ Non-Hispanic	White/ Hispanic	Black	American Indian	Asian and Pacific Islanders
6	151	82	69	110	11	27	1	2
7	222	117	105	157	17	31	10	7
8-9	566	280	286	413	45	77	18	13
10-12	838	445	393	602	68	122	15	31
13-16	809	419	390	577	74	125	16	17
17-18	299	140	159	234	12	44	5	4
Total	2885	1483	1402	2093	227	426	65	74

Table 6. Participant distribution and characteristics by grade group.

Grade group	Total n	Male	Female	White/ Non-Hispanic	White/ Hispanic	Black	American Indian	Asian and Pacific Islanders
1	195	104	91	143	12	31	4	5
2	234	132	102	162	21	36	9	6
3	301	144	157	215	27	40	12	7
4-6	874	454	420	640	62	126	17	29
7-9	639	331	308	453	62	93	14	17
10-12	505	255	250	375	34	81	8	7
Total	2748	1420	1328	1988	218	407	64	71

## Data Analysis

### *Logistics*

Data from these participants is held and managed by the Woodcock-Munoz Foundation, an organization under the direction of Dr. Frederick Schrank. A letter of request for pertinent data, and approval of this request, are attached in Appendix B. Because this investigation utilized “on the shelf” data that did not include personally identifiable information, this study qualified for exemption by the Internal Review Board (IRB) of Vanderbilt University. Application for exemption, and approval from IRB, are attached in Appendix C. According to the recommendations of the IRB, all data transmitted to the investigator by the foundation for the purpose of analysis was stored on a password-protected personal computer.

### *Addressing the Research Questions*

The research questions for this study were as follows:

- (1) What is the relationship between achievement in Language, Sound Awareness, and Basic Reading and achievement in Reading Comprehension and Reading Fluency, as measured by the *Woodcock Johnson III Tests of Achievement*, across the age range of 6 to 18 years?
- (2) What is the relationship between achievement in Language, Sound Awareness, and Basic Reading and achievement in Reading Comprehension and Reading Fluency, as measured by the *Woodcock Johnson III Tests of Achievement*, across the grade range 1 through 12?

These relationships were examined through multiple regression analyses, as previously demonstrated by McGrew (1993) in his analysis of shifts of influence of cognitive abilities (as measured by tests in the *Woodcock Johnson-Revised Cognitive Battery*) on reading achievement (as measured by the *Woodcock Johnson-Revised Tests of Achievement*) across age groups. In that study, general equations were specified and were calculated separately for each age group to allow examination of differences among standardized regression coefficients across groups. The present study utilized a similar approach, specifying five general equations to be calculated separately for each age and grade group to allow examination of differences among standardized regression coefficients. All of the calculations used W-scores, computed at the cluster level for two equations (“a” and “b” below) and at the test level for three equations (“c,” “d,” and “e” below). The general equations were constructed as follows:

- a) Basic Reading cluster, Sound Awareness test, Oral Expression cluster, and Listening Comprehension cluster scores regressed onto Reading Comprehension cluster score,
- b) Basic Reading cluster, Sound Awareness test, Oral Expression cluster, and Listening Comprehension cluster scores regressed onto Reading Fluency cluster score,
- c) Letter-Word Identification, Word Attack, Sound Awareness, Story Recall, Picture Vocabulary, Understanding Directions, and Oral Comprehension test scores regressed onto Passage Comprehension test score,



- d) Letter-Word Identification, Word Attack, Sound Awareness, Story Recall, Picture Vocabulary, Understanding Directions, and Oral Comprehension test scores regressed onto Reading Vocabulary test score, and
- e) Letter-Word Identification, Word Attack, Sound Awareness, Story Recall, Picture Vocabulary, Understanding Directions, and Oral Comprehension test scores regressed onto Reading Fluency test score.

These equations were computed separately for each of the six age groups and each of the six grade groups, for a total of 12 calculations of each of the 5 equations specified above. It is notable that the cross-sectional design of this study dictates that the 5 regression equations are not repeated on the same participant data set; rather, they are computed for separate groups of participants at each age group and at each grade group. However, it is acknowledged that the age-level and grade-level analyses themselves are not independent, but they are also not systematically overlapping.

## CHAPTER III

### RESULTS

Regression analyses were computed to address the research questions by age and by grade. All regression models yielded significant overall  $F$ -statistics ( $p < .001$ ), and regression equations for all analyses are presented in Appendix D. The following results summary reports the standardized regression coefficients,  $R^2$  and  $F$ -values for all analyses computed by age and by grade. Plots of standardized regression coefficients for pertinent tests and clusters are also presented.

#### Results by Age

All regression models calculated with data organized by age yielded significant overall  $F$ -statistics ( $p < .001$ ). The overall regression equation for Reading Fluency cluster for all age groups combined was  $Y_{RFcluster} = 1.398x_{BRcluster} - .274x_{SAcluster} - 92.330$ . The overall regression equation for Reading Comprehension cluster for all age groups combined was  $Y_{RCcluster} = .405x_{BRcluster} + .254x_{SAcluster} + .073x_{OEcluster} + .054x_{LCcluster} + 107.555$ . At the cluster level,  $R^2$  values ranged from 0.313 to 0.544 for the criterion Reading Fluency, and from 0.618 to 0.704 for the criterion Reading Comprehension. At the test level,  $R^2$  values ranged from 0.339 to 0.581 for Reading Fluency, 0.473 to 0.609 for Reading Vocabulary, and 0.420 to 0.664 for Passage Comprehension.

Plots of standardized regression coefficients are presented for predictors that were significant in more than one age group for a criterion. These plots were constructed with age groups on the x-axis and standardized regression coefficients on the y-axis. Age

groups are designated with uppercase letters (A = age 6, B = age 7, C = age 8-9, D = age 10-12, E = age 13-16, and F = age 17-18). In order to examine trends across age groups, these plots were smoothed with the distance weighted least squares (DWLS) smoothing function, calculated in the SYGRAPH module of SYSTAT (Wilkinson, 1990). Both the original plots and the DWLS smoothed plots are presented in each figure.

#### *Cluster level analyses by age*

Reading Fluency and Reading Comprehension clusters were each examined as criterion measures with the following clusters and test included as predictors in regression calculations: Basic Reading cluster, Sound Awareness test, Oral Expression cluster, and Listening Comprehension cluster. These regression equations were computed separately for each of the six age groups (6, 7, 8-9, 10-12, 13-16, and 17-18 years). Standardized regression coefficients,  $R^2$ , and  $F$ -values for these analyses are presented in Table 7.

Table 7. Standardized regression coefficients,  $R^2$  and  $F$  for cluster-level regression models by age with Basic Reading, Listening Comprehension, and Oral Expression clusters and Sound Awareness test as predictors, and with Reading Fluency (RF) and Reading Comprehension (RC) clusters as criteria

	Basic Reading		Listening Comprehension		Oral Expression		Sound Awareness		$R^2$		$F$	
	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC
Age Groups												
6	.400*	.674*	.213	.119	-.018	-.025	.199	.131	.439	.643	28.559	65.632
7	.526*	.710*	.092	.058	-.069	.025	.265*	.139	.544	.704	64.630	128.803
8-9	.500*	.458*	.155*	.160*	.121*	.112*	.097	.232*	.540	.645	164.884	254.640
10-12	.378*	.313*	.254*	.209*	.045	.153*	.102	.269*	.442	.628	164.987	351.184
13-16	.330*	.306*	.294*	.189*	.022	.142*	.117*	.301*	.425	.618	148.560	324.583
17-18	.326*	.276*	.213*	.080	.031	.169*	.082	.405*	.313	.622	33.459	121.034

For coefficient significance, \* $p < .01$

### *Reading Fluency cluster*

Basic Reading cluster was a significant predictor of Reading Fluency cluster in all age groups: 6 (standardized regression coefficient = .400), 7 (.526), 8-9 (.500), 10-12 (.378), 13-16 (.330), and 17-18 (.326). Listening Comprehension cluster was a significant predictor of Reading Fluency cluster in age groups 8-9 (.155), 10-12 (.254), 13-16 (.294), and 17-18 (.213). Oral Expression cluster was a significant predictor of Reading Fluency cluster in only one age group, 8-9 (.121). Sound Awareness test was a significant predictor of Reading Fluency cluster in age groups 7 (.265) and 13-16 (.117).

Standardized regression coefficient plots were constructed for Basic Reading cluster, Listening Comprehension cluster, and Sound Awareness test as predictors of Reading Fluency cluster. These plots are presented in Figure 5. The association between Sound Awareness test and Reading Fluency decreased across age groups. The strength of the relationship between Basic Reading cluster and Reading Fluency initially increased, followed by a steady decrease across age groups. The magnitude of the standardized regression coefficients for Listening Comprehension cluster showed the opposite pattern, with an initial decrease followed by an increasing trend across age groups.

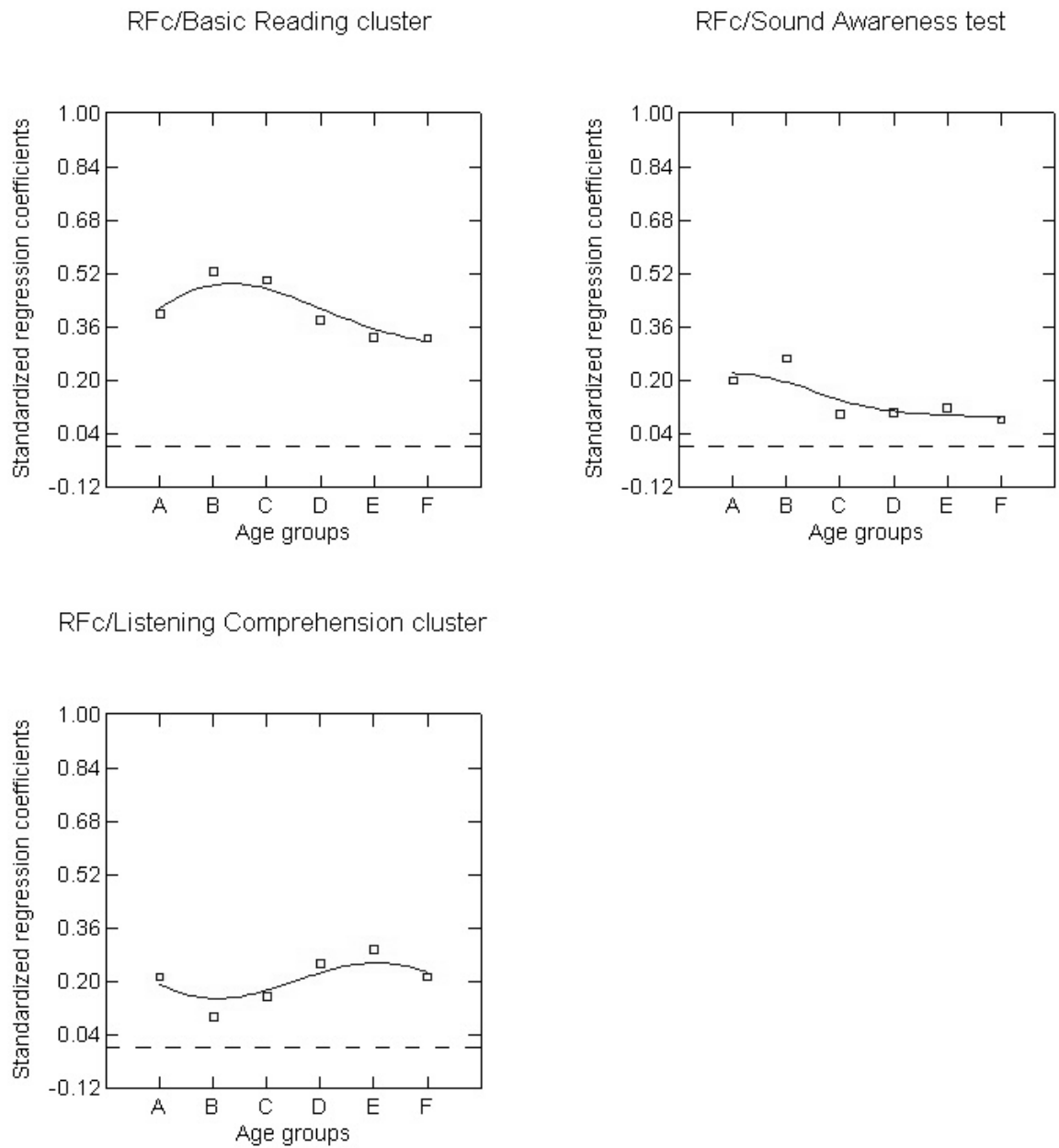


Figure 5. Standardized regression coefficient plots for predictors of Reading Fluency cluster across age groups (A = 6, B = 7, C = 8-9, D = 10-12, E = 13-16, and F = 17-18). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RF = .90 (.02), BR = .94 (.03), LC = .85 (.04), SA = .81 (.08).

### *Reading Comprehension cluster*

Basic Reading cluster was a significant predictor of Reading Comprehension cluster in all age groups: 6 (.674), 7 (.710), 8-9 (.458), 10-12 (.313), 13-16 (.306), and 17-18 (.276). Listening Comprehension cluster was a significant predictor of Reading Comprehension cluster in age groups 8-9 (.160), 10-12 (.209), and 13-16 (.189). Oral Expression cluster was a significant predictor of Reading Comprehension cluster in age groups 8-9 (.112), 10-12 (.153), 13-16 (.142), and 17-18 (.169). Sound Awareness test was a significant predictor of Reading Comprehension cluster in age groups 8-9 (.232), 10-12 (.269), 13-16 (.301), and 17-18 (.405).

Standardized regression coefficient plots, presented in Figure 6, were constructed for Basic Reading cluster, Listening Comprehension cluster, Oral Expression cluster, and Sound Awareness test. These curves indicate that the relationship between Basic Reading and Reading Comprehension decreased across age groups, whereas the degree of association between Sound Awareness and Reading Comprehension increased across age groups. The smoothed curves for both Oral Expression and Listening Comprehension each show that the smoothed trend of regression coefficients increased across age groups 6, 7, 8-9 and 10-12, followed by a plateau for Oral Expression and a decreasing trend for Listening Comprehension.

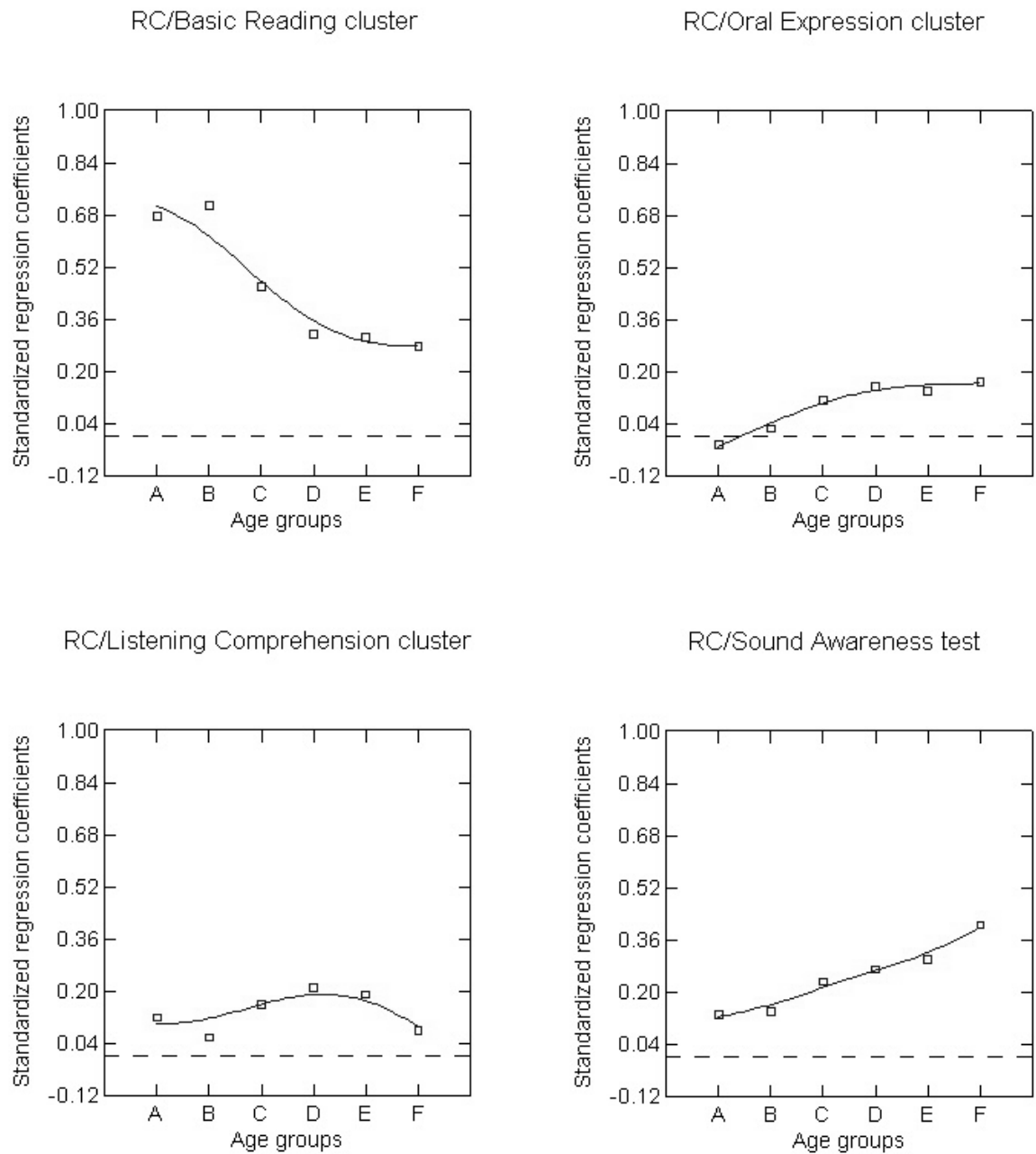


Figure 6. Standardized regression coefficient plots for predictors of Reading Comprehension cluster across age groups (A = 6, B = 7, C = 8-9, D = 10-12, E = 13-16, and F = 17-18). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RC = .91 (.03), BR = .94 (.03), LC = .85 (.04), OE = .83 (.03), SA = .81 (.08).



### *Test level analyses by age*

Reading Fluency, Reading Vocabulary, and Passage Comprehension tests were each examined as criterion measures with the following tests included as predictors in regression calculations: Letter-Word Identification, Word Attack, Understanding Directions, Story Recall, Picture Vocabulary, Oral Comprehension, and Sound Awareness. These regression equations were computed separately for each of the six age groups (6, 7, 8-9, 10-12, 13-16, and 17-18 years).

#### *Reading Fluency test*

Standardized regression coefficients,  $R^2$ , and  $F$ -values for regression equations computed with the criterion Reading Fluency test are presented in Table 8. The overall regression equation for Reading Fluency test for all age groups combined was  $Y_{RFtest} = .483x_{LWtest} + .647x_{SRtest} + 1.292x_{UDtest} + .273x_{OCtest} + .148x_{PVtest} - 833.460$ .

Letter-Word Identification test was a significant predictor of Reading Fluency test in all age groups: 6 (.545), 7(.560), 8-9 (.465), 10-12 (.300), 13-16 (.274), and 17-18 (.209). Word Attack test was a significant predictor in two age groups, 10-12 (.124) and 13-16 (.110). Understanding Directions test was a significant predictor of Reading Fluency test in age groups 8-9 (.227), 10-12 (.367), 13-16 (.388), and 17-18 (.275). Oral Comprehension test was a significant predictor in age groups 10-12 (.103) and 13-16 (.133).

Two tests were significant predictors of Reading Fluency test in only one age group each. Story Recall test was a significant predictor in age group 8-9 (.110), and Sound Awareness test was a significant predictor in age group 7 (.220). Picture Vocabulary test was not a significant predictor of Reading Fluency test in any age group.

Table 8. Standardized regression coefficients,  $R^2$  and  $F$  for test-level regression models by age with Letter-Word Identification (LWI), Word Attack (WA), Understanding Directions (UD), Story Recall (SR), Picture Vocabulary (PV), Oral Comprehension (OC), and Sound Awareness (SA) tests as predictors and Reading Fluency as criterion.

Reading Fluency									
	LWI	WA	UD	SR	PV	OC	SA	$R^2$	$F$
Age Groups									
6	.545*	-.106	-.051	.196	-.067	.172	.174	.515	21.717
7	.560*	-.001	.083	-.008	-.076	.069	.220*	.577	41.659
8-9	.465*	.090	.227*	.110*	.068	.059	-.059	.581	110.563
10-12	.300*	.124*	.367*	.059	.038	.103*	-.116	.477	108.050
13-16	.274*	.110*	.388*	.102	-.023	.133*	-.126	.479	105.217
17-18	.209*	.166	.275*	.059	-.002	.081	-.066	.339	21.351

For coefficient significance, \*  $p < .01$

Plots of standardized regression coefficients are presented in Figure 7 for Letter-Word Identification test, Word Attack test, Understanding Directions test, and Oral Comprehension test. The association between Letter-Word Identification test and Reading Fluency test steadily decreased across age groups, while the strength of association between Word Attack test and Reading Fluency test increased across age groups. The coefficients for Understanding Directions test as a predictor of Reading Fluency test also exhibited an increasing trend across age groups, with a decline observed in the oldest age group. Meanwhile, the association between Oral Comprehension test and Reading Fluency test decreased from age group 6 to age group 7, followed by a relatively stable trend across the remaining age groups.

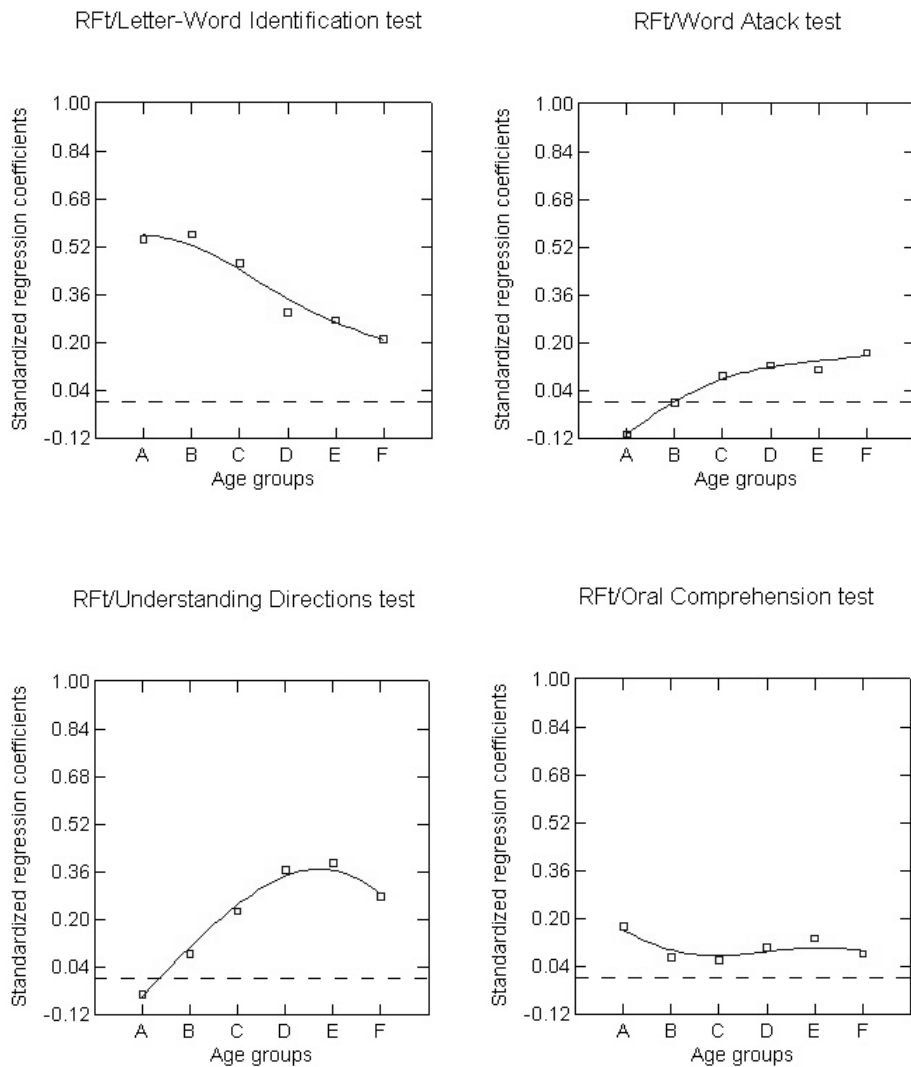


Figure 7. Standardized regression coefficient plots for predictors of Reading Fluency test across age groups (A = 6, B = 7, C = 8-9, D = 10-12, E = 13-16, and F = 17-18). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RF = .90 (.02), LWI = .92 (.03), WA = .86 (.05), UD = .77 (.08), OC = .79 (.06).

### *Reading Vocabulary test*

Standardized regression coefficients,  $R^2$ , and  $F$ -values for regression equations computed with the criterion Reading Vocabulary test are presented in Table 9. The overall regression equation for Reading Vocabulary test for all age groups combined was  $Y_{RVtest} = .174x_{LWtest} + .037x_{WAtest} + .284x_{SAtest} + .507x_{SRtest} + .087x_{UDtest} + .073x_{OCtest} + .087x_{PVtest} - 122.960$ .

Letter-Word Identification test was a significant predictor of Reading Vocabulary test in all age groups: 6 (.381), 7 (.330), 8-9 (.260), 10-12 (.221), 13-16 (.226) and 17-18 (.263). Word Attack test was a significant predictor in age groups 7 (.227) and 8-9 (.105). Story Recall test was a significant predictor of Reading Vocabulary test in age groups 7 (.185), 8-9 (.136), 10-12 (.173), 13-16 (.252), and 17-18 (.241). Picture Vocabulary test was a significant predictor of Reading Vocabulary test in age groups 8-9 (.104), 10-12 (.118), and 17-18 (.148). Oral Comprehension test was a significant predictor of Reading Vocabulary test in age groups 8-9 (.087), 10-12 (.107), and 13-16 (.114). Sound Awareness test was a significant predictor of Reading Vocabulary test in age groups 8-9 (.241), 10-12 (.220), 13-16 (.242), and 17-18 (.304). Understanding Directions test was not a significant predictor of Reading Vocabulary in any age group.

Table 9. Standardized regression coefficients,  $R^2$  and  $F$  for test-level regression models by age with Letter-Word Identification (LWI), Word Attack (WA), Understanding Directions (UD), Story Recall (SR), Picture Vocabulary (PV), Oral Comprehension (OC), and Sound Awareness (SA) tests as predictors and Reading Vocabulary as criterion.

Reading Vocabulary									
	LWI	WA	UD	SR	PV	OC	SA	$R^2$	$F$
Age Groups									
6	.381*	.074	.093	.003	.149	.064	.168	.473	18.306
7	.330*	.227*	-.049	.185*	.075	-.010	.201	.580	42.160
8-9	.260*	.105*	.084	.136*	.104*	.087*	.241*	.609	124.075
10-12	.221*	.056	.058	.173*	.118*	.107*	.220*	.562	151.915
13-16	.226*	.051	.001	.252*	.062	.114*	.242*	.589	163.855
17-18	.263*	-.006	-.050	.241*	.148*	-.069	.304*	.511	43.391

For coefficient significance, \*  $p < .01$

Standardized regression coefficient plots were constructed for Letter-Word Identification, Word Attack, Story Recall, Picture Vocabulary, Oral Comprehension, and Sound Awareness tests, presented in Figure 8. The relationship between Letter-Word Identification test and Reading Vocabulary test decreased across the first four age groups, followed by a modest increase. In contrast, the association between Word Attack test and Reading Vocabulary test decreased across age groups after an initial increase. The associations of Story Recall test and Sound Awareness test with Reading Vocabulary test increased across age groups. The trend of the relationship between Picture Vocabulary test and Reading Vocabulary test was relatively stable across age groups. The association between Oral Comprehension test and Reading Vocabulary test was also relatively stable across groups, although a decline was noted in the oldest age group.

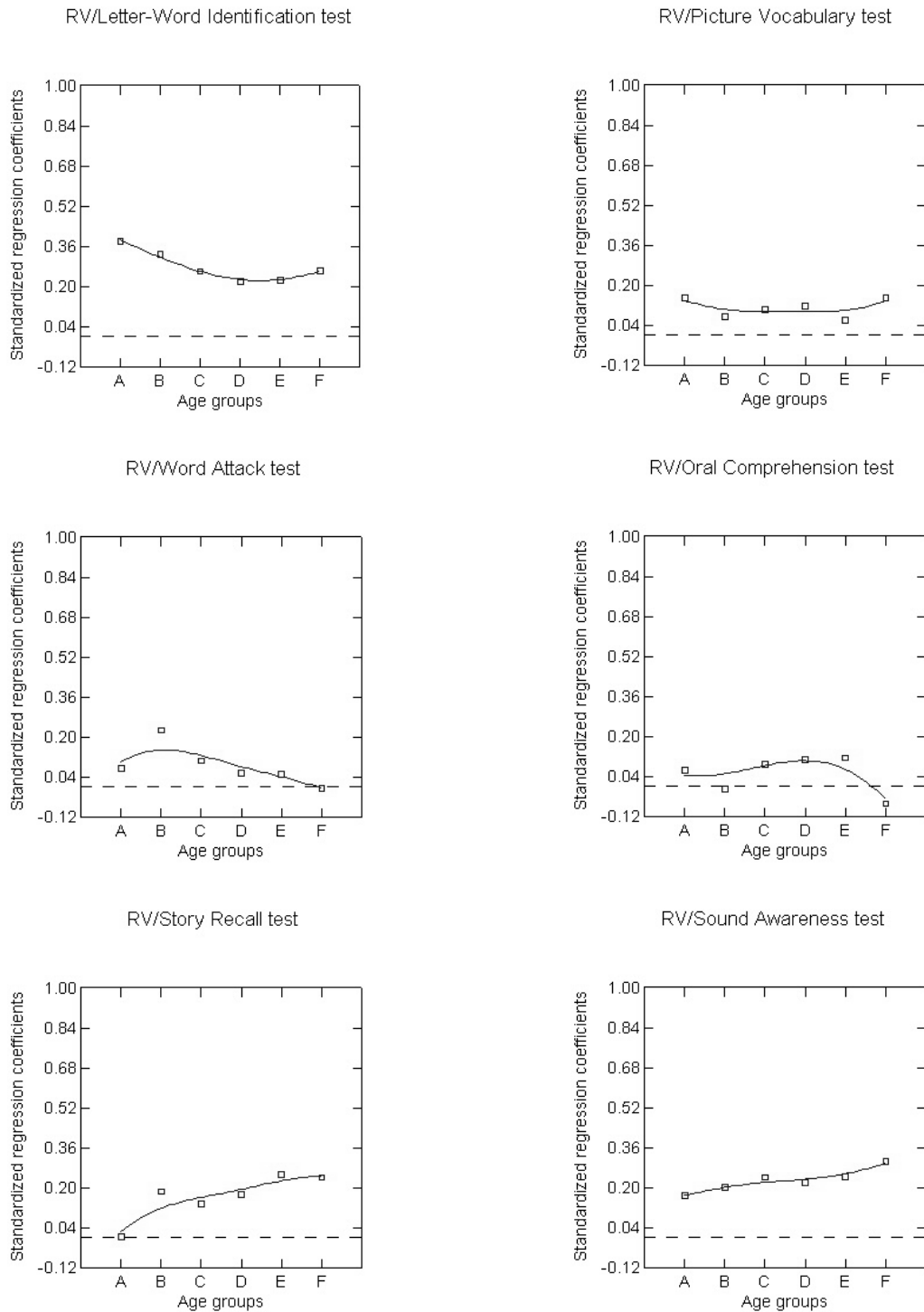


Figure 8. Standardized regression coefficient plots for predictors of Reading Vocabulary test across age groups (A = 6, B = 7, C = 8-9, D = 10-12, E = 13-16, and F = 17-18). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RV = .87 (.03), LWI = .92 (.03), SR = .86 (.03), PV = .77 (.04), SA = .81 (.08).

### *Passage Comprehension test*

Standardized regression coefficients,  $R^2$ , and  $F$ -values for regression equations computed with the criterion Passage Comprehension test are presented in Table 10. The overall regression equation for Passage Comprehension test for all age groups combined was  $Y_{PCtest} = .309x_{LWtest} + .086x_{WAtest} + .197x_{SAtest} + .162x_{UDtest} + .098x_{OCtest} + 42.648$ .

Letter-Word Identification test was a significant predictor of Passage Comprehension test in 5 of the 6 age groups: 6 (.480), 7 (.715), 8-9 (.422), 10-12 (.291), and 13-16 (.241). Oral Comprehension test was a significant predictor of Passage Comprehension test in age groups 8-9 (.116), 10-12 (.120), and 13-16 (.107). Sound Awareness test was a significant predictor of Passage Comprehension test in age groups 10-12 (.176), 13-16 (.148), and 17-18 (.331).

Three tests were significant predictors of Passage Comprehension test in only one age group each. Word Attack test was a significant predictor in age group 6 (.282), Understanding Directions test was a significant predictor in age group 10-12 (.124), and Story Recall test was a significant predictor in age group 13-16 (.160). Picture Vocabulary test was not a significant predictor of Passage Comprehension test in any age group.

Table 10. Standardized regression coefficients,  $R^2$  and  $F$  for test-level regression models by age with Letter-Word Identification (LWI), Word Attack (WA), Understanding Directions (UD), Story Recall (SR), Picture Vocabulary (PV), Oral Comprehension (OC), and Sound Awareness (SA) tests as predictors and Passage Comprehension as criterion.

Passage Comprehension									
	LWI	WA	UD	SR	PV	OC	SA	$R^2$	$F$
Age Groups									
6	.480*	.282*	.126	-.088	-.074	.041	.053	.612	32.197
7	.715*	.065	-.021	-.060	-.055	.079	.116	.664	60.291
8-9	.422*	.111	.019	.068	.022	.116*	.133	.509	82.663
10-12	.291*	.057	.124*	.041	.066	.120*	.176*	.482	110.338
13-16	.241*	.063	.054	.160*	.071	.107*	.148*	.446	92.143
17-18	.106	.098	.041	.071	.011	.139	.331*	.420	30.162

For coefficient significance, \*  $p < .01$

Standardized regression coefficient plots were constructed for Letter-Word Identification test, Oral Comprehension test, and Sound Awareness test, and are presented in Figure 9. The plot for Letter-Word Identification test reveals that the magnitude of its association with Passage Comprehension decreased across age groups after an initial rise from age group 6 to age group 7. In contrast, the association between Sound Awareness and Passage Comprehension increased across age groups. The relationship between Oral Comprehension and Passage Comprehension also exhibited a modest increase across age groups.



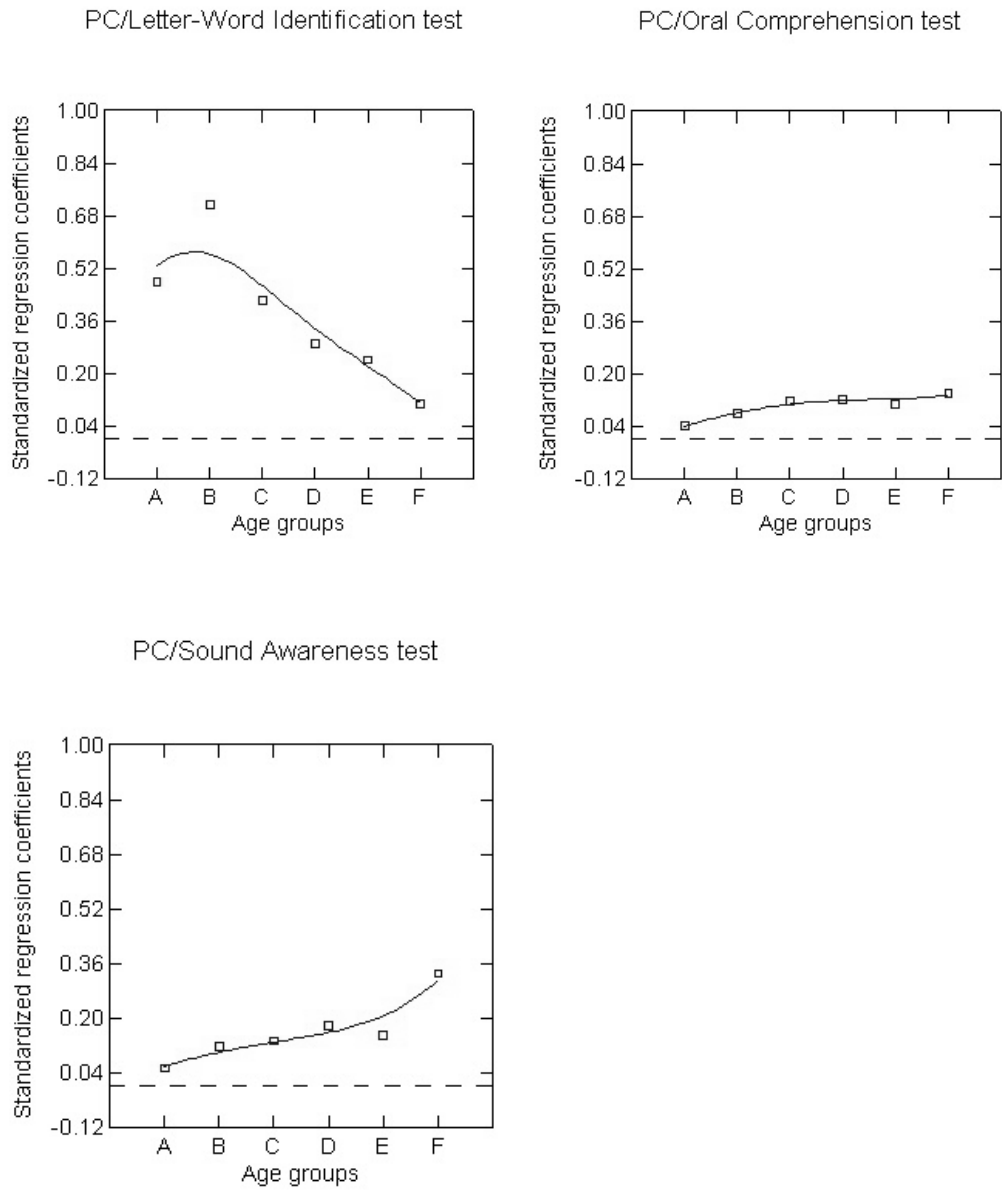


Figure 9. Standardized regression coefficient plots for predictors of Passage Comprehension test across age groups (A = 6, B = 7, C = 8-9, D = 10-12, E = 13-16, and F = 17-18). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: PC = .85 (.07), LWI = .92 (.03), OC = .79 (.06), SA = .81 (.08).

## Results by Grade

All regression models calculated with data organized by grade yielded significant overall F-statistics ( $p < .001$ ). The overall regression equation for Reading Fluency cluster for all grade groups combined was  $Y_{RFcluster} = 1.414x_{BRcluster} - .262x_{SAcluster} + .137x_{LCcluster} - 90.389$ . The overall regression equation for Reading Comprehension cluster for all grade groups combined was  $Y_{RCcluster} = .393x_{BRcluster} + .244x_{SAcluster} + .089x_{OEcluster} + .061x_{LCcluster} + 107.035$ .

At the cluster level,  $R^2$  values ranged from 0.349 to 0.530 for the criterion Reading Fluency, and from 0.577 to 0.701 for the criterion Reading Comprehension. At the test level,  $R^2$  values ranged from 0.390 to 0.587 for Reading Fluency, 0.524 to 0.636 for Reading Vocabulary, and 0.396 to 0.622 for Passage Comprehension.

Plots of standardized regression coefficients are presented for predictors that were significant in more than one grade group for a criterion. These plots were constructed with grade groups on the x-axis and standardized regression coefficients on the y-axis. Grade groups are designated with lowercase letters (a = 1, b = 2, c = 3, d = 4-6, e = 7-9, and f = 10-12). In order to examine trends across grade groups, these plots were smoothed with the distance weighted least squares (DWLS) smoothing function, calculated in the SYGRAPH module of SYSTAT (Wilkinson, 1990). Both the original plots and the DWLS smoothed plots are presented in each figure.

### *Cluster level analyses by grade*

Reading Fluency and Reading Comprehension clusters were each examined as criterion measures with the following clusters and test included as predictors in

regression calculations: Basic Reading cluster, Sound Awareness test, Oral Expression cluster, and Listening Comprehension cluster. These regression equations were computed separately for each of six grade groups (1, 2, 3, 4-6, 7-9, and 10-12). Standardized regression coefficients and  $R^2$  and F-values for cluster-level analyses are presented in Table 11.

#### *Reading Fluency cluster*

Basic Reading cluster was a significant predictor of Reading Fluency cluster in all grade groups: 1 (standardized regression coefficient = .579), 2 (.482), 3 (.414), 4-6 (.391), 7-9 (.293), and 10-12 (.351). Listening Comprehension cluster was a significant predictor in grade groups 2 (.186), 3 (.282), 4-6 (.224), 7-9 (.306), and 10-12 (.270). Neither Oral Expression cluster nor Sound Awareness test was a significant predictor of Reading Fluency cluster in any grade group.

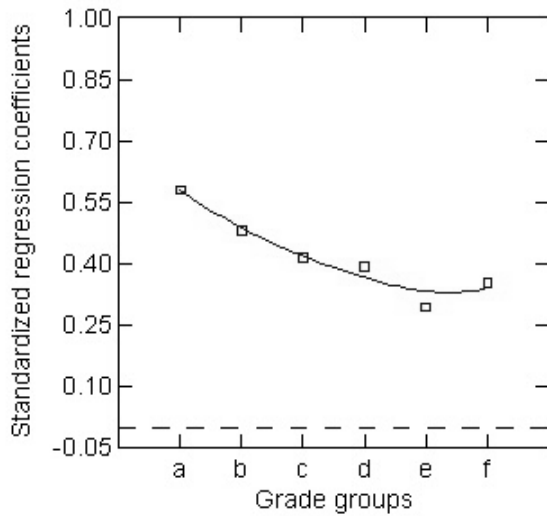
Standardized regression coefficient plots were constructed for Basic Reading cluster and Listening Comprehension cluster, and are presented in Figure 10. The association between Basic Reading cluster and Reading Fluency cluster exhibited a decreasing trend across age groups. In contrast, the strength of the relationship between Listening Comprehension cluster and Reading Fluency cluster increased across age groups.

Table 11. Standardized regression coefficients,  $R^2$  and  $F$  for cluster-level regression models by grade with Basic Reading, Listening Comprehension, and Oral Expression clusters and Sound Awareness test as predictors, and with Reading Fluency (RF) and Reading Comprehension (RC) clusters as criteria

	Basic Reading		Listening Comprehension		Oral Expression		Sound Awareness		$R^2$		$F$	
	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC	RF	RC
Grade Groups												
1	.579*	.723*	.150	.084	-.038	-.026	.129	.116	.530	.675	53.641	98.766
2	.482*	.577*	.186*	.179*	.026	.125*	.152	.131	.509	.701	59.300	133.950
3	.414*	.415*	.282*	.221*	.069	.081	.119	.243*	.520	.611	80.050	116.316
4-6	.391*	.302*	.224*	.188*	.056	.158*	.096	.279*	.419	.595	156.940	319.027
7-9	.293*	.316*	.306*	.153*	.044	.172*	.122	.309*	.419	.622	114.143	260.705
10-12	.351*	.290*	.270*	.174*	-.006	.140*	.073	.309*	.349	.577	66.918	170.529

For coefficient significance, \*  $p < .01$

RFc/Basic Reading cluster



RFc/Listening Comprehension cluster

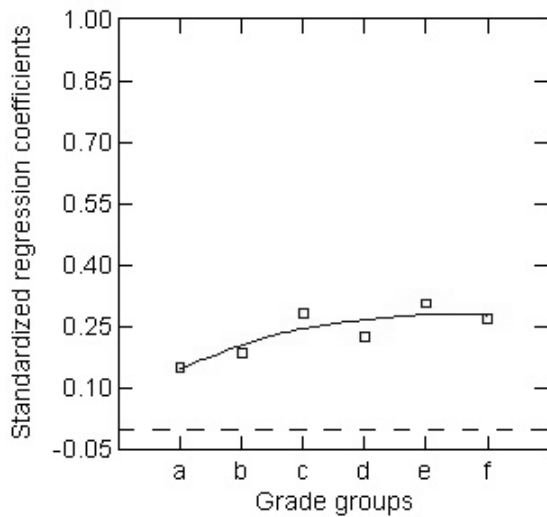


Figure 10. Standardized regression coefficient plots for predictors of Reading Fluency cluster across grade groups (a = 1, b = 2, c = 3, d = 4-6, e = 7-9, and f = 10-12). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RF = .90 (.02), BR = .94 (.03), LC = .85 (.04).

### *Reading Comprehension cluster*

Basic Reading cluster was a significant predictor of Reading Comprehension cluster in all grade groups: 1 (.723), 2 (.577), 3 (.415), 4-6 (.302), 7-9 (.316), and 10-12 (.290). Listening Comprehension was a significant predictor in grade groups 2 (.179), 3 (.221), 4-6 (.188), 7-9 (.153), and 10-12 (.174). Oral Expression cluster was a significant predictor of Reading Comprehension cluster in grade groups 2 (.125), 4-6 (.158), 7-9 (.172), and 10-12 (.140). Sound Awareness test was a significant predictor in grade groups 3 (.243), 4-6 (.279), 7-9 (.309) and 10-12 (.309).

Standardized regression coefficient plots were constructed for Basic Reading cluster, Listening Comprehension cluster, Oral Expression cluster, and Sound Awareness test. These plots are presented in Figure 11. The trend of the relationship between Basic Reading cluster and Reading Comprehension cluster decreased across the first 4 grade groups, followed by a plateau. The trends for both Oral Expression cluster and Sound Awareness test as predictors of Reading Comprehension cluster increased across grade groups. The relationship between Listening Comprehension cluster and Reading Comprehension cluster also increased across the three earliest grade groups, stabilizing across the latest three grade groups.

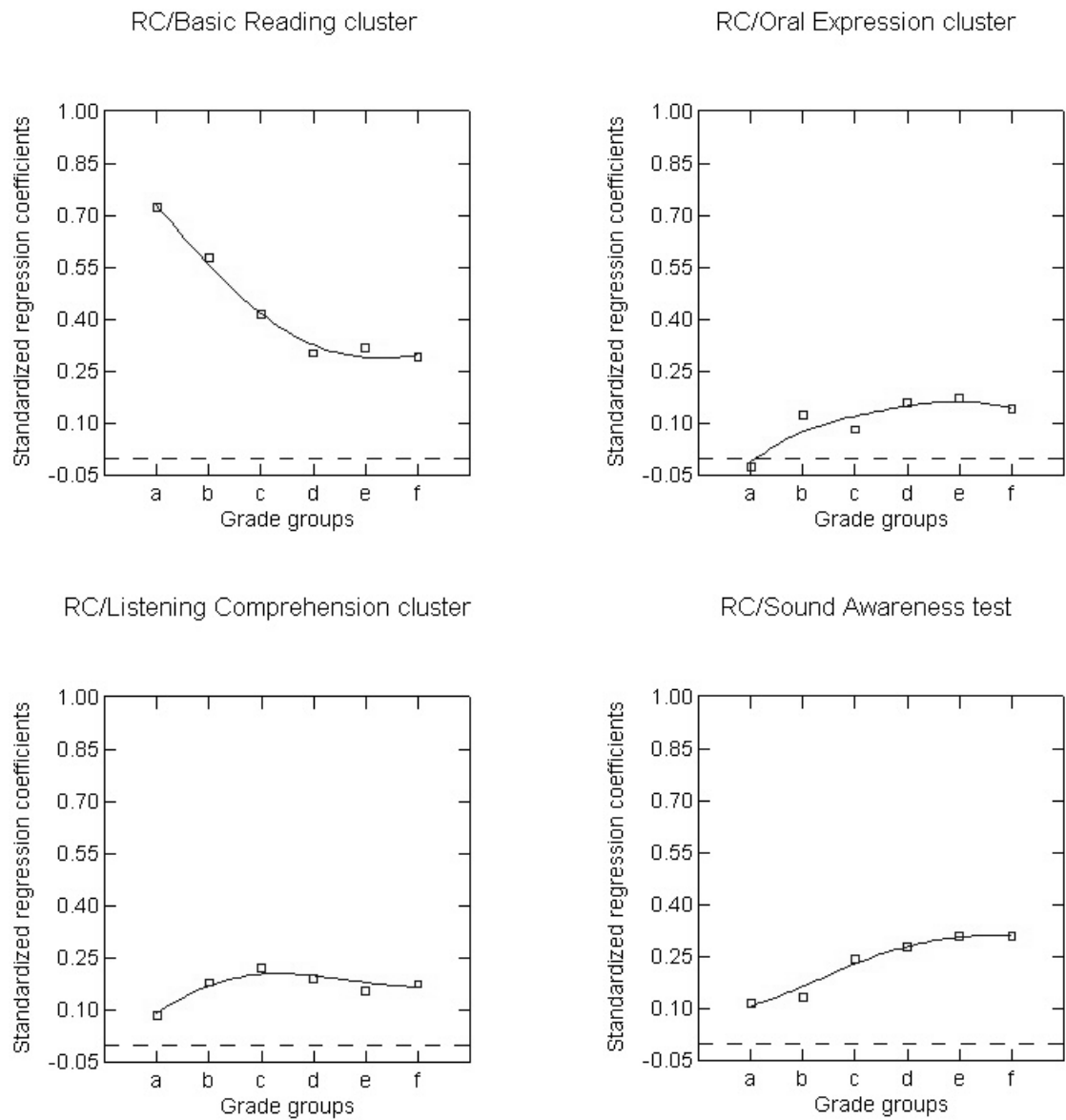


Figure 11. Standardized regression coefficient plots for predictors of Reading Comprehension cluster across grade groups (a = 1, b = 2, c = 3, d = 4-6, e = 7-9, and f = 10-12). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RC = .91 (.03), BR = .94 (.03), LC = .85 (.04), OE = .83 (.03), SA = .81 (.08).

### *Test level analyses by grade*

Reading Fluency, Reading Vocabulary, and Passage Comprehension tests were each examined as criterion measures with the following tests included as predictors in regression calculations: Letter-Word Identification, Word Attack, Understanding Directions, Story Recall, Picture Vocabulary, Oral Comprehension, and Sound Awareness. These regression equations were computed separately for each of six grade groups (1, 2, 3, 4-6, 7-9, and 10-12).

#### *Reading Fluency test*

Standardized regression coefficients,  $R^2$ , and  $F$ -values for regression equations computed with the criterion Reading Fluency test are presented in Table 12. The overall regression equation for Reading Fluency test for all grade groups combined was  $Y_{RFtest} = .482x_{LWtest} + .476x_{SRtest} + 1.340x_{UDtest} + .294x_{OCtest} + .116x_{PVtest} - 762.923$ .

Letter-Word Identification test was a significant predictor of Reading Fluency test in all grade groups: 1 (.640), 2 (.436), 3 (.334), 4-6 (.308), 7-9 (.213), and 10-12 (.256). Word Attack test was a significant predictor of Reading Fluency test in grade groups 4-6 (.137), 7-9 (.136), and 10-12 (.134). Understanding Directions test was a significant predictor of Reading Fluency test in grade groups 3 (.307), 4-6 (.349), 7-9 (.343), and 10-12 (.354). Story Recall test was a significant predictor in only one grade group, 4-6 (.096). Neither Picture Vocabulary test nor Sound Awareness test was a significant predictor of Reading Fluency test for any age group. Oral Comprehension test was a significant predictor for grade groups 3 (.138), 7-9 (.153), and 10-12 (.122).



Table 12. Standardized regression coefficients,  $R^2$  and  $F$  for test-level regression models by grade with Letter-Word Identification (LWI), Word Attack (WA), Understanding Directions (UD), Story Recall (SR), Picture Vocabulary (PV), Oral Comprehension (OC), and Sound Awareness (SA) tests as predictors and Reading Fluency as criterion.

Reading Fluency									
	LWI	WA	UD	SR	PV	OC	SA	$R^2$	$F$
Grade Groups									
1	.640*	-.038	.019	.040	-.038	.140	.128	.587	37.987
2	.436*	.089	.114	.104	-.014	.089	.085	.532	36.759
3	.334*	.123	.307*	.078	.039	.138*	-.030	.544	49.981
4-6	.308*	.137*	.349*	.096*	.031	.078	-.130	.459	104.827
7-9	.213*	.136*	.343*	.057	.018	.153*	-.056	.449	73.481
10-12	.256*	.134*	.354*	.078	-.029	.122*	-.135	.390	45.396

For coefficient significance, \*  $p < .01$

Plots of standardized regression coefficients were constructed for Letter-Word Identification, Word Attack, Understanding Directions, and Oral Comprehension test, and are presented in Figure 12. The association between Letter-Word Identification test and Reading Fluency test decreased across age groups, with a plateau observed across the two latest groups. The magnitude of the coefficients for Word Attack test increased across the three earliest grade groups with a plateau observed across the three latest age groups. This is similar to the trend observed for Understanding Directions test across age groups, though the increase was greater in magnitude and spanned the first four grade groups. The association between Oral Comprehension test and Reading Fluency test was relatively stable across grade groups.

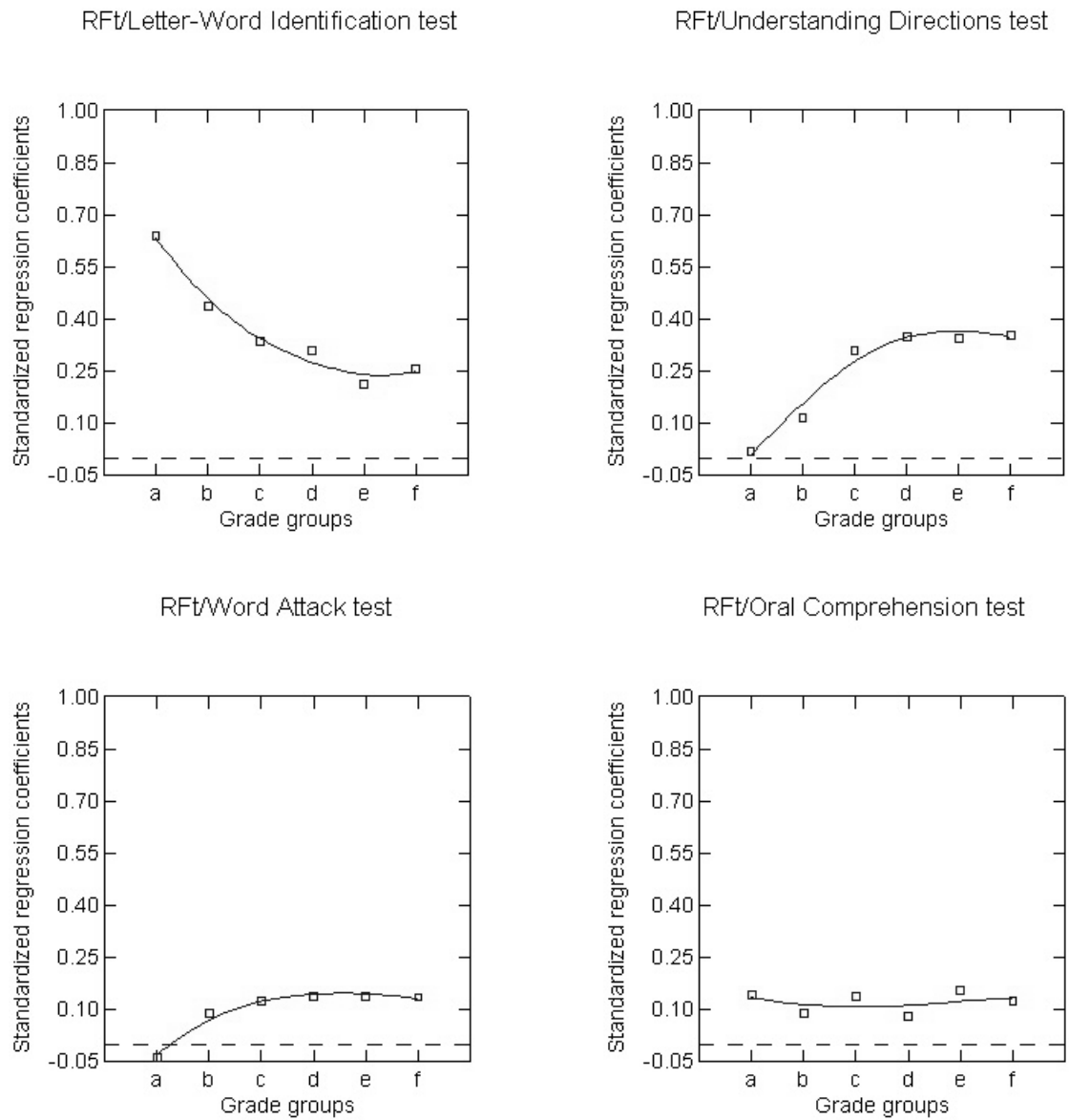


Figure 12. Standardized regression coefficients for predictors of Reading Fluency test across grade groups (a = 1, b = 2, c = 3, d = 4-6, e = 7-9, and f = 10-12). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RF = .90 (.02), LWI = .92 (.03), WA = .86 (.05), UD = .77 (.08), OC = .79 (.06).

### *Reading Vocabulary test*

Standardized regression coefficients,  $R^2$ , and  $F$ -values for regression equations computed with the criterion Reading Vocabulary test are presented in Table 13. The overall regression equation for Reading Vocabulary test for all grade groups combined was  $Y_{RVtest} = .165x_{LWtest} + .043x_{WAtest} + .284x_{SAtest} + .504x_{SRtest} + .086x_{UDtest} + .083x_{OCtest} + .082x_{PVtest} - 120.850$ .

Letter-Word Identification test was a significant predictor of Reading Vocabulary test in all grade groups: 1 (.375), 2 (.203), 3 (.287), 4-6 (.178), 7-9 (.198), and 10-12 (.278). Word Attack test was a significant predictor in grade group 2 (.270); Understanding Directions test was a significant predictor in grade group 3 (.202). Story Recall test was a significant predictor of Reading Vocabulary test in grade groups 2 (.194), 3 (.133), 4-6 (.181), 7-9 (.240) and 10-12 (.218). Picture Vocabulary test was a significant predictor in grade groups 3 (.116), 4-6 (.122), and 7-9 (.097). Oral Comprehension test was a significant predictor of Reading Vocabulary test in grade groups 4-6 (.111) and 7-9 (.103). Sound Awareness test was a significant predictor in grade groups 2 (.213), 3 (.187), 4-6 (.283), 7-9 (.225), and 10-12 (.250).

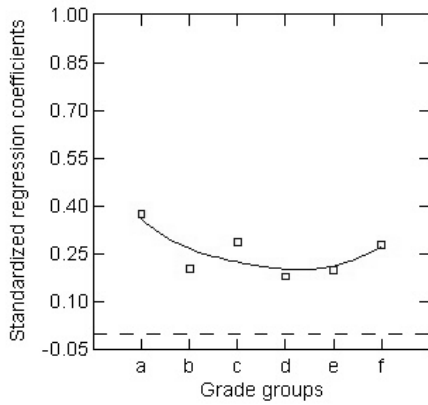
Table 13. Standardized regression coefficients,  $R^2$  and  $F$  for test-level regression models by grade with Letter-Word Identification (LWI), Word Attack (WA), Understanding Directions (UD), Story Recall (SR), Picture Vocabulary (PV), Oral Comprehension (OC), and Sound Awareness (SA) tests as predictors and Reading Vocabulary as criterion.

Reading Vocabulary									
	LWI	WA	UD	SR	PV	OC	SA	$R^2$	$F$
1	.375*	.164	.082	-.010	.097	.031	.244	.574	36.000
2	.203*	.270*	-.079	.194*	.101	.105	.213*	.595	47.429
3	.287*	.065	.202*	.133*	.116*	.076	.187*	.636	73.198
4-6	.178*	.068	-.004	.181*	.122*	.111*	.283*	.538	144.196
7-9	.198*	.072	.017	.240*	.097*	.103*	.225*	.566	117.624
10-12	.278*	.007	-.006	.218*	.082	.054	.250*	.524	78.229

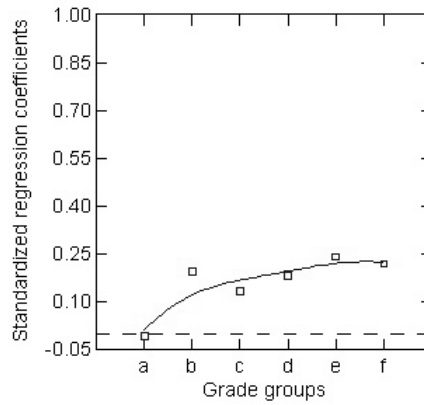
For coefficient significance, \*  $p < .01$

Standardized regression coefficient plots were constructed for Letter-Word Identification, Story Recall, Picture Vocabulary, Oral Comprehension, and Sound Awareness tests, and are presented in Figure 13. The strength of the association between Letter-Word Identification test and Reading Vocabulary test decreased across the four earliest age groups and increased across the two latest age groups. The magnitude of the coefficients for Story Recall test as a predictor of Reading Vocabulary test increased across age groups. Relatively stable trends were noted for Picture Vocabulary test and Sound Awareness test as they related to Reading Vocabulary test. The trend for Oral Comprehension test as a predictor of Reading Vocabulary test was also fairly stable, with an increase from the first to the second grade group and a decrease noted in the latest grade group.

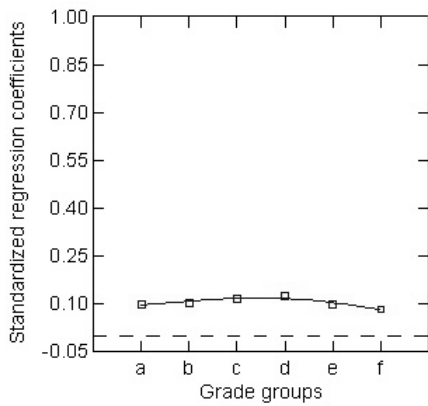
RV/Letter-Word Identification test



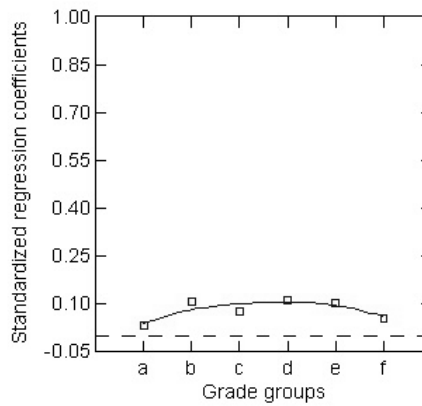
RV/Story Recall test



RV/Picture Vocabulary test



RV/Oral Comprehension test



RV/Sound Awareness test

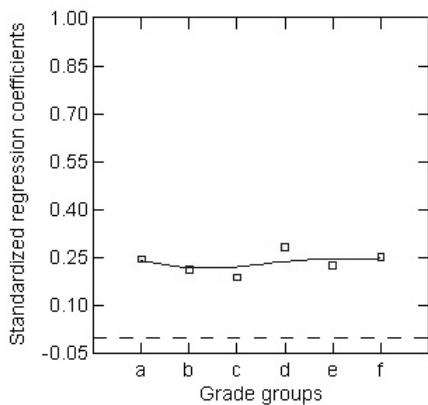


Figure 13. Standardized regression coefficients for predictors of Reading Vocabulary test across grade groups (a = 1, b = 2, c = 3, d = 4-6, e = 7-9, and f = 10-12). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: RV = .87 (.03), LWI = .92 (.03), SR = .86 (.03), PV = .77 (.04), OC = .79 (.06), SA = .81 (.08).

*Passage Comprehension test*

Standardized regression coefficients,  $R^2$ , and  $F$ -values for regression equations computed with the criterion Passage Comprehension test are presented in Table 14. The overall regression equation for Passage Comprehension test for all grade groups combined was  $Y_{PCtest} = .292x_{LWItest} + .076x_{WAtest} + .178x_{SAtest} + .156x_{UDtest} + .107x_{OCtest} + 29.752$ .

Letter-Word Identification test was a significant predictor of Passage Comprehension test in all grade groups: 1 (.592), 2 (.510), 3 (.348), 4-6 (.294), 7-9 (.247), and 10-12 (.196). Word Attack test was a significant predictor in grade group 1 (.205); Story Recall test was a significant predictor in grade group 7-9 (.194). Neither Understanding Directions test nor Picture Vocabulary test was a significant predictor of Passage Comprehension test in any grade group. Oral Comprehension test was a significant predictor in grade groups 3 (.156), 4-6 (.120), and 10-12 (.172). Sound Awareness test was a significant predictor of Passage Comprehension test in grade groups 4-6 (.191), 7-9 (.155), and 10-12 (.220).

Table 14. Standardized regression coefficients,  $R^2$  and  $F$  for test-level regression models by grade with Letter-Word Identification (LWI), Word Attack (WA), Understanding Directions (UD), Story Recall (SR), Picture Vocabulary (PV), Oral Comprehension (OC), and Sound Awareness (SA) tests as predictors and Passage Comprehension as criterion.

Passage Comprehension									
	LWI	WA	UD	SR	PV	OC	SA	$R^2$	$F$
1	.592*	.205*	.106	-.056	-.068	.058	-.021	.622	43.911
2	.510*	.135	.032	-.039	.067	.122	.125	.603	48.999
3	.348*	.100	.053	.041	-.024	.156*	.154	.420	30.252
4-6	.294*	.054	.065	.067	.062	.120*	.191*	.447	100.032
7-9	.247*	.101	.055	.194*	.064	.048	.155*	.469	79.695
10-12	.196*	.048	.068	.051	.054	.172*	.220*	.396	46.453

For coefficient significance, \*  $p < .01$

Plots of standardized regression coefficients were constructed for Letter-Word Identification, Oral Comprehension, and Sound Awareness tests, presented in Figure 14. The strength of association between Letter-Word Identification test and Passage Comprehension test decreased across grade groups. The relationship between Sound Awareness test and Passage Comprehension test increased across grade groups. The strength of association between Oral Comprehension test and Passage Comprehension test varied, increasing across the three earliest grade groups, decreasing across two age groups, and increasing across the latest age groups.

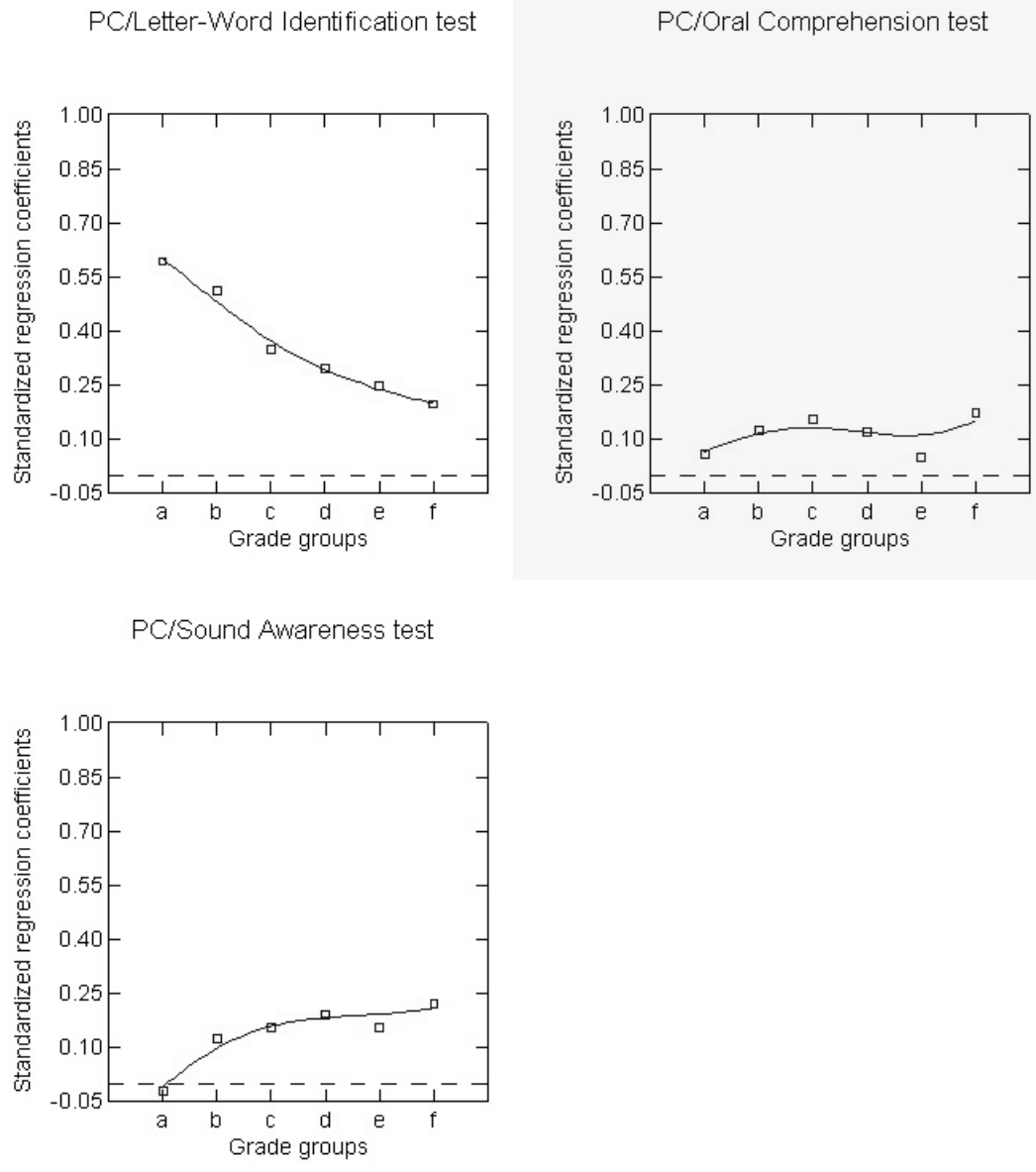


Figure 14. Standardized regression coefficient plots for predictors of Passage Comprehension test across grade groups (a = 1, b = 2, c = 3, d = 4-6, e = 7-9, and f = 10-12). Mean reliability (with standard deviation in parentheses) for tests for ages 6 through 18 years: PC = .85 (.07), LWI = .92 (.03), OC = .79 (.06), SA = .81 (.08).



## CHAPTER IV

### DISCUSSION

#### Introduction

The relationship between language and reading has been studied from several perspectives but is not fully understood. Studies of this relationship have examined the relative importance of decoding and basic reading skills versus broader language skills for reading comprehension, reporting that phonological awareness and decoding are more important for reading comprehension early in the process of literacy acquisition, whereas broader language skills become more important with reading proficiency (e.g., Curtis, 1980; Perfetti, 1985; Vellutino et al., 1991). This study sought to explore these relationships in the context of WJ III ACH, an integrated test battery that includes measures of each of these areas.

A repeated multiple regression approach in which Reading Fluency cluster and Reading Comprehension cluster served as criteria and Sound Awareness test, Basic Reading cluster, Listening Comprehension cluster, and Oral Expression cluster served as predictors was used to examine these issues. These analyses were computed for six age groups and six grade groups to allow for comparison of relationships throughout the school years. Standardized regression coefficients were utilized as measures of relative importance, and were plotted to reveal trends in these relationships.

The results of this study revealed several significant relationships, as well as trends for these relationships across age and grade groups. Consequently, this study offers insight regarding the relationship between language and reading in school-age individuals. This discussion will focus on the key relationships and trends identified in this study. These relationships and trends were comparable for data analyzed by age and data analyzed by grade. For this reason, results for analyses computed by age and by grade will be discussed simultaneously. Potential weaknesses of this study will also be addressed, as well as future directions for this line of research.

### Overall Findings

There were three main findings in this study:

- (1) The relative importance of Letter-Word Identification (the primary influence on Basic Reading cluster scores) for Reading Comprehension and Reading Fluency decreased across age and grade groups, although it continued to be important into the later grades.
- (2) For Reading Fluency, the decrease in association with Basic Reading across age groups and grade groups was accompanied by an increase in association with Listening Comprehension.
- (3) For Reading Comprehension, the decrease in association with Basic Reading was accompanied by an increase in associations with Oral Expression cluster, Listening Comprehension cluster, and Sound Awareness test.

Each of these findings will be discussed in the contexts of previous studies and implications for the relationship between language and reading.

*Basic Reading cluster and Letter-Word Identification test*

Overall, two consistent relationships were observed for both Reading Fluency cluster and Reading Comprehension cluster: (1) Basic Reading cluster was a significant predictor of both criterion clusters across analyses, and was the only significant predictor of either criterion cluster for age group 6 and grade group 1, and (2) the magnitude of the standardized regression coefficients for Basic Reading cluster decreased across age groups and grade groups for both criteria. These findings support previous longitudinal studies of these relationships (Curtis, 1980; Vellutino et al., 1991). For younger children with age-appropriate reading skills and for older children with deficient reading skills, Curtis (1980) found that decoding was the strongest predictor of reading comprehension. In older, competent readers, listening comprehension was more important than decoding for reading comprehension. Curtis attributed this shift to decoding becoming more automatic with increased proficiency (defined, for the purpose of this discussion, as increased decoding speed and accuracy that allows for focus on text meaning as opposed to text form), decreasing the relative importance of decoding for reading comprehension. This same conclusion was drawn by Vellutino et al. (1991) in their study comparing the decoding and reading comprehension skills of children in second and third grade with those of children in sixth and seventh grade. For children in the earlier grades, word identification and decoding were the best predictors of reading comprehension. For children in the later grades, listening comprehension was more strongly associated with reading comprehension.

The findings of the present study are consistent with those of previous studies with respect to the decreasing trend of importance of Basic Reading across age groups

and grade groups. Its significance into the older age groups and later grade groups indicates that Basic Reading continues to contribute unique variance to Reading Fluency and Reading Comprehension. Previous studies have left the impression that broader receptive and expressive language skills might subsume this variance in the later school years, but this shift was not observed. Although broader language skills are more important than Basic Reading in the later age groups and grade groups, Basic Reading continues to be a significant predictor. This finding highlights the pertinence of the Simple View of Reading, that reading comprehension is the product of decoding and linguistic comprehension (Gough & Tunmer, 1986), across age groups and grade groups, as well as other models of the language-reading relationship that emphasize the importance of input (e.g., decoding) for reading comprehension (e.g., Just & Carpenter, 1987).

In order to clarify these results from WJ III ACH, this relationship was examined at the test level. Basic Reading cluster score is the average of scores from the tests Letter-Word Identification and Word Attack. Standardized regression coefficients for Letter-Word Identification test were significant in all but one of the 36 test-level analyses. The trend of these coefficients across age groups and grade groups decreased, although they continued to be significant into the later grades.

Standardized regression coefficients for Word Attack test were significant for 10 of the 36 analyses. As a predictor of Reading Fluency test, coefficients for Word Attack test increased across age and grade groups. In contrast, Word Attack was not associated with either of the tests that comprise Reading Comprehension cluster, with the exception of Reading Vocabulary test in two age groups. These findings confirm that Letter-Word

Identification and Word Attack tests tap different skills, and offer support for differentiating between these constructs in research on basic reading. The association between Reading Fluency and Word Attack could be due to similarities in the analytical cognitive operations required for Word Attack and Reading Fluency tests, which could be examined in future studies. In summary, the consistent decrease in standardized regression coefficients for Basic Reading cluster is associated with the consistent decrease in coefficients for Letter-Word Identification test, rather than Word Attack test.

#### *Reading Fluency Cluster*

For Reading Fluency cluster, the decrease in association with Basic Reading cluster across age groups and grade groups was accompanied by an increase in association with Listening Comprehension. In analyses computed by grade, Listening Comprehension cluster surpassed Basic Reading to become a stronger predictor of Reading Fluency at grade group 7-9. Approximation (but not crossover) of standardized regression coefficients for Listening Comprehension and Basic Reading was noted in age group 13-16. These findings indicate that language comprehension skills become as important as (if not more important than) letter and word identification for efficient reading comprehension in the middle school to early high school years, and serve as further support of the findings by Curtis (1980) and Vellutino et al. (1991).

Models of the relationship between language and reading have noted that decoding skills are the most important aspect of reading in the early years but that linguistic knowledge becomes more important for reading comprehension as readers encounter more elaborate texts (Kamhi & Catts, 2002; Konold et al., 2003). Such models

have represented listening comprehension as the foundation for reading comprehension (Konold et al., 2003) and described listening comprehension and reading comprehension as processes that both rely upon a shared set of linguistic knowledge (Kamhi & Catts, 2002). As such, this association between Listening Comprehension (a measure of receptive language) and Reading Fluency (a measure of reading comprehension) was anticipated.

The role of receptive language knowledge for reading comprehension has been described in studies of children with language impairment (Bishop & Adams, 1990; Rissman et al., 1990). Rissman et al. reported that receptive language level at age 4 was predictive of academic placement at age 8. The authors concluded that receptive language demands permeate all academic work, including reading comprehension, and speculated that it becomes more important for academic success over time. In another study of 8-year-olds, Bishop and Adams reported that children who had been diagnosed with receptive and expressive language difficulties at age 4 and continued to show weakness in these areas exhibited reading comprehension skills that were “disproportionately poor relative to their reading accuracy” at age 8 (Bishop & Adams, 1990, p. 1033). The present study expands upon these findings, demonstrating the importance of receptive language for reading speed and accuracy in a sample of the general population. Whereas studies of clinical populations have indicated that impaired linguistic skills are associated with relatively poorer reading comprehension, the present study reveals that Listening Comprehension is associated with Reading Fluency beyond clinical populations.

This finding is also important in light of recent research on processing speed as measured by Woodcock-Johnson batteries, given that Reading Fluency is a timed test. A recent study by Camarata and Woodcock (in press) reported that processing speed (as measured by WJ –R and WJ III, as well as the 1977 version of the battery) is significantly greater for females versus males. Likewise, scores for Reading Fluency are significantly higher for females versus males. The sex differences for scores on these tests increase across grade groups, particularly during adolescence. These results were interpreted as evidence that processing speed may be an additional contributor to variance in Reading Fluency that becomes more important in the later school years. Thus, processing speed may be an additional contributor to Reading Fluency outside of basic reading or language skills that was not measured in this study.

Listening Comprehension cluster score is the average of scores from the tests Understanding Directions and Oral Comprehension. Test-level analyses were examined to further clarify the relative importance of these tests. For Understanding Directions test as a predictor of Reading Fluency test, standardized regression coefficients were significant in all but the youngest age groups and grade groups and exhibited an increasing trend. Coefficient significance for Oral Comprehension test as a predictor of Reading Fluency test was less consistent (3 of 6 grade groups, 2 of 6 age groups). However, the coefficients were significant in grade groups 7-9 and 10-12, coinciding with the crossover point at which Listening Comprehension surpassed Basic Reading as a predictor of Reading Fluency, and at the point of approximation in age group 13-16.

Therefore, scores from both tests are considered responsible for the observed increase in standardized regression coefficients for Listening Comprehension across age

and grade groups. This finding is logical given that both Understanding Directions and Oral Comprehension tests are measures of linguistic knowledge and that Reading Fluency test requires sufficient linguistic knowledge for completion of test items. Furthermore, the increased association of these tests with Reading Fluency in the later grades reflects the increased importance of receptive language for interpreting more complex texts. At both the test level and the cluster level, this relationship between Listening Comprehension and Reading Fluency was expected.

#### *Reading Comprehension Cluster*

For Reading Comprehension cluster, the decrease in association with Basic Reading cluster was accompanied by an increase in associations with Listening Comprehension cluster, Oral Expression cluster, and Sound Awareness test. This indicates that skills in areas other than Basic Reading emerge as important predictors of Reading Comprehension beyond the initial period of literacy acquisition. These findings indicate that receptive and expressive language skills, in addition to sound knowledge, are increasingly important for reading comprehension (as measured by the tests Passage Comprehension and Reading Vocabulary) across age and grade groups. Each of these cluster-level findings will be discussed separately.

#### *Listening Comprehension cluster*

As observed for Reading Fluency, Listening Comprehension cluster was an important predictor for Reading Comprehension cluster. The strength of this relationship increased across three age groups and three grade groups, but the magnitude of these coefficients did not approximate or cross over those for Basic Reading.



Listening Comprehension cluster score is the average of scores from the tests Understanding Directions and Oral Comprehension. Test-level analyses were examined to clarify the association of these tests with the tests Reading Vocabulary and Passage Comprehension, which comprise the Reading Comprehension cluster. Oral Comprehension test was a significant predictor of Reading Vocabulary test in three age groups (8-9, 10-12, and 13-16) and in two grade groups (4-6 and 7-9), and was a significant predictor of Passage Comprehension test in three age groups (8-9, 10-12, and 13-16) and in three grade groups (3, 4-6, and 10-12). Understanding Directions was not associated with either Reading Vocabulary test or Passage Comprehension test. Thus, scores for Oral Comprehension test, and not Understanding Directions test, are associated with the cluster-level findings for Listening Comprehension as a predictor of Reading Comprehension.

This difference is likely due to the differences in test structure. Understanding Directions test involves listening to a series of instructions and pointing in the appropriate manner. In contrast, Oral Comprehension test involves providing a word that makes sense in an oral passage. This task requires a verbal response, as do the tests Reading Vocabulary and Passage Comprehension. In addition, review of test items for Oral Comprehension, Passage Comprehension, and Reading Vocabulary reveals that these tests may be more vocabulary driven, whereas Understanding Directions is more related to grammar and syntax. Together, these differences may contribute to the lack of association of Understanding Directions with Passage Comprehension and Reading Vocabulary tests.

These differences may also be responsible for the disparate associations of Listening Comprehension cluster with Reading Fluency and Reading Comprehension clusters. Whereas both Understanding Directions and Oral Comprehension were associated with Reading Fluency, only Oral Comprehension was associated with tests for Reading Comprehension. These differences are most likely associated with the structure of Reading Fluency test as compared with the Reading Comprehension cluster tests (Reading Vocabulary and Passage Comprehension). Reading Fluency test involves reading sentences and determining whether they are true or false, and indicating their choice by circling the correct answer. Scoring is based on both speed and accuracy. This test may tap a broader range of receptive language knowledge than the Reading Comprehension cluster tests because it requires both understanding the written sentence and considering its veracity. Moreover, this test, like Understanding Directions test, does not require a verbal response. The other tests (Oral Comprehension, Reading Vocabulary, and Passage Comprehension) each require a verbal response, so it is likely that some of their shared variance is due to expressive vocabulary skills in addition to the receptive language skills they are designed to capture. Together, these differences are responsible for the stronger relationship between Listening Comprehension and Reading Fluency than for Listening Comprehension and Reading Comprehension.

#### *Oral Expression cluster*

Oral Expression cluster was associated with Reading Comprehension cluster in four age groups and four grade groups, and exhibited an increasing trend followed by a plateau across the oldest age and grade groups. This result presents another difference in the associations of predictors with Reading Fluency cluster and Reading Comprehension,

because Oral Expression was not associated with Reading Fluency. Test-level analyses explain these differences.

Oral Expression cluster score is the average of scores from the tests Story Recall and Picture Vocabulary. Test-level analyses were examined to clarify the association of these tests with the tests that comprise Reading Comprehension cluster (Passage Comprehension and Reading Vocabulary). Story Recall and Picture Vocabulary tests were not associated with Passage Comprehension test, but were associated with Reading Vocabulary test. Thus, the relationship between Oral Expression and Reading Comprehension is limited to an association at the level of reading vocabulary. Although Story Recall has a morphosyntactic component, it also has a strong vocabulary component. Thus, the association between Reading Vocabulary and Oral Expression, and the lack of association between Passage Comprehension and Oral Expression, is likely due to the emphasis on vocabulary in both of the tests that comprise the Oral Expression cluster. This may also explain the lack of association between Oral Expression and Reading Fluency, for which vocabulary is not a focus.

The magnitude of standardized regression coefficients for Story Recall test as a predictor of Reading Vocabulary test exhibited an increasing trend across age groups and grade groups. This increase was sufficient for Story Recall test to surpass Letter-Word Identification test as a predictor of Reading Vocabulary test in age group 13-16 and grade groups 4-6 and 7-9. Picture Vocabulary was a significant predictor of Reading Vocabulary in three age groups (8-9, 10-12, and 17-18) and in three grade groups (3, 4-6, and 7-9). The magnitude of the regression coefficients for Picture Vocabulary test as a predictor of Reading Vocabulary test was stable across age groups and grade groups, and

did not exceed other predictors at any point. These patterns of association with Reading Vocabulary (increasing for Story Recall and stable for Picture Vocabulary) may represent the increasing importance of syntactic knowledge versus word knowledge for comprehension of written words across age groups and grade groups. This supports the idea that linguistic knowledge and awareness of context facilitates understanding of unfamiliar words.

In summary, the relationship between Oral Expression cluster and Reading Comprehension cluster is carried by Reading Vocabulary test, which is associated with both Story Recall and Picture Vocabulary tests. This finding indicates that oral language was associated with a vocabulary-focused measure of reading comprehension (Reading Vocabulary) but was not associated with a broader measure of reading comprehension (Passage Comprehension), both of which require verbal responses. Although Story Recall involves listening to stories and recalling details, it draws heavily from vocabulary knowledge and was also designed to tap listening and memory abilities. It does have a morphosyntactic component, but it does not appear to require the level of grammatical and syntactic knowledge needed for Passage Comprehension. This difference may be responsible for the lack of association between the tests Story Recall and Passage Comprehension, despite their ostensible similarities.

#### *Sound Awareness test*

Although previous studies have emphasized the importance of Sound Awareness in the early stages of literacy acquisition, these data indicate that Sound Awareness is increasingly important for Reading Comprehension across age groups and grade groups. Aside from Basic Reading cluster, the strongest predictor of Reading Comprehension

cluster was Sound Awareness test. Standardized regression coefficients for Sound Awareness as a predictor of Reading Comprehension cluster were greater than those for Listening Comprehension cluster and Oral Expression cluster across age and grade groups, and the trend of increase was steeper than for other predictors. Coefficients for Sound Awareness test surpassed those for Letter-Word Identification test in the oldest age group and the latest grade group, rendering it the strongest predictor of Reading Comprehension in those groups. Thus, for Reading Comprehension, there was a decreasing relationship with Basic Reading and increasing relationships with Listening Comprehension, Oral Expression, and, most strongly, Sound Awareness across age groups and grade groups.

This finding for Sound Awareness warrants consideration of its test structure. Like all WJ III tests, items for this test are presented in an order of increasing difficulty. In Sound Awareness, the first set of items consists of rhyming tasks and the later items involve deletion and substitution. Although the name “Sound Awareness” could imply that these tasks only involve single phonemes, many of the test items involve manipulation of multiple-sound units, including morphemes in compound words. As a result, this test goes beyond the basic tasks involved in other measures of phonological awareness and includes items that could arguably be influenced by additional language faculties, including vocabulary and morphology.

The relationship of Sound Awareness with Reading Comprehension was examined at the test level, with Sound Awareness test as a predictor of Reading Vocabulary test and Passage Comprehension test. In age-based analyses, Sound Awareness test was a significant predictor of Reading Vocabulary test in all but the two

youngest age groups. Magnitude of standardized regression coefficients for Sound Awareness test was greater than those for all other predictors across all age groups, with the exception of Letter-Word Identification test and, in age group 7, Word Attack test, and surpassed those for Letter-Word Identification test in the two oldest age groups. A similar pattern was observed in grade-based analyses, with standardized regression coefficients exceeding those for all other predictors with the exception of Letter-Word Identification test and, in grade group 2, Word Attack test. Coefficients for Sound Awareness test exceeded those for Letter-Word Identification test in grade groups 2, 4-6 and 7-9. For Passage Comprehension test, Sound Awareness test was a significant predictor in the three oldest age groups and the three latest grade groups. It was generally a stronger predictor than other tests, with the exception of Letter-Word Identification test and, in age group 13-16 and grade group 7-9, Story Recall test. The magnitude of the coefficients for Sound Awareness exceeded those for Letter-Word Identification in the oldest age group and the latest grade group.

Together, these results for Sound Awareness test as a predictor of Passage Comprehension test and Reading Vocabulary test indicate that trends of significance for both tests contributed to the cluster-level findings for Reading Comprehension, rendering the increased importance of Sound Awareness over time a robust finding. Most studies of the influence of phonological awareness on reading have focused on the early stages of literacy acquisition, either in young typically-developing children (e.g., Swank & Catts, 1994; Juel, 1988) or in older children and adults with disorders of language and/or reading (e.g., Pennington et al., 1990). In these groups, phonological awareness has been identified as an important predictor of reading comprehension. However, the prevailing

conclusion has been that phonological awareness becomes less important as decoding becomes more automatic, and that broader language skills become more closely associated with reading comprehension as the complexity of language in texts increases.

There are several possible explanations for the results of the present study. Although phonological awareness is generally considered a facilitator of decoding (e.g., Juel, 1988; Swank & Catts, 1990), it is possible that reading proficiency itself improves phonological awareness, causing the association between reading and phonological abilities to become stronger over time. This relationship was proposed by Wagner and Torgesen (1987), who speculated that reading experience reinforces awareness that words can be segmented into sounds. Likewise, advances in oral language skills, particularly in derivational morphology, may serve to advance phonological awareness and performance on the advanced tasks included in Sound Awareness test. Manipulation of morphemes to alter word meanings and ensure grammatical agreement is inherently based on the ability to add and remove parts of words. Consequently, such experience should improve performance on Sound Awareness test items. This possibility could be explored by examining the association between expressive language skills, particularly for grammatical structures, with Sound Awareness. Another possibility, though less probable, is that the focus on phonological awareness in the earlier stages of reading acquisition caused its later importance to be overlooked, and that phonological awareness makes a unique contribution to comprehension in proficient readers that has heretofore been undiscovered. At this juncture, this finding is unique and warrants further examination in studies that span the school years.

### *Weaknesses and Directions for Future Studies*

This study offers directions for future research on the relationship between language and reading. As noted throughout the discussion of results, each of the significant findings of this broad-based study warrant further examination. Additional issues for consideration are the influence of fluid intelligence, the cross-sectional design of this study, the limitation of this study to associations with reading comprehension, and the potential benefits of including other measures in addition to WJ III ACH. Also, the results herein indicate that the related constructs of Basic Reading, Reading Fluency, and Reading Comprehension should be considered individually when studying their relationships with other constructs such as language.

#### *Fluid Intelligence*

One weakness of this study was that there was no direct control for fluid intelligence. This is important because reading is a highly inferential process, and facility in fluid reasoning would hypothetically be important for proficiency in reading comprehension. In order to examine the influence of Fluid Intelligence on Reading Fluency and Reading Comprehension as measured by WJ III, all analyses were re-run with the inclusion of W-scores from the Concept Formation test from the Cognitive battery of WJ III, which were available for this normative sample.

Standardized regression coefficients for Concept Formation test as an additional predictor across age groups and grade groups are presented in Table 15.



Table 15. Standardized regression coefficients for Concept Formation test as a predictor of Reading Fluency cluster (RFc), Reading Fluency test (RFt), Reading Comprehension cluster (RCc), Reading Vocabulary test (RVt), and Passage Comprehension test (PCt).

	RFc	RFt	RCc	RVt	PCt
<b>Age groups</b>					
6	-.275*	-.378*	-.024	-.006	-.008
7	-.092	-.131	-.115	-.119	-.095
8-9	-.081	-.176*	-.103*	-.094	-.141*
10-12	-.114*	-.274*	-.067	-.112*	-.091
13-16	-.004	-.185*	.005	-.047	-.035
17-18	.024	-.085	-.004	-.120	.055
<b>Grade groups</b>					
1	-.286*	-.362*	-.061	-.123	-.020
2	-.059	-.169	-.139*	-.196*	-.129
3	-.078	-.192*	-.035	-.045	-.096
4-6	-.082	-.236*	-.108*	-.112*	-.125*
7-9	-.042	-.189*	-.005	-.009	-.109
10-12	-.006	-.155	.014	-.117	.091

\*  $p < .01$

For Reading Fluency cluster and test analyses across age and grade groups, Concept Formation was a significant predictor in 11 of the 24 analyses. For Reading Comprehension cluster and its component tests across age and grade groups, Concept Formation cluster was a significant predictor in 8 of the 36 analyses. In all 19 instances of significance, the standardized regression coefficients for Concept Formation were negative. For Reading Comprehension, this replicates the finding of Evans et al. (2002) that Fluid Reasoning was not an important predictor. Instead, Comprehension-Knowledge cluster was found to be the most important predictor of reading in WJ III COG. That study did not include analyses for Reading Fluency.

The consistent relationship between Reading Fluency and Concept Formation likely lies in the structure of the Reading Fluency test. As described earlier, this test involves reading statements and responding to true-false questions, and may tap additional abilities that are not involved in the other Reading Comprehension tests. Negative coefficients imply that this is an inverse relationship, and that a higher Reading Fluency score would be accompanied by a lower Concept Formation score. This finding is counterintuitive, considering that better Fluid Reasoning skills would be expected to facilitate decision-making in this type of task. One possibility is that individuals with superior Concept Formation scores would spend additional time considering the truth of the test item because of their developed abilities for making such decisions. This approach to the test would slow down performance and lead the test taker to complete fewer items. Further research is needed to clarify this relationship. Similarly, the manual of the WJ III indicates a moderate relationship between working memory and Concept

Formation, so may also be useful in future research to examine the relationship between Reading Fluency and working memory.

#### *Longitudinal research*

Another direction for future research is use of a longitudinal approach following the important associations in this study to examine these functional relationships. This is the only way to verify the conclusions of the present study. In addition, an experimental longitudinal study could attempt to capture causal relationships that cannot be examined in a cross-sectional design, as suggested by Catts et al. (2002). These authors proposed that such an approach could be used to explore the hypothesis that the relationships between language and reading are reciprocal in nature once reading is established. A longitudinal design could also group participants on the basis of initial testing to determine whether the observed trends of association across the school years differ according to initial level of performance.

#### *Association between Basic Reading and Language in WJ III ACH*

The present study was limited to examining associations with Reading Comprehension and Reading Fluency, and did not explore the associations between Basic Reading cluster and Language clusters (Oral Expression and Listening Comprehension) of WJ III ACH. For example, Nation and Snowling (1998) proposed that vocabulary knowledge influences both decoding and comprehension through bootstrapping. Such a finding would have important implications for the understanding of the broader relationship between language and reading. In light of the importance of Sound Awareness across age groups and grade groups, study of Sound Awareness and the Language curricular area of WJ III could offer insight into this relationship. Future

studies could address these issues by considering the relationships between Basic Reading and Language in addition to their associations with reading comprehension.

#### *Beyond WJ III ACH*

One final issue that could be addressed in a future study is replication with tests in addition to WJ III ACH. The present study was designed to examine relationships in the context of WJ III ACH because of the inherent advantages in use of one instrument for the entire age range and grade range. However, this approach limits interpretation of findings to the manner in which constructs are addressed in this battery. For instance, WJ III ACH does not have separate measures of expressive grammar and syntax, nor does it differentiate between semantics, grammar, and syntax in measures of receptive language. As noted throughout this discussion, the actual components of language that influence particular tests may go beyond the construct that is the focus of particular tests. Future studies that focus on the relationships observed in the present study with additional measures could elaborate upon the present findings, particularly in these components of language.

#### *Caveats*

This study was based on a sample of the general population. Although the relationships revealed in these analyses may have implications for individuals with language disorders or reading disorders, children with disabilities or impairments were not the focus of this study. Therefore, these results cannot be generalized to these populations. As such, the instructional relevance of these results is extremely limited. The direction of the associations identified in these analyses has also not been specified. For example, it would be inappropriate to presume that the association between Sound

Awareness and Reading Comprehension implies that a phonological-awareness-based intervention would have an impact on reading comprehension. Further research is necessary to examine the directions of these relationships, and to explore their relevance for clinical populations.

### *Summary and Conclusions*

This study examined the relationships of Basic Reading, Sound Awareness, and Language (Oral Expression and Listening Comprehension) with Reading Fluency and Reading Comprehension, as measured by WJ III ACH. The strength of the relationships of Reading Fluency and Reading Comprehension with Basic Reading (particularly Letter-Word Identification) decreased across age and grade groups, although Basic Reading continues to be significantly associated with both Reading Fluency and Reading Comprehension across all age and grade groups.

For Reading Fluency, this decrease is accompanied by an increased association with Listening Comprehension across age and grade groups, so that language comprehension becomes increasingly important in the older groups. This finding supports those of previous studies, as well as the hypothesis that receptive language skills become more strongly associated with reading comprehension as decoding proficiency increases. This finding was also noted for Reading Comprehension, as well as an increased association with Oral Expression and Sound Awareness across age and grade groups. These results indicate that receptive morphosyntactic knowledge and expressive vocabulary become more strongly associated with reading vocabulary in the later age and

grade groups. Future studies could elaborate upon these findings with more specific measures of receptive and expressive vocabulary, grammar, and syntax.

The finding that Sound Awareness was increasingly associated with Reading Comprehension across age groups and grade groups was not anticipated given the literature in this area, which suggests that this ability would no longer be important once decoding skills are acquired. These results may be due to the structure of Sound Awareness test and the possible influence of broader language skills (beyond phonology) on test scores. This finding warrants further study to determine the actual relationships reflected by these results and the directions of influence among these factors.

Finally, the relationships examined in this study differed across groups, with some shifts in relationships observed only in the oldest age and grade groups. This finding implies that future studies of these relationships should include a similarly wide range to allow for consideration of shifts across, and even beyond, the school years.

APPENDIX A  
SAMPLE TEST ITEMS

## SAMPLE TEST ITEMS

### **Letter-Word Identification**

Requires the test-taker to name a letter or read the item aloud

Examples: H, especially

### **Word Attack**

Requires the test-taker to read the nonsense word aloud

Examples: ip, zalubooba

### **Reading Fluency**

Requires the test-taker to read a sentence and circle “yes” or “no” on the test record to indicate if the sentence is true or false.

Example: Cows are purple.

Grass is green.

### **Understanding Directions**

Requires the test taker to point according to the directions.

Examples: Point to the fence.

Point to the frog, then the cat under the tree.

### **Passage Comprehension**

Requires the test-taker to read a stimulus word or phrase and identify pictures (in earlier items) or provide missing words in a sentence about the passage (in later items).

Example: Put your finger on the house.

Some cats are mischievous, and enjoy playing with strings, balls, and toys.

Other cats are lazy, seeking out a warm sunny spot to lounge all day long.

These cats are sedentary, but the others are \_\_\_\_\_.

### **Reading Vocabulary**

Requires the test-taker to read a word and provide either a synonym or antonym, or complete an analogy.

Examples: mom (synonym is mother)

far (antonym is near)

sit...down stand...(up)



**Story Recall**

A few sentences are presented verbally to the test-taker, who receives points for each component (in italics, in this example) that is recalled.

Example: *Heather*/likes to *read*./Then she *draws pictures*/about the *story*.

**Picture Vocabulary**

The test-taker names pictures verbally.

Examples: a picture of a tree, a picture of a cyclone

**Oral Comprehension**

The test-taker provides a word that fits in a sentence that they hear using a cloze procedure.

Examples: We swim in the (pool).

Several Italian specialties, such as lasagna and minestrone, can be prepared in unconventional ways. It is very important to read your recipe before shopping to be sure that you purchase all of the right (ingredients).

APPENDIX B

MLC DATA REQUEST AND APPROVAL LETTER

**Proposal to:** Woodcock-Munoz Foundation

**By:** Heather Gillum, Doctoral Student (Child Language), Vanderbilt University

**Faculty Advisor:** Dr. Stephen Camarata

**Proposed study-rationale and research questions:**

There is a long history of research on the relationship between language and reading. Such studies have examined early language ability as a predictor of future reading ability (e.g., Catts, Fey, Zhang, & Tomblin, 2001; Snowling, 1998; Whitehurst & Lonigan, 1998), the influence of various cognitive abilities on reading proficiency (Evans, Floyd, McGrew, & Leforgee, 2001), and the impact of speech and language disorders on literacy (e.g., Aram & Nation, 1980; Bishop & Adams, 1990; Nathan, Stackhouse, Goulandris, & Snowling, 2004). One logical relationship that has not yet been addressed in detail in the literature is concurrent performance in language and reading achievement across age and grade level.

No *pragmatic* (versus theoretically-driven) study has explored the relationship of performance in sound awareness, language comprehension, oral language, and basic reading with performance in reading comprehension as children acquire literacy and progress through the school years. Assessment professionals need to know how the primary batteries they use on a regular basis help with understanding the relationship between measured language abilities and reading comprehension. Understanding possible developmental variations in this relationship is of significant importance to those who design and conduct school-based assessments.

To our knowledge, no study has examined the pragmatic question of “what is the relationship between measures of language and reading comprehension on the WJ III Tests of Achievement Battery and, do these relationships vary as a function of developmental status?” Given the large number of assessment professionals who do not engage in cognitive ability assessment, but instead, focus their work only on tests from achievement batteries, it is important to provide guidance on the relationship of language and reading comprehension measures in one of the more frequently used individually administered achievement batteries in education—WJ III Tests of Achievement.

The purpose of the study is to examine aspects of this relationship with tests/clusters from the Woodcock Johnson III Tests of Achievement (WJ III ACH) across age and grade levels. The specific research questions to be addressed are:

- What is the relationship between scores on the WJ III tests of language, sound awareness, and basic reading achievement and scores on tests of reading comprehension achievement across the age range of 6 to 18 years?
- What is the relationship between scores on the WJ III tests of language, sound awareness, and basic reading achievement and scores on tests of reading comprehension achievement across the grade range 1 through 12?

Within the broader context of a language-reading relationship, it is hypothesized that the relationships among scores on tests of these skills will shift over time. In younger ages and earlier grades, basic reading skills and sound awareness may account for a greater proportion of reading comprehension variance. However, broader language skills may be more predictive of reading comprehension in older children in the later grades.

### **Proposed study data analyses:**

These hypothesized relationships would be examined through multiple regression analyses, as demonstrated by McGrew (1993) in his analysis of shifts of the relationship between cognitive abilities (as measured by tests in the Woodcock Johnson Revised Cognitive Battery) and reading achievement (as measured by the Woodcock Johnson Revised Tests of Achievement) across age groups. In that study, general equations were specified and were calculated separately for each age group. This method allowed for the examination of differences among standardized regression coefficients across groups.

The proposed study would utilize a similar approach, specifying five general regression equations to be calculated separately for each age and grade group. All of the regression equations will utilize W-scores, computed at the cluster level for two equations and at the test level for three equations. The general regression equations would be constructed as follows:

- f) Basic Reading Skills, Sound Awareness, Oral Expression, and Listening Comprehension cluster scores regressed onto *Reading Comprehension cluster* score
- g) Basic Reading Skills, Sound Awareness, Oral Expression, and Listening Comprehension cluster scores regressed onto *Reading Fluency test* score
- h) Letter-Word Identification, Word Attack, Sound Awareness, Story Recall, Picture Vocabulary, Understanding Directions, and Oral Comprehension test scores regressed onto *Passage Comprehension test* score
- i) Letter-Word Identification, Word Attack, Sound Awareness, Story Recall, Picture Vocabulary, Understanding Directions, and Oral Comprehension test scores regressed onto *Reading Vocabulary test* score
- j) Letter-Word Identification, Word Attack, Sound Awareness, Story Recall, Picture Vocabulary, Understanding Directions, and Oral Comprehension test scores regressed onto *Reading Fluency test* score.

The regression equations will be calculated separately for each age group (ages 6 through 18 years) and each grade level (grades 1 through 12). Upon completion of the analyses, standardized regression coefficients (for clusters and tests) will be examined, with the expectation that recognizable patterns and/or shifts will emerge that will demonstrate the relative importance of basic reading skills and language skills for reading comprehension across age and grade levels. The regression coefficients will be plotted as a function of age/grade and population trends will be approximated with an appropriate non-linear smoothing function (e.g., DWLS smoothing algorithm used by McGrew, 1993).

**Data requested:**

Completion of this proposed study would involve collection of data for individual participants in the WJ III norming sample for age groups 6 through 18 and grade groups 1 through 12. Given the emphasis on language skills in this study, it is desirable that only participants who spoke English as a first language would be included in this sample. No other exclusionary criteria are necessitated by the design of this study.

For each of the included participants, the following descriptive information is requested: gender, ethnicity, census region, community size, parents' education, and type of school attended.

With respect to WJ III test/cluster scores (as specified above), it is understood that all norming sample participants were not administered all WJ III ACH tests. Thus, all *available* W-scores within the reading and oral language curricular areas, as well as the Sound Awareness test, for each of the norming participants, are requested.

**Proposed dissemination plan:**

- Preparation of dissertation, to be presented to Vanderbilt community at large and to be published and held in University library
- Presentation at state and national conferences, including Tennessee Audiology and Speech-Language Pathology Association state conference, American Speech-Language and Hearing Association national conference, and the annual Child Language Research conference held in Madison, WI
- Submission for publication in a research journal, such as Journal of Speech-Language-Hearing Research or Child Language.

**Student contact information:**

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The  
*Woodcock-Muñoz*  
Foundation

Kevin S. McGrew, PhD  
603 Graceview Drive  
St. Joseph, MN 56374

05-10-05

Heather Gillum  
9410 Brookview Dr.  
Brentwood, TN, 37027

*RE: Proposed study – An investigation of the developmental relations between measures of language and reading comprehension on the WJ III Tests of Achievement Battery*

Dear Heather,

I am pleased to report that your 5-9-05 request to analyze portions of the WJ III COG standardization data has been approved.

I will be preparing and emailing the data to you within the next week. All I need to know is the type of data file format you need (SYSTATPC; SYSTAT, Excel, etc.). I have a stat transfer program and can likely provide the data in whatever stat program you plan to use.

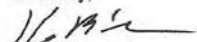
As a reminder, the data are the property of *The Woodcock-Muñoz Foundation*. You and/or your faculty advisors may not release the data to a third party nor can the data be used for the direct or indirect development of commercial products.

Please provide me a synopsis of your research findings at an appropriate point. Also, if you should publish a paper using the data, please provide the WMF with an offprint. Please send it to my attention at the address listed above.

As WMF Research Director, all correspondence regarding the implementation of your study should be sent directly to me (kmcgrew@earthlink.net; regular mail address above). If you need any technical assistance and/or consultation during any stage of your project, including help with the preparation of presentation materials and/or manuscripts, please don't hesitate to contact me.

I look forward to working with you and your advisor on this study.

Sincerely,

  
Kevin S. McGrew, PhD  
Research Director

*How is your office  
Lottor  
6-29-05*

APPENDIX C

IRB APPLICATION AND APPROVAL LETTER

Principal Investigator: Heather Gillum Version Date: 03/09/2005  
 Study Title: Influence of basic reading skills and language skills on reading comprehension  
 Institution/Hospital: Vanderbilt University

**Vanderbilt University Institutional Review Board  
 Request for Exemption**

**1. Principal Investigator Information**

**VU Human Subjects Training Completed**

First Name: Heather		Middle Initial: L	Last Name: Gillum	
Degree(s): <input type="checkbox"/> Ed.D. <input type="checkbox"/> J.D. <input type="checkbox"/> M.D. <input type="checkbox"/> Ph.D. <input type="checkbox"/> R.N. <input checked="" type="checkbox"/> Other, specify: M.A.				
Job Title: Doctoral student			Affiliation: <input checked="" type="checkbox"/> VU <input type="checkbox"/> Stallworth <input type="checkbox"/> VA-TN Valley HS <input type="checkbox"/> Other, specify:	
Department/Division: Hearing & Speech Sciences			School/College: Graduate School	
Campus Address:			Zip+4:	
Campus Phone:	Fax:	Pager:	Email: heather.l.gillum@vanderbilt.edu	
<b>Complete if PI does not have campus address:</b>				
Address: 9410 Brookview Dr.			City: Brentwood	
State: TN	Zip: 37027	Phone: (615)463-7596		

**2. Faculty Advisor (complete if PI is a student, resident, or fellow)**  **NA**

**VU Human Subjects Training Completed**

Faculty Advisor's name: Stephen Camarata		Title: Associate Professor/ Deputy Director Kennedy Center		
Department/Division: Hearing & Speech Sciences		School/College: Graduate School		
Campus Address: Vanderbilt Bill Wilkerson Center		Zip+4: 37212-8700		
Campus Phone: 6-5111	Fax:	Pager:	Email: Stephen.camarata.2@vanderbilt.edu	

**3. Study Contact Information (complete if primary contact is different from PI)**  **NA**

**VU Human Subjects Training Completed**

First Name:		Middle Initial:	Last Name:	
Degree(s): <input type="checkbox"/> Ed.D. <input type="checkbox"/> J.D. <input type="checkbox"/> M.D. <input type="checkbox"/> Ph.D. <input type="checkbox"/> R.N. <input type="checkbox"/> Other, specify:				
Job Title:			Affiliation: <input type="checkbox"/> VU <input type="checkbox"/> Stallworth <input type="checkbox"/> VA-TN Valley HS <input type="checkbox"/> Other, specify:	
Department/Division:			School/College:	
Campus Address:			Zip+4:	
Campus Phone:	Fax:	Pager:	Email:	
<b>Complete if contact does not have campus address:</b>				
Address:			City:	
State:	Zip:	Phone:		

**4. Study Information:**

A. Give a brief synopsis of the research, including background information and rationale.

There is a rich history of research on the acquisition of literacy and predictors of reading ability. However, this research has largely ignored the influence of broader language ability on reading proficiency, and the possibility of shifts in influences on reading achievement across age and school experience. The hypothesis of the proposed study is that reading comprehension (understanding the meaning of written language) of younger children is highly associated with the ability to decode written text, but that broader language skills (such as vocabulary knowledge and listening comprehension) become more strongly associated with reading comprehension with age and school experience. To test this hypothesis, normative data collected during the standardization of the Woodcock Johnson III Tests of Achievement (McGrew & Woodcock, 2001) will be statistically analyzed to examine these relationships. This study has the potential to reveal significant patterns of influence on reading comprehension. Such revelations would lead to a better



Principal Investigator: Heather Gillum

Version Date: 03/09/2005

Study Title: Influence of basic reading skills and language skills on reading comprehension

Institution/Hospital: Vanderbilt University

understanding of the relationship between language and reading across age and school experience, with the potential for influencing practice in assessment of reading and language achievement as well as instructional methods in these curricular areas.

- B. Describe the subject population/ type of data/specimens to be studied.

Prisoners (Note: Research involving prisoners is not eligible for exemption).

Children (Note: Research involving children has more restrictive exemption criteria; see instructions).

Other: on the shelf, de-identified numerical data

The data for this study are held by Measurement Learning Consultants (MLC), an organization charged with storage and management of the normative data collected during standardization of the Woodcock Johnson III Psychoeducational Battery (published in 2001). This organization provides de-identified test score data to researchers for the purpose of further analysis upon request. For the proposed study, the PI will request de-identified individual test scores for all participants in the norming sample between the ages of 6 and 16 years who spoke English as a first language and who were administered all 9 tests pertinent to the study.

- C. Describe the source of data/specimens and if these are publicly available. If not publicly available, describe how prior approval will be obtained before accessing this information (attach approval letter if available).

As noted in (B) above, the data for this study are held by Measurement Learning Consultants (MLC), an organization charged with storage and management of the normative data collected during standardization of the Woodcock Johnson III Psychoeducational Battery (published in 2001). A written request for the specific de-identified data pertinent to this study will be made, and if approved, the requested data will be provided to the PI via e-mail in a spreadsheet format. MLC will not disclose any of the 18 HIPPA identifiers for the individuals from which the data were collected, and it will be impossible for the PI to make such an association. Once received by the PI, this file will be stored on a password-protected personal computer and will be statistically analyzed. Data will be maintained in this format indefinitely.

- D. Does this study involve the collection of existing records or data often referred to as "on-the-shelf" data [see 45 CFR 46.101 (b)(4)]? Describe how this data is collected, stored and de-identified.

Yes, as described above. The data provided to the PI by MLC will not contain any identifiers, and it would be impossible for the PI to make such an association.

- E. Describe the recruitment process, including any advertisements, to be used for this study.

There is no recruitment associated with this study.

- F. Describe any procedures to be used during this study.

The data provided to the PI by MLC will be statistically analyzed using a hybrid approach of multiple regression with analysis of standardized regression coefficients using distance weighted least-squares (DWLS; Wilkinson, 1990), as demonstrated in other analyses of Woodcock Johnson normative data (Evans, Floyd, McGrew, & Leforgee, 2001; McGrew, 1993). The predictor variables for the multiple regression analyses will be W-scores (individuals' standard scores) for Letter-Word Identification, Word Attack, Understanding Directions, Picture Vocabulary, Oral Comprehension, and Sound Awareness tests. Separate analyses will be conducted for each of the following criterion variables: Reading Fluency, Passage Comprehension, and Reading Vocabulary subtests. In order to examine potential differences in the magnitude of standardized regression coefficients across ranges of age (6 to 16 years), grade (1 through 11), and years in school (1 to 11), separate analyses will be run on the same group of participants organized in each of these ways. Therefore, the analyses for this study will involve a total of 99 multiple regression equations (33 for each criterion variable, which will consist of 11 groups organized in three ways—age, grade, and years in school). These multiple regression equations will yield standardized regression coefficients for significant predictors, which will be plotted in corresponding graphs (separately for ranges of age, grade, and years in school) to visually exhibit age-related (and grade-related and years in school-related) differences in the magnitude of these coefficients. These coefficients will then be analyzed with the DWLS smoothing function. This approach uses a weighted quadratic multiple regression on all the points to reduce the influence of sampling error and to produce a true curve without presupposing the shape of the function (Zachary & Gorsuch, 1985). Both the original standardized regression coefficient plots and the

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Institution/Hospital: Vanderbilt University

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smoothed curves will be presented for each significant predictor in separate graphs corresponding to equations based on age, grade, and years in school.

G. Is this study affiliated with any other IRB-approved studies?

No  Yes

If "Yes", please list by IRB#:

H. Is this proposal associated with a grant or contract?

No  Yes

If "Yes", attach copy and list the funding source associated with the grant or contract.

I. Does this research involve any approved or unapproved FDA regulated items (including foods, including dietary supplements, that bear a nutrient content claim or a health claim, infant formulas, food and color additives, drugs for human use, medical devices for human use, biological products for human use, and electronic products.)

No  Yes (Note: FDA regulated research has more restrictive exemption criteria; see instructions).

J. Will This Research be conducted on VATVHS property or involve VATVHS patients or resources?

No  Yes (Note: The VATVHS R&D Committee must also review and approve all exempt research activities prior to initiation of the research.)

#### CATEGORIES OF EXEMPTION

Involvement of human subject research in the following categories may be declared exempt from IRB Review by the IRB. Only the IRB may determine which activities qualify for an exempt review. From the six categories presented below, check "Yes" for the categories that you believe describe your proposed research and "No" for all others. If none of the categories apply, complete an application for expedited or standard IRB review or contact the IRB staff for instructions.

#### YOU MUST CHECK "YES" OR "NO" FOR ALL OF THE FOLLOWING:

##### 45 CFR 46.101(b)(1):

Yes  No

##### EVALUATION/COMPARISON OF INSTRUCTIONAL STRATEGIES/CURRICULA

Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods. This exemption category cannot be used for FDA regulated research.

If "Yes", describe the educational setting in which the research will be conducted and the type of normal educational practices involved.

##### 45 CFR 46.101(b)(2):

Yes  No

##### EDUCATIONAL TESTS, SURVEYS, INTERVIEWS, OR OBSERVATIONS

Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation. This exemption category cannot be used for FDA regulated research.

**Note: When the research involves children as subjects this exemption must be limited to educational tests (cognitive, diagnostic, aptitude, achievement) and**

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**observation of public behavior when the investigators do not participate in the activities being observed. Research that uses survey procedures, interview procedures, or observation of public behavior when the investigators participate in the activities being observed cannot be granted an exemption.**

**45 CFR 46.101(b)(3):**

Yes  No

**PUBLIC OFFICIALS OR CANDIDATES FOR PUBLIC OFFICE**

Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior that is not exempt under the previous paragraph if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) Federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter. This exemption category cannot be used for FDA regulated research.

Describe how subjects may be identified or are at risk, or state the federal statute that allows the confidentiality of the subject to be maintained throughout the research and thereafter.

**45 CFR 46.101(b)(4):**

Yes  No

**COLLECTION OR STUDY OF EXISTING DATA**

Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. This exemption category cannot be used for FDA regulated research.

**Note: To qualify for this exemption, the data, documents, records, or specimens must be in existence before the project begins. Additionally, under this exemption, an investigator (with proper authorization) may inspect identifiable records, but may only record information in a non-identifiable manner. See [IRB Policy III.C](#) for additional information and examples regarding this exemption.**

**45 CFR 46.101(b)(5):**

Yes  No

**RESEARCH & DEMONSTRATION PROJECTS**

Research and demonstration projects which are conducted by or subject to approval of federal Departmental or Agency heads (such as the Secretary of HHS), and which are designed to study, evaluate, or otherwise examine: (i) Public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; (iv) possible changes in methods or levels of payment for benefits or services under those programs. This exemption category cannot be used for FDA regulated research.

Proof of approval by Department/Agency Head is attached.  Yes  No

**Note: This exemption applies to federally funded projects only and requires authorization or concurrence from the funding agency. Additionally, specific criteria must be satisfied to invoke this exemption. See [IRB Policy III.C](#). Also, this exemption category does not apply if there is a statutory requirement that this project be reviewed by an IRB or if the research involves physical invasion or intrusion upon the privacy of subjects.**

**45 CFR 46.101(b)(6) and 21 CFR 56.104(d):**

Yes  No

**FOOD QUALITY EVALUATION & CONSUMER ACCEPTANCE STUDIES**

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Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome food, without additives are consumed or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA or approved by the EPA or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

5. Will Protected Health Information (PHI)<sup>1</sup> be accessed (used within VUMC) in the course of preparing for this research?

No  Yes

If "No", skip to the Conflict of Interest statement on the next page.

**STATEMENT OF AFFIRMATION**

If Protected Health Information (PHI)<sup>1</sup> is accessed (used) in the course of preparing for this research the following 3 conditions **must** be met:

1. The use or disclosure of the PHI is sought solely for the purpose of preparing this research protocol.
2. The PHI will not be removed from the covered entity.
3. This PHI is necessary for the purpose of this research study.

The above 3 conditions must be met to allow for the access (use) of PHI as "preparatory to research."

- A. Will a de-identified data set be created (all 18 HIPAA identifiers must be removed, see list attached)?

No  Yes

- B. Will a limited data set be created?

No  Yes If "Yes", complete the VUMC "Data Use Agreement" below.

The data use agreement below sets forth the terms and conditions in which the Covered Entity (VUMC) will allow the use and disclosure of a limited data set<sup>2</sup> to the Data Recipient (Principal Investigator). The limited data set must have direct identifiers removed, but may include town, city, and/or 5-digit ZIP codes as well as date elements (e.g., dates of birth, admission, discharge, etc.).

**VUMC DATA USE AGREEMENT**

NOT APPLICABLE

In addition to the Principal Investigator, identify all individuals who will be requesting authorization to access the limited data set:

Name of Institution and/or Individual	Non-VUMC Data Use Agreement Required?*	
	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	<input type="checkbox"/> Yes	<input type="checkbox"/> No
	<input type="checkbox"/> Yes	<input type="checkbox"/> No

\*A Non-VUMC data use agreement is required to disclose the limited data set to an Individual or an Institution outside of VUMC. A template is available at:

<http://www.mc.vanderbilt.edu/irb/Forms/Form1109DataUseAgreement.doc>

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**As the Principal Investigator of this study I agree:**

Not to use or disclose the limited data set for any purpose other than the research project or as required by law.

To use appropriate safeguards to prevent use or disclosure of the limited data set other than as provided for by this Agreement.

To report to the Covered Entity (Vanderbilt University Medical Center) any use or disclosure of the limited data set not provided for by this agreement, of which I become aware, including without limitation, any disclosure of PHI to an unauthorized subcontractor.

To ensure that any agent, including a subcontractor, to whom I provide the limited data set, agrees to the same restrictions and conditions that applies through this agreement to the Data Recipient with respect to such information.

Not to identify the information contained in the limited data set or contact the individual.

**6. Potential Conflict of Interest**

**A. Is there a potential conflict of interest for the Principal Investigator or key research personnel?**

*Assessment should include anyone listed as Principal Investigator, or other research personnel on page 1 of this application. Please note that the thresholds of ownership described below apply to the aggregate ownership of an individual investigator, his/her spouse, domestic partner and dependent children (e.g., if an investigator, his/her spouse, domestic partner and dependent children own together \$10,000 or 5% worth of equities in the sponsor, it should be reported below). Do not consider the combined ownership of all investigators.*

No

Yes *If "Yes", the investigator must complete and submit IRB Form #1120, "Conflict of Interest Supplemental Form" with this application. Form #1120 and the protocol must be reviewed by the VU Conflict of Interest Committee.*

**NOTE: Although approval may be granted by the IRB, the Investigator may not proceed with the research until a final determination letter has been rendered by the MCCOIC or the University Conflicts Committee.**

**B. If "Yes", check all that apply:**

Compensation whose value could be affected by the study outcome.

A proprietary interest in the tested product included but not limited to, a patent, trademark, copyright or licensing agreement, or the right to receive royalties from product commercialization.

Any equity interest in the sponsor or product whose value cannot be readily determined through preference to public prices (e.g., ownership interest or stock options).

Any equity interest in the sponsor or product that exceeds \$10,000 or 5%.

Significant payments or other sorts with a cumulative value of \$10,000 made directly by the sponsor to any of the investigators listed on page 1 of this application as an unrestricted research or educational grant, equipment, consultation or honoraria.

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**Investigator Assurance and Compliance Statement**

As the PI of this study I agree:

- To accept responsibility for the scientific and ethical conduct of this project;
- To ensure all investigators and key study personnel have completed the VU human subjects training program;
- To submit for approval any additions, corrections or modifications to the protocol or informed consent document to the IRB prior to the implementation of any changes; and
- This project will not be started until final approval has been granted from the IRB.

\_\_\_\_\_  
Principal Investigator's Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Faculty Advisor (if PI is non-faculty)

\_\_\_\_\_  
Date

<sup>1</sup> **Protected Health Information (PHI):** Protected health information (PHI) is individually identifiable health information that is or has been collected or maintained by Vanderbilt University Medical Center, including information that is collected for research purposes only, and can be linked back to the individual participant. Use or disclosure of such information must follow HIPAA guidelines.

Individually identifiable health information is defined as any information collected from an individual (including demographics) that is created or received by a health care provider, health plan, employer, and/or health care clearinghouse that relates to the past, present or future physical or mental health or condition of an individual, or the provision of health care to an individual or the past, present or future payment for the provision of health care to an individual and identifies the individual and/or to which there is reasonable basis to believe that the information can be used to identify the individual (**45 CFR 160.103**).

A covered entity (VUMC) may determine that health information is not individually identifiable (**De-identified**) health information only if all of the following identifiers of the individual or of relatives, employers, or household members of the individual are removed:

1. Names;
2. Any geographic subdivisions smaller than a State, including street address, city, county, precinct, zip code, and their equivalent geocodes, except for the initial three digits of a zip code;
3. All elements of dates (except year) for dates directly related to an individual (e.g., date of birth, admission);
4. Telephone numbers;
5. Fax numbers;
6. Electronic mail addresses;
7. Social security numbers;
8. Medical record numbers;
9. Health plan beneficiary numbers;
10. Account numbers;
11. Certificate/license numbers;
12. Vehicle identifiers and serial numbers, including license plate numbers;
13. Device identifiers and serial numbers;
14. Web Universal Resource Locators (URLs);
15. Internet Protocol (IP) address numbers;
16. Biometric identifiers, including finger and voiceprints;
17. Full-face photographic images and any comparable images; and
18. Any other unique identifying number, characteristic, or code.

<sup>2</sup> **Limited data set:** The limited data set is protected health information that **excludes** all above data elements with the exception of elements of dates, geographic information (not as specific as street address), and any other unique identifying element not explicitly excluded in the list above.



Vanderbilt University

Institutional Review Board

D-3232 Medical Center North Nashville, Tennessee 37232-2568  
(615) 322-2918 Fax: (615) 343-2648  
www.mc.vanderbilt.edu/irb

April 20, 2005

Heather L. Gillum, MA  
9410 Brookview Dr.  
Brentwood, TN 37027

Stephen M. Camarata, Ph.D.  
Hearing & Speech; Kennedy Center  
Bill Wilkerson Center

RE: IRB# 050367 "Influence of Basic Reading Skills and Language Skills on Reading Comprehension"

Dear Ms. Gillum:

A designee of the Institutional Review Board reviewed the Request for Exemption application identified above. It was determined the study poses minimal risk to participants. This study meets 45 CFR 46.101 (b) category (4) for Exempt Review.

Exempt studies do not require annual reviews, however, any changes to the research proposal must be presented to the IRB for approval before implementation.

DATE OF IRB APPROVAL: 04/20/2005

Sincerely,

*Jenni Beadles*  
Jenni Beadles, BS, CIM, CIP  
Institutional Review Board  
Behavioral Sciences Team

JGB

Gillum, Heather L. IRB # 050367

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04/20/2005

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APPENDIX D  
REGRESSION EQUATIONS

Regression equations for Reading Fluency cluster with predictors Basic Reading cluster (BR), Sound Awareness test (SA), Oral Expression cluster (OE), and Listening Comprehension cluster (LC),  $p < .01$ .

---

Age groups	Overall	$Y_{RFcluster} = 1.398x_{BRcluster} - .274x_{SAcluster} - 92.330$
	6	$Y_{RFcluster} = .259x_{BRcluster} - 89.096$
	7	$Y_{RFcluster} = .415x_{BRcluster} + .582x_{SAcluster} - 2.910$
	8-9	$Y_{RFcluster} = .494x_{BRcluster} + .335x_{OEcluster} + .332x_{LCcluster} - 200.050$
	10-12	$Y_{RFcluster} = .564x_{BRcluster} + .756x_{LCcluster} - 399.903$
	13-16	$Y_{RFcluster} = .777x_{BRcluster} + .474x_{SAcluster} + 1.033x_{LCcluster} - 200.050$
	17-18	$Y_{RFcluster} = .918x_{BRcluster} + .940x_{LCcluster} - 399.903$

---

Grade groups	Overall	$Y_{RFcluster} = 1.414x_{BRcluster} - .262x_{SAcluster} + .137x_{LCcluster} - 90.389$
	1	$Y_{RFcluster} = .407x_{BRcluster} + 18.004$
	2	$Y_{RFcluster} = .414x_{BRcluster} + .386x_{LCcluster} - 106.631$
	3	$Y_{RFcluster} = .397x_{BRcluster} + .552x_{LCcluster} - 197.962$
	4-6	$Y_{RFcluster} = .552x_{BRcluster} + .594x_{LCcluster} - 305.226$
	7-9	$Y_{RFcluster} = .588x_{BRcluster} + .984x_{LCcluster} - 582.250$
	10-12	$Y_{RFcluster} = .949x_{BRcluster} + 1.086x_{LCcluster} - 646.771$

---

Regression equations for Reading Comprehension cluster with predictors Basic Reading cluster (BR), Sound Awareness test (SA), Oral Expression cluster (OE), and Listening Comprehension cluster (LC),  $p < .01$ .

---

Age groups	Overall	$Y_{RCcluster} = .405x_{BRcluster} + .254x_{SAcluster} + .073x_{OEcluster} + .054x_{LCcluster} + 107.555$
	6	$Y_{RCcluster} = .437x_{BRcluster} + 33.052$
	7	$Y_{RCcluster} = .442x_{BRcluster} + 82.490$
	8-9	$Y_{RCcluster} = .258x_{BRcluster} + .315x_{SAcluster} + .178x_{OEcluster} + .196x_{LCcluster} + 28.904$
	10-12	$Y_{RCcluster} = .180x_{BRcluster} + .346x_{SAcluster} + .200x_{OEcluster} + .240x_{LCcluster} + 19.186$
	13-16	$Y_{RCcluster} = .205x_{BRcluster} + .347x_{SAcluster} + .185x_{OEcluster} + .189x_{LCcluster} + 42.262$
	17-18	$Y_{RCcluster} = .181x_{BRcluster} + .455x_{SAcluster} + .233x_{OEcluster} + 31.778$

---

Grade groups	Overall	$Y_{RCcluster} = .393x_{BRcluster} + .244x_{SAcluster} + .089x_{OEcluster} + .061x_{LCcluster} + 107.035$
	1	$Y_{RCcluster} = .459x_{BRcluster} + 98.338$
	2	$Y_{RCcluster} = .344x_{BRcluster} + .254x_{OEcluster} + .259x_{LCcluster} - 18.193$
	3	$Y_{RCcluster} = .245x_{BRcluster} + .329x_{SAcluster} + .266x_{LCcluster} + 18.522$
	4-6	$Y_{RCcluster} = .171x_{BRcluster} + .348x_{SAcluster} + .199x_{OEcluster} + .199x_{LCcluster} + 43.900$
	7-9	$Y_{RCcluster} = .203x_{BRcluster} + .363x_{SAcluster} + .219x_{OEcluster} + .157x_{LCcluster} + 33.591$
	10-12	$Y_{RCcluster} = .197x_{BRcluster} + .359x_{SAcluster} + .190x_{OEcluster} + .176x_{LCcluster} + 45.121$

---

Regression equations for Reading Fluency test with predictors Letter-Word Identification (LWI), Word Attack (WA), Sound Awareness (SA), Oral Comprehension (OC), Understanding Directions (UD), Story Recall (SR), and Picture Vocabulary (PV),  $p < .01$ .

---

Age groups	Overall	$Y_{RFtest} = .483x_{LWtest} + .647x_{SRtest} + 1.292x_{UDtest} + .273x_{OCtest} + .148x_{PVtest} - 833.460$
	6	$Y_{RFtest} = .318x_{LWtest} - 409.361$
	7	$Y_{RFtest} = .357x_{LWtest} + .483x_{SAtest} + 10.866$
	8-9	$Y_{RFtest} = .376x_{LWtest} + .005x_{SRtest} + .541x_{UDtest} - 320.773$
	10-12	$Y_{RFtest} = .375x_{LWtest} + .186x_{WAtest} + 1.223x_{UDtest} + .209x_{OCtest} - 541.565$
	13-16	$Y_{RFtest} = .526x_{LWtest} + .260x_{WAtest} + 1.618x_{UDtest} + .316x_{OCtest} - 1038.921$
	17-18	$Y_{RFtest} = .468x_{LWtest} + 1.382x_{UDtest} - 950.772$

---

Grade groups	Overall	$Y_{RFtest} = .482x_{LWtest} + .476x_{SRtest} + 1.340x_{UDtest} + .294x_{OCtest} + .116x_{PVtest} - 762.923$
	1	$Y_{RFtest} = .389x_{LWtest} - 49.602$
	2	$Y_{RFtest} = .306x_{LWtest} - 276.319$
	3	$Y_{RFtest} = .268x_{LWtest} + .675x_{UDtest} + .179x_{OCtest} - 306.841$
	4-6	$Y_{RFtest} = .368x_{LWtest} + .192x_{WAtest} + .591x_{SRtest} + 1.055x_{UDtest} - 496.180$
	7-9	$Y_{RFtest} = .360x_{LWtest} + .267x_{WAtest} + 1.277x_{UDtest} + .333x_{OCtest} - 762.931$
	10-12	$Y_{RFtest} = .544x_{LWtest} + .376x_{WAtest} + 1.697x_{UDtest} + .330x_{OCtest} - 1020.986$

---

Regression equations for Reading Vocabulary test with predictors Letter-Word Identification (LWI), Word Attack (WA), Sound Awareness (SA), Oral Comprehension (OC), Understanding Directions (UD), Story Recall (SR), and Picture Vocabulary (PV),  $p < .01$ .

---

Age groups	Overall	$Y_{RVtest} = .174x_{LWtest} + .037x_{WAtest} + .284x_{SAtest} + .507x_{SRtest} + .087x_{UDtest} + .073x_{OCtest} + .087x_{PVtest} - 122.960$
	6	$Y_{RVtest} = .186x_{LWtest} + 17.016$
	7	$Y_{RVtest} = .146x_{LWtest} + .136x_{WAtest} + .705x_{SRtest} - 146.783$
	8-9	$Y_{RVtest} = .120x_{LWtest} + .062x_{WAtest} + .327x_{SAtest} + .400x_{SRtest} + .071x_{OCtest} + .097x_{PVtest} - 93.266$
	10-12	$Y_{RVtest} = .112x_{LWtest} + .297x_{SAtest} + .487x_{SRtest} + .088x_{OCtest} + .095x_{PVtest} - 93.216$
	13-16	$Y_{RVtest} = .137x_{LWtest} + .309x_{SAtest} + .746x_{SRtest} + .086x_{OCtest} - 181.272$
	17-18	$Y_{RVtest} = .166x_{LWtest} + .413x_{SAtest} + .786x_{SRtest} + .143x_{PVtest} - 180.553$

---

Grade groups	Overall	$Y_{RVtest} = .165x_{LWtest} + .043x_{WAtest} + .284x_{SAtest} + .504x_{SRtest} + .086x_{UDtest} + .083x_{OCtest} + .082x_{PVtest} - 120.850$
	1	$Y_{RVtest} = .168x_{LWtest} + 39.980$
	2	$Y_{RVtest} = .096x_{LWtest} + .162x_{WAtest} + .293x_{SAtest} + .761x_{SRtest} - 202.324$
	3	$Y_{RVtest} = .147x_{LWtest} + .263x_{SAtest} + .402x_{SRtest} + .283x_{UDtest} + .111x_{PVtest} - 151.323$
	4-6	$Y_{RVtest} = .089x_{LWtest} + .368x_{SAtest} + .467x_{SRtest} + .084x_{OCtest} + .094x_{PVtest} - 66.361$
	7-9	$Y_{RVtest} = .118x_{LWtest} + .2914x_{SAtest} + .708x_{SRtest} + .079x_{OCtest} + .079x_{PVtest} - 170.717$
	10-12	$Y_{RVtest} = .171x_{LWtest} + .335x_{SAtest} + .687x_{SRtest} - 149.423$

---

Regression equations for Passage Comprehension test with predictors Letter-Word Identification (LWI), Word Attack (WA), Sound Awareness (SA), Oral Comprehension (OC), Understanding Directions (UD), Story Recall (SR), and Picture Vocabulary (PV),  $p < .01$ .

---

Age groups	Overall	$Y_{PCtest} = .309x_{LWItest} + .086x_{WAtest} + .197x_{SAtest} + .162x_{UDtest} + .098x_{OCtest} + 42.648$
	6	$Y_{PCtest} = .393x_{LWItest} + .248x_{WAtest} + 267.590$
	7	$Y_{PCtest} = .472x_{LWItest} + 294.254$
	8-9	$Y_{PCtest} = .235x_{LWItest} + .115x_{OCtest} + 29.142$
	10-12	$Y_{PCtest} = .166x_{LWItest} + .268x_{SAtest} + .188x_{UDtest} + .112x_{OCtest} + 21.405$
	13-16	$Y_{PCtest} = .150x_{LWItest} + .194x_{SAtest} + .486x_{SRtest} + .083x_{OCtest} - 42.858$
	17-18	$Y_{PCtest} = .441x_{SAtest} + 9.653$

---

Grade groups	Overall	$Y_{PCtest} = .292x_{LWItest} + .076x_{WAtest} + .178x_{SAtest} + .156x_{UDtest} + .107x_{OCtest} + 29.752$
	1	$Y_{PCtest} = .445x_{LWItest} + .180x_{WAtest} + 270.330$
	2	$Y_{PCtest} = .310x_{LWItest} + 128.408$
	3	$Y_{PCtest} = .205x_{LWItest} + .149x_{OCtest} + 62.881$
	4-6	$Y_{PCtest} = .170x_{LWItest} + .287x_{SAtest} + .104x_{OCtest} + 29.187$
	7-9	$Y_{PCtest} = .153x_{LWItest} + .208x_{SAtest} + .593x_{SRtest} - 92.564$
	10-12	$Y_{PCtest} = .121x_{LWItest} + .294x_{SAtest} + .135x_{OCtest} + 60.603$

---

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