THE DEVELOPMENT OF READING: WHICH FACTORS PLAY A ROLE?

by

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(date) ___3/16/10_____________________

*We also certify that written approval has been obtained for any proprietary material contained therein.
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The Development of Reading: Which Factors Play a Role?

Abstract

by: CRYSTEN MELISSA SKEBO

Factors that have been used to predict reading competence vary widely from study to study. Phonological awareness is a well-documented factor in reading development, but other skills such as oral language, IQ, vocabulary, and verbal working memory also have been shown to play a role. This study examined the relationship between cognitive skills (expressive and receptive language, phonological awareness, Performance IQ, vocabulary, and verbal memory) and reading (decoding and comprehension) at three different stages of reading development: Early Elementary, Middle School, and High School. Results showed that different cognitive skills predict reading ability at different ages and to differing degrees. Vocabulary as measured by standardized assessments was found to be a better predictor of reading than vocabulary in conversation.
The Development of Reading: Which Factors Play a Role?

Reading is an important component of literacy that is essential for functioning in our society. The National Assessment of Adult Literacy (NAAL), most recently conducted in 2003, found that 30 million American adults aged 16 and older scored at the “Below Basic” level of literacy. This means that 14 percent of the adult population was only proficient in the most simple and concrete literacy skills, such as signing a form or reading simple instructions about what to drink before a medical procedure (Baer, Kutner, & Sabatini, 2009). Of these 30 million, 7 million were functionally illiterate in English (Baer et al., 2009). With the inception of the No Child Left Behind Act (2001) and programs created within it such as Reading First and Early Reading First, the U.S. Department of Education has made reading education a priority (White & Dillow, 2005). Speech-Language Pathologists have become increasingly involved in the prevention and remediation of reading disorders due to the link between reading disabilities and oral language skills (Catts, Fey, Zhang, & Tomblin, 2001). However, oral language is just one of the numerous factors that influence a child’s reading ability. Not enough is known about the many factors that predict reading abilities at different ages and how these variables change with development.

I. Components of Reading

In order to understand why different factors can be used to predict reading, one must first have a general understanding of the components of reading and how they develop. Reading is a “complex cognitive activity” that is not easily defined (Catts & Kamhi, 2005, p. 3). Gough and colleagues divide reading into two main components in
the simple view of reading: decoding and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). Decoding refers to the process of translating printed words into sounds, while linguistic comprehension is the process used to interpret words, sentences, and discourse (Gough & Tunmer, 1986). The comprehension process relies on vocabulary and higher-level cognitive abilities. Another view of reading, the broad view, also includes higher-level cognitive processes, such as thinking, reasoning, and problem-solving (Perfetti, 1986). This paper will focus on three major components of reading: decoding, comprehension, and vocabulary.

II. Developmental Trajectory of the Components of Reading

A. General Reading Development

Since there is much individual variation in the timing and the method in which children learn to read, it is difficult to adequately describe the development of reading in a manner that is universally applicable to all children. Stage theories have commonly been used to describe the process of reading development, though the required number of stages needed to attain proficiency in reading differs according to theorist. However, the different theories of reading development include common skills that must be present in order for a child to become a mature and fluent reader.

Chall’s Stages of Reading Development (1983) are widely known and describe how reading develops throughout the lifespan. Prereading, or Stage 0, can be described as the “emergent literacy” phase. In this stage, children are exposed to print, learn graphemes, and memorize labels and signs in their environment (Chall, 1983). The Decoding Stage (Stage 1) includes the development of skills such as phoneme-grapheme
correspondence and knowledge and use of the alphabetic principle. The next stage, Fluency (Stage 2), involves an integration of the skills learned in the first two stages. The child now uses context and semantic knowledge along with decoding skills to identify unfamiliar words (Chall, 1983). Learning the New, or Stage 3, has also been referred to as the transition from “learning to read” to “reading to learn”. In this stage, children are able to use reading as a tool for learning new information, and their vocabularies and cognitive abilities are continuing to develop and grow (Chall, 1983). Stage 4, Multiple Viewpoints, describes the refining of children’s reading skills as they become able to read and comprehend complex information. Finally, Stage 5, Construction and Reconstruction, describes the reading of most adults, who read for the purpose of learning or pleasure (Chall, 1983).

Chall (1983) assigned a “reading grade level” to each of these stages of reading development: Stage 0 is before first grade; Stage 1 takes place in grades 1 and the beginning of 2; Stage 2 is grade levels 2 and 3; Stage 3 is grades 4 through 8; Stage 4 is high school (grades 9 through 12); and Stage 5 is college-level and beyond. However, it is important to note that not all people develop reading in the same manner or at the same time; therefore, these reading stages may be achieved beyond the grade level that is typically associated with them. For example, an adult may be in Stage 2 of reading development and be reading material that has the complexity of what would typically be presented to children in grades 2 and 3. The ability of a person, whether adult or child, to master reading, depends on individual and environmental factors, including such things as disabilities, education, and home and community influences (Chall, 1987).
B. Reading Decoding and Word Recognition

Catts and Kamhi (2005) have summarized Chall’s stages along with theories of reading development by Ehri and McCormick (1998) and Frith (1985). They describe reading as consisting of the development of word recognition skills, along with development of comprehension skills. Word recognition is divided into 3 stages that must occur before the child can automatically recognize words: Logographic, Alphabetic, and Orthographic/Automatic Word Recognition (Catts & Kamhi, 2005). The Logographic Stage is a visual stage in which a child memorizes the way a word looks and “reads” it without using knowledge of phoneme-grapheme correspondence. However, this stage is controversial, and studies have found that logographic reading is not related to later reading proficiency (Share & Stanovich, 1995). Therefore, children do not need to become skilled at logographic reading before they can learn to read phonetically (Catts & Kamhi, 2005).

The hallmark characteristic of the Alphabetic Stage is the development of the ability to read using phoneme-grapheme correspondence (Catts & Kamhi, 2005). Children use this skill in order to decode unfamiliar words. In order to accomplish this, children must first have an understanding of the alphabetic principle (knowledge that letters and combinations of letters represent sounds used in spoken language). Learning to decode words is a complicated process, since the sounds produced in the English language do not always correspond exactly to graphemes, and there are many sounds that can be represented by more than one grapheme (Catts & Kamhi, 2005; Sanders, 2001). In order to become successful decoders, children must learn the allophonic variations of
phonemes and understand the effects of coarticulation in spoken words (Catts & Kamhi, 2005).

The final stage, the Orthographic/Automatic Word Recognition Stage, occurs when the child can visually recognize words without having to decode them (Ehri, 1991; Frith, 1985). This is accomplished with the help of semantic memory. As children decode words, they begin to recognize letter patterns and store them in their memories; therefore, a child cannot master this stage of reading without mastery of phonological decoding (Ehri, 1991). Once the child has stored these mental representations of words, he/she can rely on memory to read (“sight reading”) instead of decoding each word, which improves comprehension (Apel & Swank, 1999). However, the ability to phonologically decode is never completely forgotten; adults still use these skills to read unfamiliar words (Catts & Kamhi, 2005).

C. Reading Comprehension

Before a child is able to efficiently decode and recognize words, he/she has a stronger understanding of spoken language than written language (Catts & Kamhi, 2005). However, when a child develops the ability to automatically recognize words and no longer needs to decode everything, he/she can focus more intently on the meaning of the text he/she is reading and use reading to gain knowledge (Verhoeven & Van Leeuwe, 2008). This is the “reading to learn” stage, described in Chall’s stage 3, where children begin gaining information regarding concepts, facts, and instructions from text (Chall, 1983). Word recognition is not the only skill that must be in place before a child can truly comprehend what he/she reads. Readers also rely on vocabulary, as well as
cognitive skills such as reasoning, problem-solving, and abstract thinking (Catts & Kamhi, 2005). The process of developing reading comprehension skills is not linear, and the necessary linguistic and cognitive skills required to be successful in this area are difficult to measure quantitatively (Catts & Kamhi, 2005).

D. Vocabulary

Reading comprehension depends in part on vocabulary. Reading comprehension and vocabulary have a reciprocal relationship; the more a child reads, the more his/her vocabulary is expanded, and the more his/her vocabulary expands, the more he/she will comprehend (Verhoeven & Van Leeuwe, 2008). When a person is reading, he/she must select the appropriate definitions of words based on context in order to derive meaning from text. Several models have attempted to explain this, one being the selective access model, which states that a person uses context to access a word’s possible meanings and then chooses the one that fits into the context (Glucksberg, Kreuz, & Rho, 1986). Another possible model is multiple access, which states that the brain automatically activates all possible meanings of a word without using context first. Then, the meaning that fits the context is selected from the possibilities (Perfetti, 1999).

Vocabulary also plays a role in word recognition. Connectionist models of reading development (such as the model proposed by Plaut, McClelland, Seidenberg, & Patterson, 1996) divide reading into two pathways: phonological (connections between phonological and orthographic information) and semantic (connections between semantic, phonological, and orthographic information). When children are beginning readers, they are establishing their phonological pathways. As their experience and
practice with reading grows, children depend less on the phonological pathways and
more on the semantic pathways, especially for words that do not fit the expected
orthographic-phonological map (e.g., words that are not spelled the way they sound)
(Nation & Snowling, 2004). Therefore, a child’s vocabulary will influence his/her word
recognition abilities, and also his/her reading comprehension skills.

III. Predictors of Reading

A. Phonological Awareness

Factors that have been used to predict reading competence vary widely from study
to study. One of the most commonly examined skills is phonological awareness, which
has been found to be correlated with reading in numerous studies (Catts, Fey, Zhang, &
Tomblin, 1999; Justice, Bowles, & Skibbe, 2006; Nathan, Stackhouse, Goulandris, &
Snowling, 2004; Scarborough, 1989; Webster, Plante, & Couvillion, 1997). However,
phonological awareness is not the only factor that is associated with reading
development, and it is not necessarily the strongest factor predicting future reading skills
(Scarborough, 2005). Oral language has been found to be a stronger predictor of word
recognition than phonology (Nation & Snowling, 2004). Phonological awareness may
play a bigger role in reading competence when reading skills are first emerging, but after
children learn to read, reading skills influence phonological awareness skills (Hogan,
Catts, & Little, 2005). Hogan et al. (2005) conducted a longitudinal study of 570
kindergarteners, and found that in second grade, phonological awareness skills predicted
word reading, but in the fourth grade, the opposite occurred.
B. Language Skills and IQ

Standardized measures of language have been used to predict reading comprehension. Catts (1993) studied the reading outcomes of 41 kindergarteners with language impairments, 15 with speech disorders, and 30 typically-developing peers. The best predictors of reading comprehension skills (as measured by the Woodcock Reading Mastery Test-Revised [WRMT-R, Woodcock, 1987] and the Gray Oral Reading Test-Revised [GORT-R, Wiederholt & Bryant, 1986]) were scores on measures of semantics and syntax, whereas rapid naming was slightly correlated with reading comprehension and phonological awareness was not at all related (Catts, 1993). Lombardino, Riccio, Hynd, & Pinheiro (1997) found expressive language itself to be the strongest predictor of reading comprehension in a sample of children with reading disorders, ADHD, and typical controls; it accounted for 49% of the variance in scores on the WRMT-R Passage Comprehension subtest.

Lombardino et al. (1997) analyzed the language, phonemic awareness, reading, and IQ scores of 80 children with a mean age of 9;8: 32 with reading disabilities, 34 with ADHD and no reading disabilities, and 14 controls. Children with reading disabilities scored lower than the other two groups on the expressive language component of the Clinical Evaluation of Language Fundamentals (CELF-R; Wiig, Secord, & Semel, 1992) and the Elision subtest of the Comprehensive Test of Phonological Processing (C-TOPP; Wagner, Torgesen, & Rashotte, 1999). The relationship between performance on the Elision subtest and performance on the Word Attack Subtest of the WRMT-R was found to be the strongest, and Elision also predicted the Passage Comprehension subtest of the WRMT-R (along with scores on the CELF-R) (Lombardino et al., 1997).
Nation and Snowling (2004) studied the impact of language on reading development for 72 children at age 8.5 and again at age 13. They found that the children’s oral language skills contributed to their vocabulary development, as well as their reading comprehension abilities. Conversational language skills were found to predict a significant amount of variance in early reading development in a longitudinal study of 380 twins (DeThorne, Petrill, Schatschneider, & Cutting, 2010). In this study, conversational language was a stronger predictor of reading than standardized measures of vocabulary; however, this was only true for children with a history of language impairment (DeThorne et al., 2010).

Other factors that may affect reading development are verbal working memory and IQ. A longitudinal study of 45 children age 3;6 (29 with moderate to severe phonologic impairments) found that there was a strong relationship between normal phonology and verbal working memory, though the direction of that relationship is not known (Webster et al., 1997). Low IQ contributes to deficits in skills related to reading. In a longitudinal study of reading disabilities, poor readers with low IQs obtained lower scores on oral language measures than those with normal IQs (Catts et al., 1999).

C. Vocabulary

Expressive and receptive vocabulary skills appear to impact reading competence in different ways. 279 second and third-graders with reading disabilities participated in a study of the relationship between vocabulary, reading and listening comprehension, pre-reading skills, and word identification skills (Wise, Sevcik, Morris, Lovett, & Wolf, 2007). The purpose of the study was to examine the relationships between all of these
factors and reading ability. The results were presented in a model which demonstrated that receptive and expressive vocabulary were related to pre-reading skills (measured by experimental versions of the Blending and Elision subtests of the CTOPP and the Sound Symbol Identification Test [SSI]), but the relationship between receptive vocabulary and pre-reading was stronger (Wise et al., 2007). Expressive vocabulary and listening comprehension significantly predicted word identification abilities (measured by the Wide Range Achievement Test [WRAT-3], an experimental version of the Test of Word Reading Efficiency [TOWRE], and the Woodcock Reading Mastery Test-Revised [WRMT-R]), while receptive vocabulary was not a predictive factor (Wise et al., 2007).

Verhoeven and Van Leeuwe (2008) analyzed the development of reading comprehension in a longitudinal study of 2143 children in the Dutch equivalents of American grades 1 through 6. Factors that were hypothesized to predict reading comprehension in this study were word decoding, vocabulary, and listening comprehension (Verhoeven & Van Leeuwe, 2008). Word decoding was found to be more predictive of reading comprehension skills in the first grade than in the sixth. Vocabulary was found to predict reading comprehension at each grade level; however, reading comprehension did not have a strong influence on vocabulary. Vocabulary skills combined with listening comprehension skills were found to influence a child’s ability to build models of text during reading comprehension. The level of these skills at grade 1 was found to be highly predictive of later reading competence (Verhoeven & Van Leeuwe, 2008).
D. Predictors of Reading across the Developmental Trajectory

Different cognitive skills appear to predict reading at different ages. Scarborough (2005) reported that preschoolers who developed reading disabilities by the second grade had different areas of weakness at different ages as compared to children who did not have reading disabilities. Children aged 2.5 and 3 years who later developed reading disabilities had weaker syntactic and speech production abilities. At ages 3.5 and 4 years, these children were weaker in regards to syntax and vocabulary. Vocabulary and phonological awareness were the two areas of difficulty for these children at age 5. Foster and Miller (2007) conducted a longitudinal study of 12,621 kindergarteners grouped by reading readiness and found that those with low readiness had delays in decoding. By the time these children had reached the third grade, their decoding skills had matched those of the average and high readiness groups at the end of first grade, and phonics was no longer a predictor of reading skills. In the third grade, these children in the low readiness group were found to be delayed in text comprehension when compared to peers (Foster & Miller, 2007).

Another longitudinal study of children from preschool through grade 4 examined how decoding and reading comprehension were predicted by phonological awareness, print knowledge, vocabulary, and narrative comprehension over time (Storch & Whitehurst, 2002). In preschool, decoding was highly predicted by oral language, but the strength of this relationship decreased with time. Letter knowledge and phonological awareness best predicted reading comprehension in grades 1 and 2, but at grades 3 and 4, oral language skills such as vocabulary and narrative comprehension were the strongest predictors (Storch & Whitehurst, 2002).
Purpose

Despite the extensive literature examining the factors that may predict reading, reports vary widely as to which factors predict reading competence at different stages of development. Additionally, findings from existing studies have been contradictory. Thus far there have been few studies that attempt to correlate these factors with specific periods of reading development beyond the emergent stage, so studies such as this that examine the developmental trajectory of reading are necessary. Therefore, the purpose of the present study is to determine which cognitive factors are related to future reading skills at different ages for children with no history of reading disabilities. A secondary purpose of the study is to examine vocabulary as a predictor of reading ability, specifically the relationship between a child’s vocabulary in conversation and his/her vocabulary on standardized tests. Therefore, this research seeks to answer the following questions:

What cognitive skills (expressive and receptive language, phonological awareness, vocabulary, verbal memory, Performance IQ) predict reading (decoding and comprehension) at 3 stages during reading development (early elementary, middle school, and high school)?

A. Are reading skills predicted by different cognitive skills at different ages (early elementary, middle school, high school)?

B. If vocabulary is a predictor of reading ability, does a child’s vocabulary in conversation predict reading skills to the same extent as his/her score on standardized measures of vocabulary?
Hypothesis A

Based on the literature reviewed (Foster & Miller, 2007; Scarborough, 2005; Storch & Whitehurst, 2002, etc.), it is hypothesized that different cognitive skills predict reading outcomes at each of the 3 age levels. Specifically, it is hypothesized that for the Early Elementary group, phonological awareness will be most predictive of reading ability. For the Middle School group, the children’s vocabulary and syntax will be most predictive, and for the High School group, Performance IQ will be the most predictive factor.

Hypothesis B

Vocabulary is a predictor of reading abilities, and a child’s vocabulary in conversation will be a stronger predictor of reading skills than standardized measures of vocabulary (DeThorne et al., 2010, Storch & Whitehurst, 2002; Wise et al., 2007, etc.).

Methods

Participants: Original Study

The current study included subjects from an aggregated database of participants from ongoing longitudinal studies of the genetics of speech sound disorders (SSD) (see Lewis & Freebairn, 1998; Lewis, Freebairn, Hansen, Stein, Shriberg, Iyengar, & Taylor, 2006; Sices, Taylor, Freebairn, Hansen, & Lewis, 2007). In these studies, subjects were referred by speech-language pathologists from community speech and hearing clinics or private practices in the greater Cleveland, Ohio area. Children who were between the ages of 3 and 6 with SSD, language impairment (LI), or a combination of the two (SSD + LI) were recruited and followed throughout their formal schooling years and into
adulthood. Siblings with typical language (TL) were also recruited and followed as a control group.

For the purposes of the original study, SSD included articulation disorders (errors in the production of phonemes) and phonological disorders (linguistic errors). Participants had been diagnosed with a moderate to severe SSD, as determined by: 1) a score at or below the tenth percentile on the Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986) and 2) 3 or more types of phonological errors on the Khan-Lewis Phonological Analysis (KLPA; Khan & Lewis, 1986).

The LI diagnosis was determined based on Tomblin et al.’s (1997) criteria: 1) scores greater than or equal to 1.25 SD below the mean on two subtests of the Test of Language Development (TOLD-P:2; Newcomer and Hammill, 1988) or Clinical Evaluation of Language Fundamentals (CELF-P; Wiig, Secord, & Semel, 1992) and 2) parental report of the child receiving language intervention.

Children with SSD + LI met the defining criteria for both disorders. Children with TL scored within normal limits on tests of articulation (GFTA-2), phonology (KLPA-2), and language (CELF-R, CELF-3, or CELF-P; TOLD-P or TOLD-P:2).

All children who participated in the study spoke Standard American English as their first language. They were required to meet the following criteria: 1) normal hearing, as defined by a) passing a pure tone hearing screening at 25 dB and b) having less than six episodes of otitis media before the age of 3; 2) normal oral mechanisms, as defined by the Oral and Speech Motor Control Protocol (Robbins & Klee, 1987); 3) a Performance IQ score of 80 or above on the Wechsler Preschool and Primary Scale of
Intelligence- Revised (WPPSI-R; Wechsler, 1989); and 4) no history of neurological or developmental disorders according to parental report. Data regarding the children’s socioeconomic status (SES) was collected and analyzed using the Hollingshead Four Factor Index of Social Class (Hollingshead, 1975).

Participants: Current Study

The present study included a subsample of the children who participated in Lewis et al.’s studies, consisting of 63 children ranging in age from 7.08 to 17.5 years. To be eligible for inclusion in this study, the participants must have completed the standardized tests used as predictive and outcome measures (see Tables 3 and 4) and have a recorded conversational speech sample allowing for analysis of 50 complete utterances. Only children with normal reading abilities were included; “normal reading” was defined by no history of reading disabilities and/or never receiving additional reading intervention outside of the classroom. These factors were determined according to parental report. Children whose total CELF scores were more than 1 standard deviation (SD) below the mean were also excluded to ensure that poor language skills were not affecting group performance on reading outcome measures. Children with SSD, LI, or co-morbid SSD and LI were included along with children with TL, given that they also met the above criteria.

Three groups were created based on stages of educational and reading achievement: Early Elementary (ages 7;0-8;11 years), Middle School (ages 10;0-12;11 years), and High School (ages 14;0-17;11). Year-long gaps between age groups were chosen to minimize the overlap in skills at each age level. The Early Elementary group
had an *n* of 19; one of these participants did not have data for PIQ and the WIAT Listening Comprehension subtest. Two other participants did not have recorded conversational speech samples. SES data was not available for one participant.

However, these subjects were included to allow for as large of an *n* as possible. The Middle School group, with an *n* of 24, and the High School group, with an *n* of 20, had no missing data. The 3 groups did not differ significantly in PIQ. Detailed demographic data for each of the 3 groups is presented in Table 1, and speech and language characteristics for each group are presented in Table 2.

**Table 1.** Demographic Characteristics of Participants (*n*=63)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Early Elementary (<em>n</em>=19)</th>
<th>Middle School (<em>n</em>=24)</th>
<th>High School (<em>n</em>=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean in years (SD)</td>
<td>7.98 (.52)</td>
<td>11.52 (.86)</td>
<td>15.97 (1.03)</td>
</tr>
<tr>
<td>Range, years</td>
<td>7.08-8.91</td>
<td>10.33-12.91</td>
<td>14.16-17.50</td>
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<tr>
<td>Gender, <em>n</em> (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8 (42)</td>
<td>14 (58)</td>
<td>9 (45)</td>
</tr>
<tr>
<td>Female</td>
<td>11 (58)</td>
<td>10 (42)</td>
<td>11 (55)</td>
</tr>
<tr>
<td>Performance IQ, mean (SD)</td>
<td>113.56 (14.87)</td>
<td>112.83 (14.19)</td>
<td>110.70 (14.67)</td>
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<tr>
<td>Hollingshead SES, mean (SD)</td>
<td>4.06 (1.16)</td>
<td>4.08 (.83)</td>
<td>3.90 (1.07)</td>
</tr>
</tbody>
</table>

*Performance IQ data is based on *n* of 18 for the Early Elementary group; this information was not available for 1 participant. SES data is based on *n* of 18 for the Early Elementary group; this information was not available for 1 participant.

*SES is reported as an ordinal score of 1-5, with 1 being lowest SES and 5 being highest.*
Table 2. Presence of Speech and Language Disorders within the Sample (n=63)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Early Elementary (n=19)</th>
<th>Middle School (n=24)</th>
<th>High School (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LI, n (%)</td>
<td>2 (11)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>SSD, n (%)</td>
<td>7 (37)</td>
<td>15 (63)</td>
<td>8 (40)</td>
</tr>
<tr>
<td>LI + SSD, n (%)</td>
<td>4 (21)</td>
<td>3 (13)</td>
<td>1 (5)</td>
</tr>
<tr>
<td>TL, n (%)</td>
<td>6 (32)</td>
<td>6 (25)</td>
<td>11 (55)</td>
</tr>
</tbody>
</table>

Procedures: Original Study

Children in the original study of genetics and SSD were given a variety of standardized and non-standardized assessment measures in the areas of speech, language, literacy, and intelligence (see Lewis et al., 1992, 1998, 2006; Sices et al., 2007 for the complete test battery). These tests were administered and scored by licensed speech-language pathologists, according to the instructions of the test manual. The children were first tested at ages 3-6, with follow-up testing at early school age, adolescence, and adulthood. Each assessment took place over two sessions that were conducted in the children’s homes by the speech-language pathologists. Assessments of speech production and conversational speaking samples were recorded using professional audio equipment (Sony Professional Walkman, model WM-D6C, with an Audio Technica omnidirectional microphone, model AT804). This study was approved by the Human Subjects Committee of University Hospitals of Cleveland. Informed consent and assent were obtained from participants prior to testing, and they were assured that all of their identifying information would be kept confidential.

Procedures: Current Study

The present study is a secondary analysis of data collected from the studies of genetics and SSD. Specific cognitive skills associated with reading development were
selected based on the literature for analysis in the present study (Catts et al., 1999; Lombardino et al., 1997; Nation & Snowling, 2004, Scarborough, 2005, etc.). These cognitive skills used as predictive measures of reading ability included expressive and receptive language, phonological awareness, Performance IQ, and expressive and receptive vocabulary. Table 3 describes the assessments that were chosen to obtain the best picture of the participants’ cognitive skills pertaining to reading development.
### Table 3. Standardized Tests Used as Predictive Measures

<table>
<thead>
<tr>
<th>Cognitive Skill Assessed</th>
<th>Test/s</th>
<th>Test Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>Clinical Evaluation of Language Fundamentals (CELF-3): Expressive and Receptive Language Subtest Scores</td>
<td>Measures expressive and receptive language in the areas of syntax, morphology, semantics, and pragmatics</td>
</tr>
<tr>
<td>Phonological awareness</td>
<td>Comprehensive Test of Phonological Processing (C-TOPP): Elision subtest</td>
<td>Measures the ability to manipulate sounds in words</td>
</tr>
<tr>
<td>Vocabulary</td>
<td>Expressive One-Word Picture Vocabulary Test (EOWPVT; Lower Extension ages 2-11;11, Upper Extension ages 11-15;11)</td>
<td>Measures expressive vocabulary</td>
</tr>
<tr>
<td></td>
<td>Peabody Picture Vocabulary Test (PPVT)</td>
<td>Measures receptive vocabulary</td>
</tr>
<tr>
<td>Intelligence</td>
<td>Wechsler Intelligence Scale for Children-III (WISC-III): Block Design, Coding, Mazes, Object Assembly, Picture Completion, Picture Arrangement, and Symbol Search Subtests</td>
<td>Measure cognitive skills such as problem solving, spatial perception, working memory, and visual-motor coordination. Subtest scores are combined to create a Performance IQ score.</td>
</tr>
<tr>
<td></td>
<td>Wechsler Adult Intelligence Scale-III (WAIS-III): Block Design, Digit Symbol Coding, Matrix Reasoning, Object Assembly, Picture Arrangement, Picture Completion, and Symbol Search Subtests</td>
<td></td>
</tr>
</tbody>
</table>

Standardized reading assessments were also administered during the original study; these were used as reading outcomes measures in the current study. Outcomes
measures were chosen to illustrate the participants’ performance in the two components of reading: decoding and comprehension. Table 4 describes these measures.

Table 4. Standardized Tests Used as Reading Outcomes Measures

<table>
<thead>
<tr>
<th>Component of Reading</th>
<th>Test/s</th>
<th>Test Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading decoding</td>
<td>Woodcock Reading Mastery Test (WRMT): Word Attack Subtest</td>
<td>Measures ability to read single nonsense words</td>
</tr>
<tr>
<td></td>
<td>WRMT Word ID Subtest</td>
<td>Measures ability to read single real words</td>
</tr>
<tr>
<td>Reading comprehension</td>
<td>Wechsler Individual Achievement Test (WIAT): Reading Comprehension Subtest</td>
<td>Measures comprehension of written paragraphs and ability to match words to pictures</td>
</tr>
<tr>
<td></td>
<td>WIAT Listening Comprehension Subtest</td>
<td>Measures ability to match pictures to spoken words and listen to passages and answer questions</td>
</tr>
</tbody>
</table>

The conversational speech samples of 61 of the 63 participants were transcribed and analyzed using the Computerized Profiling software (Long, Fey, & Channell, 2006). Two participants from the Early Elementary group did not have recorded speech samples and were therefore not included in the vocabulary analyses. The first 50 complete, intelligible utterances of each sample were transcribed using the relevant SALT transcription conventions (Miller & Iglesias, 2008). The samples were then analyzed with the Computerized Profiling software’s Profile in Semantics-Lexical (PRISM-L) program (Crystal, 1982; Long et al., 2006). PRISM-L was utilized to classify the individual words within the child’s sample into major and minor lexemes. Major lexemes consist of words that have independent meaning (e.g., nouns, verbs, adjectives) while minor lexemes are words that have a grammatical function or are variations of major lexemes (e.g., articles, auxiliary verbs) (Long & Hand, 1996). PRISM-L provides a type-token ratio (TTR) for major and minor lexemes, as well as all lexemes combined.
Design and Analysis

This study utilized a cross-sectional, correlational design. Longitudinal data was not yet available for all participants who had begun the study as preschoolers, so no children were included in more than one group. Correlations were used to examine the relationships between the participants’ performance on predictive and outcome measures.

The participants’ standard scores on the predictive measures were compared to those on the reading outcome measures for each of the 3 groups, with gender as a covariate. Regressions were conducted in a backwards-stepwise fashion, such that all variables were in the starting model, and variables were taken out one at a time starting with the highest p-values. Each iteration checked the $R^2$ values to make sure the highest possible $R^2$ value was used with the lowest p-values for each variable in the model. The final models included only significant variables ($p$-values < 0.05) unless there were no significant variables. In cases where there were no significant variables, the model with the highest $R^2$ and variables close to significant values was chosen.

Linear regressions were also conducted using the stepwise method to determine which of the four measures of vocabulary best predicted each of the four reading outcomes measures (WRMT Word Attack and Word ID subtests, WIAT Reading and Listening Comprehension subtests) for the entire sample. The three groups were combined for this analysis to increase the $n$ and allow for the results to reach statistical significance. The four vocabulary measures included two standardized tests: the EOWPVT and the PPVT, which provide information regarding expressive and receptive vocabulary, and two non-standardized assessments, the Ratio for All Lexemes and Ratio for Major Lexemes. These ratios were chosen from the data obtained through the
PRISM-L analyses of conversational language since they most accurately represent the participants’ vocabularies in conversation. Ratio scores for each group were standardized separately so that age would not be a factor in the regressions for the whole sample. The probability criteria of F was changed to .100 to .500 to allow variables to be entered into the models. The most significant vocabulary variable/s was/were included in the final model for each outcome measure.

Results

*Hypothesis A: Different cognitive skills will predict reading outcomes for each age group.*

Correlations between the predictive reading measures and the reading outcomes measures are presented for each group in Tables 5 through 7. For the Early Elementary group, reading decoding abilities (as measured by the WRMT Word ID and Word Attack subtests) were correlated with scores on the PPVT and EOWPVT, while reading comprehension (consisting of the WIAT Reading Comprehension and Listening Comprehension subtests) was correlated with scores on the CELF-3, EOWPVT, and PPVT. For the Middle School group, both reading decoding and reading comprehension were correlated with scores on the CELF-3, EOWPVT, and PPVT. Only the WIAT Reading Comprehension Subtests was correlated with PIQ. In the High School group, PPVT and EOWPVT scores were correlated with reading decoding, and scores on the CELF-3 were correlated with reading comprehension. PIQ was correlated with the WRMT Word ID Subtest alone.
**Table 5.** Correlation of Scores on Predictive Measures to Scores on Outcomes Measures for Early Elementary Group \((n=19)\)

<table>
<thead>
<tr>
<th>Predictive Measures</th>
<th>Outcomes Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WRMT Word ID Subtest</td>
</tr>
<tr>
<td>CELF-3</td>
<td>.318</td>
</tr>
<tr>
<td>EOWPVT</td>
<td>.482*</td>
</tr>
<tr>
<td>PPVT</td>
<td>.522*</td>
</tr>
<tr>
<td>C-TOPP Elision Subtest</td>
<td>.392</td>
</tr>
<tr>
<td>PIQ</td>
<td>.115</td>
</tr>
</tbody>
</table>

WIAT Listening Comprehension Subtest and PIQ data are based on \(n\) of 18; this information was not available for 1 participant.

* \(p < 0.05\)

** \(p < 0.001\)

**Table 6.** Correlation of Scores on Predictive Measures to Scores on Outcomes Measures for Middle School Group \((n=24)\)

<table>
<thead>
<tr>
<th>Predictive Measures</th>
<th>Outcomes Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WRMT Word ID Subtest</td>
</tr>
<tr>
<td>CELF-3</td>
<td>.717**</td>
</tr>
<tr>
<td>EOWPVT</td>
<td>.418*</td>
</tr>
<tr>
<td>PPVT</td>
<td>.436*</td>
</tr>
<tr>
<td>C-TOPP Elision Subtest</td>
<td>.245</td>
</tr>
<tr>
<td>PIQ</td>
<td>.286</td>
</tr>
</tbody>
</table>

* \(p < 0.05\)

** \(p < 0.001\)
Table 7. Correlation of Scores on Predictive Measures to Scores on Outcomes Measures for High School Group (n=20)

<table>
<thead>
<tr>
<th>Predictive Measures</th>
<th>Outcomes Measures</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WRMT Word ID Subtest</td>
<td>WRMT Word Attack Subtest</td>
<td>WIAT Reading Comprehension Subtest</td>
<td>WIAT Listening Comprehension Subtest</td>
<td></td>
</tr>
<tr>
<td>CELF-3</td>
<td>.097</td>
<td>.205</td>
<td>.518*</td>
<td>.428</td>
<td></td>
</tr>
<tr>
<td>EOWPVT</td>
<td>.523*</td>
<td>.112</td>
<td>.152</td>
<td>.215</td>
<td></td>
</tr>
<tr>
<td>PPVT</td>
<td>.647*</td>
<td>.122</td>
<td>.147</td>
<td>.417</td>
<td></td>
</tr>
<tr>
<td>C-TOPP Elision Subtest</td>
<td>.335</td>
<td>.412</td>
<td>.249</td>
<td>.381</td>
<td></td>
</tr>
<tr>
<td>PIQ</td>
<td>.551*</td>
<td>.150</td>
<td>.182</td>
<td>.355</td>
<td></td>
</tr>
</tbody>
</table>

* p < 0.05
** p < 0.001

Stepwise regression analyses were conducted for each age group to determine which factors best predicted reading outcomes. Final models for each group are presented and explained below.

Early Elementary

For the WRMT Word Attack subtest, 28.4% of the variance (R²) can be explained by the Elision subtest of the C-TOPP, along with the EOWPVT (p = 0.069). Every 1 point increase in the Elision score resulted in a 1.98 point increase in the Word Attack score. Every 1 point increase in the EOWPVT resulted in a .17 increase in Word Attack. For the other measure of reading decoding, WRMT Word ID, 35.5% of the variance was explained by the Elision subtest of the C-TOPP and the PPVT (p = 0.030). Every 1 point increase in the Elision subtest score resulted in a 1.51 point increase in the Word ID score, and every 1 point increase in the PPVT resulted in a .38 point increase in Word ID.
The PPVT explained 45.9% of the variance for the WIAT Reading Comprehension subtest score ($p = 0.001$). A 1 point increase in PPVT resulted in a .58 point increase in the WIAT Reading Comprehension score. 70.2% of the variance in Listening Comprehension was explained by the C-TOPP Elision subtest, CELF-3, and EOWPVT scores ($p = 0.001$). Every 1 point increase in the Elision score resulted in a 2.71 point decrease in the WIAT Listening Comprehension score. A 1 point increase in the CELF-3 and EOWPVT scores resulted in increases of .87 and .43 points in the Listening Comprehension score.

*Middle School*

For the WRMT Word Attack subtest, 42.1% of the variance was explained by the Elision subtest of the C-TOPP and Performance IQ ($p = 0.003$). Every 1 point increase in the Elision score led to a 2.04 increase in the Word Attack score, and every 1 point increase in Performance IQ led to a .22 point increase. 52.4% of the variance in Word ID scores was explained by the CELF-3 ($p = <0.0001$). A 1 point increase in CELF-3 score resulted in a .46 point increase in the Word ID score.

The WIAT Reading Comprehension subtest had 41.2% of its variance explained by the CELF-3 and PPVT ($p = 0.003$). Each 1 point increase in the CELF score increased the WIAT Reading Comprehension score by .31, while each 1 point increase in the PPVT score led to an increase of .41 on the WIAT Reading Comprehension subtest. 42.6% of the variance in the WIAT Listening Comprehension scores was explained by the CELF-3 ($p = 0.001$). Each 1 point increase in the CELF-3 score resulted in a .43 increase in the WIAT Listening Comprehension subtest score.
High School

For the WRMT Word Attack subtest, 17.0% of the variance was explained by the C-TOPP Elision subtest \( (p = 0.071) \). For every 1 point increase in the Elision score, the Word Attack score increased by 3.66 points. 41.8% of the variance in the WRMT Word ID subtest scores was explained by scores on the PPVT \( (p = 0.002) \). Each 1 point increase in the PPVT resulted in a .42 point increase in the Word ID score.

The CELF-3 explained 27.4% of the variance in WIAT Reading Comprehension subtest scores \( (p = 0.018) \). An increase of 1 point on the CELF-3 led to a .78 increase in the WIAT Reading Comprehension score. For the WIAT Listening Comprehension subtest, 33.3% of the variance was explained by the CELF-3 and PPVT \( (p = 0.032) \). An increase of 1 point on the CELF-3 resulted in an increase of .46 on the WIAT Listening Comprehension subtest, while a 1 point increase on the PPVT resulted in a .27 increase in the Listening Comprehension score.

A summary of the data obtained from the regression analyses is presented in Table 8.
Table 8. Summary of Regression Results for All Groups

<table>
<thead>
<tr>
<th>Outcomes Measures</th>
<th>Predictive Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early Elementary $,(n = 19)$</td>
</tr>
<tr>
<td>WRMT Word Attack Subtest</td>
<td>C-TOPP Elision</td>
</tr>
<tr>
<td></td>
<td>EOWPVT</td>
</tr>
<tr>
<td>WRMT Word ID Subtest</td>
<td>PPVT</td>
</tr>
<tr>
<td></td>
<td>C-TOPP Elision</td>
</tr>
<tr>
<td>WIAT Reading Comprehension Subtest</td>
<td>PPVT</td>
</tr>
<tr>
<td></td>
<td>CELF-3</td>
</tr>
<tr>
<td></td>
<td>C-TOPP Elision</td>
</tr>
<tr>
<td></td>
<td>EOWPVT</td>
</tr>
</tbody>
</table>

*WIAT Listening Comprehension Subtest data is based on $n$ of 18 for the Early Elementary group; this information was not available for 1 participant.

Hypothesis B: A child’s vocabulary in conversation will be a better predictor of his/her reading ability than vocabulary measured by standardized tests.

The PRISM-L program (Crystal, 1982; Long et al., 2006) was used to analyze the lexical diversity in the conversational speech samples of the participants. Data was obtained regarding the participants’ type-token ratio (TTR) for major and minor lexemes. Results are summarized in Table 9.
**Table 9.** PRISM-L Analyses for Entire Sample (n=61)

<table>
<thead>
<tr>
<th>Lexemes</th>
<th>Early Elementary (n=17)</th>
<th>Middle School (n=24)</th>
<th>High School (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Types, mean (SD)</td>
<td>58.94 (12.65)</td>
<td>63.21 (11.89)</td>
<td>61.95 (9.08)</td>
</tr>
<tr>
<td>Tokens, mean (SD)</td>
<td>217.06 (74.19)</td>
<td>240.75 (67.22)</td>
<td>231.95 (46.07)</td>
</tr>
<tr>
<td>Ratio, mean (SD)</td>
<td>.29 (.06)</td>
<td>.27 (.06)</td>
<td>.27 (.04)</td>
</tr>
<tr>
<td>Major Types, mean (SD)</td>
<td>87.65 (22.44)</td>
<td>101.54 (19.90)</td>
<td>108.40 (14.89)</td>
</tr>
<tr>
<td>Tokens, mean (SD)</td>
<td>141.82 (44.91)</td>
<td>163.08 (40.13)</td>
<td>173.20 (35.68)</td>
</tr>
<tr>
<td>Ratio, mean (SD)</td>
<td>.63 (.07)</td>
<td>.64 (.07)</td>
<td>.64 (.07)</td>
</tr>
<tr>
<td>Unclassified Types, mean (SD)</td>
<td>3.29 (3.60)</td>
<td>8.50 (33.19)</td>
<td>2.95 (3.22)</td>
</tr>
<tr>
<td>Tokens, mean (SD)</td>
<td>6.35 (7.31)</td>
<td>21.71 (90.55)</td>
<td>5.05 (6.49)</td>
</tr>
<tr>
<td>Ratio, mean (SD)</td>
<td>.75 (.31)</td>
<td>.80 (.30)</td>
<td>.78 (.24)</td>
</tr>
<tr>
<td>All Types, mean (SD)</td>
<td>149.88 (32.24)</td>
<td>166.54 (29.28)</td>
<td>173.30 (21.55)</td>
</tr>
<tr>
<td>Tokens, mean (SD)</td>
<td>365.24 (113.29)</td>
<td>407.12 (106.10)</td>
<td>410.20 (78.34)</td>
</tr>
<tr>
<td>Ratio, mean (SD)</td>
<td>.42 (.06)</td>
<td>.42 (.06)</td>
<td>.43 (.05)</td>
</tr>
</tbody>
</table>

* A conversational speech sample was not available for 2 participants in the Early Elementary Group; therefore, they were not included in this analysis.

Linear stepwise regressions were conducted to determine the utility of four measures of vocabulary (EOWPVT, PPVT, Ratio for All Lexemes, Ratio for Major Lexemes) as predictors of the reading outcomes measures (WRMT Word Attack and Word ID Subtests, WIAT Reading and Listening Comprehension Subtests). For the Word Attack Subtest, the final model included the EOWPVT as the only predictor, with an $R^2$ of .063, an F value of 3.981, and a beta weight of .251. Both the EOWPVT and the PPVT were included in the final model for WRMT Word ID, with an $R^2$ of .241, an F value of 9.222, and beta weights of .307 (for EOWPVT) and .259 (PPVT). The PPVT also was the strongest predictor of scores on the WIAT Reading Comprehension Subtest; it had an $R^2$ of .188, an F value of 13.655, and a beta weight of .434. Finally, the WIAT
Listening Comprehension Subtest score was also best predicted by the PPVT, with an $R^2$ of .177, an F value of 12.461, and a beta weight of .421.

Discussion

The primary purpose of this study was to determine which cognitive skills predicted reading outcomes for children at three levels of educational/reading development: Early Elementary, Middle School, and High School. The predictors that were analyzed included phonological awareness, expressive and receptive language, Performance IQ, vocabulary, and verbal memory, and the outcome measures included tests of reading comprehension and decoding. The predictive factors were related to the outcomes measures using correlations and stepwise regressions.

The secondary purpose of the study was to determine which vocabulary measure was a stronger predictor of the entire sample’s performance on reading outcomes measures: vocabulary as measured by standardized tests, or vocabulary in conversation. Spontaneous conversational language samples were transcribed and entered into the PRISM-L program (Crystal, 1982; Long et al., 2006) to obtain TTR for various lexemes, and this data was compared to standardized expressive and receptive vocabulary measures using stepwise regressions.

**Hypothesis A: Different cognitive skills will predict reading outcomes for each age group.**

It was hypothesized that the Early Elementary, Middle School, and High School groups would each have different predictors for the reading comprehension and decoding outcomes measures. More specifically, it was hypothesized that phonological awareness
would be the strongest predictor for the Early Elementary group, vocabulary and syntax would be strongest for the Middle School group, and Performance IQ would be the strongest predictor for the High School group. The results showed that for some outcomes measures, there were consistent predictors across all age groups, while other outcomes had both common predictors and unique predictors across groups. However, when predictors were common across the age groups, they explained different amounts of variance.

I. WRMT Word Attack Subtest

The Word Attack Subtest of the WRMT (a decoding outcomes measure) was predicted by the C-TOPP Elision Subtest for all three groups, as well as the EOWPVT for the Early Elementary group and Performance IQ in the Middle School group. It would be expected that the C-TOPP Elision subtest, which is a measure of phonological awareness, would predict performance on the Word Attack Subtest, since it measures the ability to decode nonsense words. These findings are consistent with the work of Lombardino et al. (1997), who found that scores on the C-TOPP Elision subtest were most strongly related to performance on Word Attack, though subjects in that study had reading disabilities. Phonological awareness skills are widely thought to be necessary in order to decode unfamiliar words (Catts & Kamhi, 2005; Chall, 1983; Ehri, 1991; Hogan et al., 2005). Even though decoding is typically mastered relatively early in the development of reading, adults continue to use phonological awareness skills to decode unfamiliar words throughout their lives (Catts & Kamhi, 2005). The Elision Subtest was the only predictor of Word Attack at the High School level, perhaps because at this point phonological
awareness is mastered and only used in instances such as this when decoding is necessary to read nonsense or new words.

Performance IQ was not initially expected to predict Word Attack, but this finding may be explained by the role of IQ in oral language skills. Catts et al. (1999) found that IQ combined with poor reading skills led to lower scores on measures of oral language. However, the sample in this study contained only children with normal reading abilities. When considering the development of reading, Performance IQ makes sense as a predictive factor for reading in the Middle School group. When children reach the Orthographic/Automatic Word Recognition stage of reading development, they have mastered phonological decoding and instead use semantic memory to read (Ehri, 1991). By this age, they have stored letter and word patterns in their semantic memories, and may be calling upon those memories to assist them in decoding new words.

The predictive value of EOWPVT was an unexpected finding. The relationship of expressive vocabulary to reading is not clear; some studies have found that it was related to word identification abilities (Nation & Snowling, 2004; Wise et al., 2007), but these studies included real words, not nonsense words. Therefore, it would be expected that expressive vocabulary may play a role in the decoding of real words instead of nonsense words, but this was not the case.

Interestingly, none of the variables that were found to be predictors of Word Attack scores were strongly correlated with Word Attack for any of the groups. Word Attack was not strongly correlated with any of the predictive measures for the Early Elementary and High School groups, but the CELF-3 was strongly correlated with Word
Attack for the Middle School group. Expressive and receptive language skills have been found to be related to reading comprehension abilities (Catts, 1993; Lombardino et al., 1997), but not reading decoding. However, Chall’s stages of reading development (1983) can be used to explain this finding. Children at this age are between Chall’s stages 2 and 3. In stage 2, Fluency, children use both semantic knowledge and decoding to read unfamiliar words (Chall, 1983). Perhaps these children are beginning to move towards using their semantic knowledge as their primary tool for identifying new words. Semantic knowledge is a skill assessed by the CELF-3, which may explain why it was correlated with reading decoding at the Middle School level.

II. WRMT Word ID Subtest

The Word ID Subtest of the WRMT was predicted by scores on the PPVT for the Early Elementary and High School groups, but not the Middle School group. The predictor for the Middle School group was the CELF-3, while the C-TOPP Elision subtest also contributed to the final model for the Early Elementary group.

Since the PPVT is a measure of receptive vocabulary, it would be expected to play a role in the identification of real words. This is consistent with the connectionist theory of reading development, which states that vocabulary plays a significant role in word recognition abilities due to the use of the semantic pathway in reading (Plaut et al., 1996). It is interesting that this was not true for the Middle School group only. According to Chall’s stages of reading development, these children should be in Stage 3 (approximately grades 4 through 8), which is when their vocabularies are experiencing
major growth as they transition from “learning to read” to “reading to learn” (Chall, 1983). Perhaps these children do not have well-developed receptive vocabularies yet.

The C-TOPP Elision subtest as a predictor of Word ID in the Early Elementary group is not surprising given that the Word ID Subtest is a measure of reading decoding. Children at this stage of development are using both their semantic and phonological pathways to recognize words, as neither pathway is developed enough to be specialized for familiar (semantic) or unfamiliar (phonological) word decoding (Plaut et al., 1996).

According to the literature (Nation & Snowling, 2004; Wise et al., 2007), expressive vocabulary plays a role in word recognition; however, expressive vocabulary as measured by the EOWPVT was not found to be a predictor of Word ID for any of the groups in this study. Expressive vocabulary is measured by the CELF-3 though, which may explain why the CELF-3 was a predictor of Word ID for the Middle School group.

The measures that were found to be significantly correlated with Word ID across all groups were the EOWPVT and PPVT, which is to be expected as a child uses his/her receptive and expressive vocabulary to read familiar words.

The CELF-3 was another variable that was strongly correlated with Word ID for the Middle School group; it was more highly correlated with Word ID than the expressive and receptive vocabulary measures. This finding was not expected, but it is consistent with the results for Word Attack. It seems that children at the Middle School age level are developing more mature methods of reading; they are using their language skills instead of phonological decoding skills to read both familiar and unfamiliar words.
PIQ was the additional measure that was highly correlated with Word ID for the High School group; however, it was not as statistically significant as the PPVT. At this age, children’s intellectual abilities may be more strongly related to their reading and language abilities. Catts et al. (1999) found that children who were poor readers and had low IQs did not perform as well on expressive language measures as poor readers with normal IQs. However, in that study, full-scale IQ was measured and the subjects were followed until second grade, while children in this study were as old as 17;11 and PIQ, not full-scale IQ, was measured.

III. WIAT Reading Comprehension Subtest

Scores on the WIAT Reading Comprehension subtest were found to be predicted by the PPVT only for the Early Elementary group, the CELF-3 only for the High School group, and both the PPVT and CELF-3 for the Middle School group. Vocabulary has been shown to have a reciprocal relationship with reading comprehension, so it is no surprise that the PPVT was a predictor of reading comprehension in this study (Verhoeven & Van Leeuwe, 2008). Language skills would also be expected to predict reading comprehension, as knowledge in the areas of receptive and expressive syntax, morphology, and semantics would allow children to thoroughly understand text. Measures of semantics and syntax best predicted reading comprehension in a study by Catts (1993), though the subjects in this study were kindergarteners. The inclusion of the CELF-3 as a predictor for the Middle School group is in agreement with the findings of Storch and Whitehurst (2002), who found that oral language skills best predicted reading comprehension for children in grades 3 and 4 (which would include children at the younger end of the Middle School group).
The measures that were highly correlated with reading comprehension were slightly different for each group. The PPVT, CELF-3, and EOWPVT were strongly correlated with the WIAT Reading Comprehension Subtest for the Early Elementary group. A child cannot comprehend text without knowledge of vocabulary; reading comprehension and vocabulary are thought to have a reciprocal relationship (Verhoeven & Van Leeuw, 2008).

The Middle School group results also showed strong correlations between reading comprehension and the CELF-3 and PPVT, but PIQ was also highly correlated with reading comprehension for this group. This is consistent with the findings of Catts and Kamhi (2005), who states that cognitive skills such as reasoning, problem-solving, and abstract thinking are all important components of reading comprehension. These cognitive skills may play more of a role for the Middle School group because children at this age are beginning to be exposed to more abstract curricular materials, and they are expected to “read to learn”.

At the High School level, the CELF-3 was the only variable that was highly correlated with reading comprehension. The CELF-3 assesses several components of language that are important for advanced reading comprehension, including semantics, syntax, and morphology. Children at the High School level are able to comprehend more complex information because of their ability to understand and use language at a higher level.
IV. WIAT Listening Comprehension Subtest

The WIAT Listening Comprehension subtest was predicted by a number of variables, including the CELF-3, C-TOPP Elision Subtest, EOWPVT, and PPVT. The CELF-3 was a consistent predictor across age groups.

It was interesting that expressive vocabulary (EOWPVT) was predictive of listening comprehension for the Early Elementary group, whereas receptive vocabulary (PPVT) predicted listening comprehension for the High School group; PPVT would be expected to predict listening comprehension at both age levels. It is possible that this finding may be attributed to less normative data being available for the older age group for the EOWPVT.

The measures that were most strongly correlated with listening comprehension included the EOWPVT, CELF-3, and PPVT for the Early Elementary and Middle School groups. Receptive language and vocabulary skills are necessary in order to have good listening comprehension abilities, but the correlation between EOWPVT and listening comprehension was interesting. None of the correlations for the High School group reached statistical significance; for this group, all of the variables may interact for the child to comprehend auditory information.

Hypothesis B: A child’s vocabulary in conversation will be a better predictor of his/her reading ability than vocabulary measured by standardized tests.

Results of the regressions comparing conversational vocabulary and standardized measures of vocabulary to reading outcomes negated this hypothesis. The TTR for All Lexemes and the TTR for Major Lexemes were each combined for the entire sample, and
these measures failed to predict any variance in reading outcomes. The EOWPVT and PPVT best predicted scores on the reading outcomes measures, with the EOWPVT best predicting Word Attack, the PPVT best predicting Reading and Listening Comprehension, and both the PPVT and EOWPVT predicting Word ID. This is not consistent with the findings of DeThorne et al. (2010), who found that conversational language was a better predictor of reading than standardized measures of vocabulary. However, all of the subjects in that study had a history of language impairment, while only 10 subjects in the current study did. Also, the methods used in DeThorne et al.’s study differed from the methods used in the present study. DeThorne et al. measured vocabulary from 100-utterance conversational samples; this study used 50-utterance samples. DeThorne et al. assessed the mean length of C-units, TTR, number of conjunctions, and the Developmental Sentence Score, while this study assessed the Ratio for All Lexemes and the Ratio for Major Lexemes.

A possible reason for the strength of the standardized measures over the conversational measures is that the vocabulary in written tests is typically at a higher level than in spoken conversation. Therefore, the TTRs for vocabulary in conversation would be more representative of a child’s everyday use of vocabulary versus the highest level of his/her ability to use and comprehend vocabulary. Also, vocabulary is not the most useful predictor of decoding; knowledge of real words would probably not assist the child in decoding nonsense words.
Conclusion

Phonological awareness was the strongest predictor of reading ability for the Early Elementary group for measures of reading decoding and listening comprehension. The Middle School group also confirmed the original hypothesis, with language as the best predictor for real word decoding, reading comprehension, and listening comprehension. The results for the High School group, however, did not match the hypothesis, as Performance IQ was not included in the final models for any of the reading outcomes measures. Overall, the results of this study show that different cognitive and language skills predict reading outcomes for Early Elementary and Middle School age groups. However, the High School group did not have unique reading predictors; the factors that predicted reading for this group were very similar to those that predicted reading outcomes in the Middle School group.

In regards to vocabulary, vocabulary as measured by standardized tests was found to be more predictive of reading competence than vocabulary in conversation. This was true across all age groups, which was inconsistent with the original hypothesis.

Limitations and Future Directions

A limitation of this study is the design. Since longitudinal data was not yet available for all participants, it was a cross-sectional design. Future research may examine the predictive factors for the same children at each age level to see how these factors predict reading throughout the years. The study was also a secondary data analysis, which led to limitations in the size of the sample and the measures available for analysis. Specifically, vocabulary analysis was impacted by the smaller conversational
samples of some of the older children; therefore, only 50 utterances could be used for analysis. Future studies may wish to include 100 utterances for analysis, have a larger $n$, and perhaps choose different standardized tests to predict reading based on the data obtained in this study and other research regarding reading development. Another limitation was that the CELF composite score was used as a predictor of reading, not the individual subtest scores. Had the individual subtests been included, some of the findings related to the CELF may have been less unexpected. Finally, future research may involve children who are considered “poor” readers to compare their developmental trajectories with those who have normal reading abilities.
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