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Reading Skills of Students With Speech Sound Disorders at Three Stages of Literacy Development

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Abstract

Purpose—The relationship between phonological awareness, overall language, vocabulary, and nonlinguistic cognitive skills to decoding and reading comprehension was examined for students at 3 stages of literacy development (i.e., early elementary school, middle school, and high school). Students with histories of speech sound disorders (SSD) with and without language impairment (LI) were compared to students without histories of SSD or LI (typical language; TL).

Method—In a cross-sectional design, students ages 7;0 (years; months) to 17;9 completed tests that measured reading, language, and nonlinguistic cognitive skills.

Results—For the TL group, phonological awareness predicted decoding at early elementary school, and overall language predicted reading comprehension at early elementary school and both decoding and reading comprehension at middle school and high school. For the SSD-only group, vocabulary predicted both decoding and reading comprehension at early elementary school, and overall language predicted both decoding and reading comprehension at middle school and decoding at high school. For the SSD and LI group, overall language predicted decoding at all 3 literacy stages and reading comprehension at early elementary school and middle school, and vocabulary predicted reading comprehension at high school.

Conclusion—Although similar skills contribute to reading across the age span, the relative importance of these skills changes with children's literacy stages.

Keywords

reading development; literacy; speech sound disorders; phonological awareness; language

Speech-language pathologists (SLPs) have become increasingly involved in the prevention and remediation of reading disorders (RD) due to the link between RD and oral language skills (Catts, Fey, Zhang, & Tomblin, 2001; Fallon & Katz, 2011). It is well established that students with language impairment (LI) are at risk for RD (Bishop & Adams, 1990; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004; Snowling, Bishop, & Stothard, 2000). Studies have also suggested that students with speech sound disorders (SSD) are at risk for RD (Foy & Mann, 2012; Lewis, Freebairn, & Taylor, 2000; Peterson, Pennington, Shriberg,

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& Boada, 2009). However, there is little information concerning the developmental factors that predict reading ability at different ages and the impact of SSD on reading skills at various ages. The purpose of the present study was to determine which linguistic and nonlinguistic cognitive factors are related to reading skills for students with a history of SSD only, students with SSD and LI, and students with no history of SSD at three stages of literacy development.

Stages of Literacy Development

Stage theories have commonly been used to describe the process of literacy development, although the required number of stages needed to attain proficiency in reading differs according to the theorist. Chall's (1983) stages of reading development describe how reading develops across the life span. According to Chall, pre-reading, or Stage 0 (ages birth to 6 years and prior to first grade), refers to emergent literacy during which students are exposed to print, learn graphemes, and memorize labels and signs in the environment. The decoding stage, or Stage 1 (ages 6 to 7 years; first grade and the beginning of second grade), includes the development of letter-sound correspondence rules and use of the alphabetic principle. The next stage, confirmation and fluency, or Stage 2 (ages 7–9 years; second and third grades), involves fluency and speed. The child now uses familiar context and semantic knowledge along with decoding skills to identify unfamiliar words and gain fluency and speed. Phonological awareness may predict reading fluency at this stage. Learning the new, or Stage 3 (ages 10–12 years; fourth through eighth grades), incorporates the transition from *learning to read* to *reading to learn.* In this stage, students are able to use reading as a tool for learning new information. According to Chall, there is a growing importance of word meaning and prior knowledge in Stage 3. A student's vocabulary may be predictive of reading in Stage 3. Multiple viewpoints, or Stage 4 (ages 14–18 years; ninth through 12th grades), describes the refining of students' reading skills as students become able to read and comprehend complex information. Complex language skills are required to understand multiple viewpoints and increased depth of material. Overall language may predict reading at Stage 4. Finally, construction and reconstruction, or Stage 5 (college and beyond), describes the attainment of adult reading skills. The ability to master these five stages of literacy development depends on individual and environmental factors, including education, home, and community influences (Chall, 1987). In the current study, we examined the prediction of reading skills in students who represent Chall's Stages 2, 3, and 4 based on their ages. We chose to focus on these stages because they span the school-age years that are a period of rapid literacy and cognitive growth. Further, different predictor variables are hypothesized for each literacy age group based on the focus of each stage.

Decoding and Reading Comprehension

In our study, we examined predictors of two components of reading: decoding and reading comprehension. One popular theory of reading development, known as the simple view of reading, divides reading into two processes: decoding and linguistic comprehension (Hoover & Gough, 1990). *Decoding* refers to the process of translating printed words into sounds, whereas *linguistic comprehension* refers to the process of extracting meaning from lexical information, sentences, and discourse (Gough & Tunmer, 1986; Kamhi & Catts, 2012).

Decoding targets a specific set of skills such as letter recognition, phoneme awareness, alphabetic knowledge, and word-level reading (Kamhi, 2012). In addition to linguistic skill in decoding, vocabulary, morphosyntax, syntactic parsing, and social communication, linguistic comprehension requires higher level thinking and reasoning processes, including integrating background knowledge, synthesizing, problem solving, and interpretation (Catts, 2009; Kamhi & Catts, 2012; Paris, 2005; Perfetti, 1985).

If a student is an accurate but slow decoder, he or she might use cognitive resources needed for reading comprehension to decode text, resulting in a bottleneck that may negatively influence his or her reading comprehension (Shankweiler et al., 1999). The reliance of reading comprehension on accurate and rapid decoding may confound the assessment of reading comprehension. Although decoding is mastered early in literacy development, reading comprehension continues to develop into adulthood. In the current study, we examined the predictors of decoding and reading comprehension at three stages of literacy development (i.e., early elementary school, middle school, and high school). Given the different skills that contribute to decoding versus reading comprehension, we expected that the predictors of each would differ, and that as literacy develops across the school-age years, the relative importance of these predictors would change. This view is supported by Paris (2005), who argued that some skills, such as decoding, are acquired in a brief period of time (constrained), whereas others, such as reading comprehension, have a protracted development (unconstrained).

Predictors of Reading

Many researchers have examined predictors of reading ability (Al Otaiba & Fuchs, 2006; Apel & Lawrence, 2011; Bird, Bishop, & Freeman, 1995; Catts et al., 2001; Fletcher et al., 2002). The focus of these studies has been primarily on the prediction of early reading skills, with few studies extending into the later school-age years and beyond (Scarborough, 1989, 2005; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004). Al Otaiba and Fuchs (2006) examined indicators of poor response to literacy intervention, including phonological awareness, verbal memory, rapid naming, vocabulary, verbal ability, IQ, attention or behavior problems, orthographic awareness, and socioeconomic status (SES). In the present study, we chose to focus on phonological awareness, overall language, vocabulary, and nonlinguistic cognitive skills as assessed by performance IQ (PIQ) as predictors of decoding and reading comprehension because these variables relate to Chall's (1983, 1987) stages of reading development and may differentially predict each literacy group.

Phonological awareness—One of the most commonly examined skills used to predict early reading skills is phonological awareness (Catts, Fey, Zhang, & Tomblin, 1999; Justice, Bowles, & Skibbe, 2006; Nathan, Stackhouse, Goulandris, & Snowling, 2004; Scarborough, 1989; Webster, Plante, & Couvillion, 1997). Phonological awareness has been demonstrated to best predict reading comprehension in first and second grades, but at third and fourth grades, oral language skills such as vocabulary and narrative comprehension were found to be the strongest predictors (Storch & Whitehurst, 2002). The decreasing role of phonological awareness as children develop is supported by Hogan, Catts, and Little (2005),

who found that in second grade, phonological awareness skills predicted word reading, but by fourth grade, the reverse was true: Word reading predicted phonological awareness skills.

Phonological awareness may play a bigger role in reading competence when reading skills are first emerging, but after students learn to read, reading skills influence phonological awareness skills (Hogan et al., 2005). However, the view that early reading skills are predicted by phonological awareness and later reading skills by other linguistic and cognitive skills may be too simplistic. Some studies have documented the continued importance of phonological awareness skills throughout elementary and middle school (Roman, Kirby, Parrila, Wade-Wooley, & Deacon, 2009). More skilled readers may continue to use phonological awareness skills to access low-frequency words. However, phoneme awareness skills may best predict literacy at early elementary school, Chall's Stage 2 (1983).

Overall language—Overall language may provide support for decoding as well as reading comprehension. One skill, morphological awareness, may assist in the identification of unknown words in text and improve decoding speed as "chunks" of words rather than single letters are identified (Al Otaiba, Kosanovich, & Torgesen, 2012). Skill in understanding syntactic structure may also aid in the decoding of words as it allows the student to guess the word from the context. Grammatical morphemes, function words, and syntactic structure all provide cues for sentence comprehension (Catts, 1993; Kamhi & Catts, 2012; Nation & Snowling, 2004). Both expressive language (Lombardino, Riccio, Hynd, & Pinheiro, 1997) and conversational language skills in children with LI (DeThorne, Petrill, Schatschneider, & Cutting, 2010) have been found to predict reading comprehension. These and other studies confirm that overall language predicts reading skills, and in particular, reading comprehension, in both typical students and students with SSD, LI, and/or RD. However, what is not as well documented is how these component language skills differentially impact reading across the developmental trajectory. Language skills are thought to account for more of the variance in older readers than in younger readers as the complexity of text increases (Catts, Hogan, & Fey, 2003).

Vocabulary—Expressive and receptive vocabulary skills are also predictive of decoding and reading comprehension. Vocabulary can assist in the decoding of unknown words by the making of analogies to known words (Al Otaiba et al., 2012). Nation and Snowling (2004) studied students ages 8;4 (years; months) to 13.0 and found that their oral language skills contributed to their vocabulary development as well as their reading comprehension abilities. In a longitudinal study of Dutch children from first through sixth grade, vocabulary skills combined with listening comprehension skills influenced students' ability to create models of text during reading comprehension, with first-grade skills being highly predictive of later reading competence (Verhoeven & Van Leeuwe, 2008). Vocabulary skills may be predictive of reading at middle school, Chall's Stage 3, when, according to Chall (1983), students are achieving reading fluency and speed.

Nonlinguistic cognitive skills—Nonlinguistic cognitive skills such as those assessed by a PIQ test may influence literacy development, especially reading comprehension (Fuchs & Young, 2006). These nonlinguistic cognitive skills may include working memory, executive

function, processing speed, inhibition, and attention. Studies of children with SSD and LI have reported that children with low PIQ have poorer literacy outcomes than children with normal PIQ (Bishop & Adams, 1990; Catts, Fey, Tomblin, & Zhang, 2002; Peterson et al., 2009). However, children with LI also may have lower IQs when compared to children without LI (Catts et al., 1999; Fletcher et al., 2002). The relationships among IQ, language, and literacy are not clear. Although poor language skills may influence literacy development, non-linguistic cognitive skills associated with literacy development may also influence language skills. Most studies have assessed full-scale IQ, and therefore are confounded by the verbal component of IQ measures (Fletcher et al., 2002).

The shift in the type of reading material from narrative in early elementary school to expository in middle school and high school may account for some differences reported in the cognitive skills employed in reading (Nippold, 2007). Older students rely on a variety of skills, including oral language, working memory, executive function, and processing speed, to read efficiently. Reading comprehension is not simply remembering the content of text but combining it with past knowledge to form a durable representation of the information (Catts, 2009). These higher level nonlinguistic cognitive skills needed to comprehend complex written text may be related to overall intelligence and may predict reading at high school, Chall's Stage 4 (1983).

Phonological awareness, overall language, vocabulary, and PIQ have been shown to predict decoding and reading comprehension in both typical students and students with LI and RD. However, few studies have examined how these predictors impact students with SSD. Further, students with SSD are a heterogeneous group, with some students presenting with comorbid LI and RD. The following section summarizes the literature on reading skills and students with SSD.

Reading Skills and Students With SSD

Some students with SSD demonstrate phonological processing deficits that may involve phonological awareness, phonological memory, rapid automatized naming, and phonological production (Kamhi & Catts, 2012). These students may have difficulty forming the phonological representations needed to acquire the speech sound system for spoken language and later for decoding (Lewis, Avrich, Freebairn, Hansen, et al., 2011). Phonological processing deficits may account for poor phonological awareness skills, poor verbal short-term memory, and slow lexical retrieval, which are all necessary for the development of strong literacy skills (Wagner & Torgesen, 1987). Ramus and Szenkovits (2009) offered two possibilities to explain the relationship of SSD to reading. First, phonological representations may be degraded, fuzzy, and underspecified, which results in a loss of some phonetic features before they are compared or repeated, resulting in poor decoding skills. An alternative explanation is that phonological representations of students with SSD are intact and phonetic features are correctly encoded, but short-term memory processes are limited (Ramus & Szenkovits, 2009). According to Baddeley's model of working memory (Gathercole & Baddeley, 1990), deficits in phonological short-term memory may interfere with the transfer of information into working memory that is necessary for both listening and reading comprehension.

Studies of reading ability in children with SSD indicate that only a subset of these children have reading difficulties. Peterson and colleagues (2009) reported RD in only 22% of children with SSD at 7–9 years of age, although many students with SSD but without RD had deficient phonological skills. Anthony et al. (2011) found that students with SSD scored less well than their peers with normal language skills on measures of both phonological awareness and single-word reading. Anthony et al. proposed that a phonological core deficit characterized by the quality and accessibility of phonological representations may explain these findings. There is some evidence to suggest that students with non-developmental phonological process errors are more at risk for RD than students who follow a typical developmental trajectory (Foy & Mann, 2012; Leitão & Fletcher, 2004). Nondevelopmental phonological processes are those that are not observed in the speech of typical younger students, including the use of nonnative language phonemes and sound preferences. Students who employ nondevelopmental phonological processes are considered to have a breakdown in speech processing rather than more global language deficits and may present with decoding difficulties (Leitão & Fletcher, 2004). However, contrary to this explanation, our previous studies have indicated that comorbid LI rather than SSD only places a student at risk for reading disability (Lewis et al., 2000). Studies to date have only examined children with SSD in early elementary school and have not examined older children with a history of SSD. In the present study, we examined students with SSD in three literacy stages.

Purpose

The present study extends the work of previous research in several ways. First, the present study examined the impact of SSD on literacy acquisition. There is a growing body of research that indicates that students with SSD are at risk for literacy difficulties due to poor phonological skills (Lewis, Avrich, Freebairn, Taylor, et al., 2011; Ramus & Szenkovits, 2009; Webster et al., 1997). It is not known, however, whether or not students with early SSD follow a similar developmental trajectory in literacy acquisition as typical students without a history of SSD or LI. Second, the current study examined the effect of comorbid LI with SSD on literacy acquisition. Finally, our study examined predictors of literacy in older students. Some studies have suggested that the linguistic skills essential to proficient reading change as literacy skills are acquired (Hogan et al., 2005; Storch & Whitehurst, 2002), whereas other studies have suggested that certain linguistic skills, such as phonological awareness, are used by all readers (Roman et al., 2009). The purpose of the present study was to determine which linguistic and nonlinguistic cognitive skills are related to decoding and reading comprehension at different ages for typical students with no history of SSD and for students with a history of early SSD only or students with SSD and LI.

Two research questions were addressed.

- For students with typically developing language, what linguistic skills (phonological awareness, overall language, vocabulary) and/or nonlinguistic cognitive skills (PIQ) predict reading (decoding and reading comprehension) at three stages of literacy development (i.e., early elementary school, middle school, high school)? Based on the literature reviewed earlier (Foster & Miller, 2007; Scarborough, 2005; Storch & Whitehurst, 2002), we hypothesized that different

linguistic and non-linguistic cognitive skills would predict reading outcomes at each of the three literacy stages. Specifically, we anticipated that the skills most closely related to reading ability would be phonological awareness for the early elementary school literacy group (Chall's Stage 2; 1983), vocabulary for the middle school group (Chall's Stage 3; 1983), and overall language and nonlinguistic cognitive skills for the high school group (Chall's Stage 4; 1983).

- Would the pattern of these associations differ for students with SSD only and students with SSD and LI? For students with SSD only, we hypothesized that the predictors of reading for students with early SSD would change with age in the same way as for students with typically developing language, although students with SSD may be delayed in achieving mature reading skills. For students with combined SSD and LI, we hypothesized a different pattern of association, with the poorer language skills of this group predicting both decoding and reading comprehension.

Method

Participants

The participants were enrolled in an ongoing longitudinal family study of the genetics of SSD (see Lewis & Freebairn, 1998; Lewis et al., 2006; Sices, Taylor, Freebairn, Hansen, & Lewis, 2007). Test data for the present study were drawn from the longitudinal database. Families were recruited through a proband child who was enrolled in speech and language therapy for SSD in early childhood (ages 3–6 years). The proband child was diagnosed with moderate to severe SSD, as determined by a score ≤10th percentile on the Sounds in Words subtest of the Goldman-Fristoe Test of Articulation (GFTA; Goldman & Fristoe, 1986) and production of three or more types of phonological errors on the Khan-Lewis Phonological Analysis (KLPA; Khan & Lewis, 1986). Two hundred thirty-four families participated in the current study.

All available siblings of the probands were also enrolled in the study and received the same test battery as the probands. Probands and siblings were required to meet the following criteria: (a) Standard American English as their first language; (b) normal hearing, as defined by passing a pure-tone hearing screening at 25 dB HL and <6 episodes of otitis media before the age of 3; (c) a normal oral mechanism, as defined by the Oral and Speech Motor Control Protocol (Robbins & Klee, 1987); (d) a PIQ ≥80 on the Wechsler Preschool and Primary Scale of Intelligence—Revised (WPPSI–R; Wechsler, 1989); and (e) no history of neurological or developmental disorders according to parent report. A total of 461 students (probands and siblings) met the criteria and participated in the study.

Participants were grouped by literacy level. A total of 170 participants were in Chall's Stage 2 (ages 7;0–8;11) and will hereafter be referred to as the early elementary school group. A total of 196 participants were in Chall's Stage 3 (ages 10;1–12;11) and will hereafter be referred to as the middle school group. A total of 95 participants were in Chall's Stage 4 (ages 14;0–17;11) and will hereafter be referred to as the high school group.

Within each literacy group (i.e., early elementary school, middle school, and high school), there were three clinical groups, including students with a history of SSD without comorbid LI (SSD only), students with a history of SSD and LI (SSD+LI), and students with no history of SSD or LI (typical language; TL). Students who were currently enrolled in or had a history of receiving therapy for SSD comprised the SSD group. Participants in the SSD group had been diagnosed with moderate to severe SSD at ages 3–6 years. The SSD group was divided into two groups based on whether or not the child had comorbid LI (SSD-only and SSD+LI groups). Comorbid LI was determined by Tomblin and colleagues' (1997) criterion of a score ≥1.25 *SD*s below the mean on two subtests of the Clinical Evaluation of Language Fundamentals, Third Edition (CELF–3; Semel, Wiig, & Secord, 1995). The TL group consisted of siblings who did not meet the criteria for SSD or LI.

Parents were asked to complete a history questionnaire on each child, and the family's SES was rated on the Hollingshead Four Factor Index of Social Class (Hollingshead, 1975). Ratings ranged from 1 to 5, with 1 representing *low* SES and 5 representing *high* SES. Detailed demographic data for each of the literacy and clinical groups are presented in Table 1.

Measures

Linguistic and Nonlinguistic Cognitive Measures

Speech sound development: The GFTA was administered to determine the presence of speech sound errors. The GFTA uses 35 picture plates and 44 target words to elicit consonants in the initial, medial, and final position of words as well as 12 consonant clusters (blends) in the initial position. Responses were audio recorded, phonetically transcribed, and plotted on the consonant error matrix. Age-adjusted percentile scores are reported in Table 1.

Phonological awareness: The Elision subtest of the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999) was used to assess the participants' phonological awareness. Z scores were used in the analyses.

Overall language: The CELF–3 was used to assess the participants' receptive and expressive language skills. The CELF–3 measures syntax, morphology, and semantics. The total language standard scores were used in the analyses.

Vocabulary: The Peabody Picture Vocabulary Test—Third Edition (PPVT–III; Dunn & Dunn, 1997) and the Expressive One Word Picture Vocabulary Test, Revised (EOWPVT–R; Gardner, 1990) were used to assess the participants' receptive and expressive vocabulary skills, respectively. Because the PPVT–III and EOWPVT–R scores were highly correlated ($r = 0.634$. $p < .0001$), these scores were converted to *z* scores and were combined into a single factor score based on our previous factor analysis (Lewis, Avrich, Freebairn, Hansen, et al., 2011; Stein et al., 2004). This reduced the number of variables in the analyses.

PIQ: The Wechsler Intelligence Scale for Children, Third Edition (WISC–III; Wechsler, 1991) or the Wechsler Adult Intelligence Scale—Revised (WAIS–R; Wechsler, 1981) was

used to assess the participants' PIQ depending on the age of the participant. The subtests of the WISC–III are Picture Completion, Coding, Picture Arrangement, Block Design, and Object Assembly. The WAIS–R also includes Picture Completion, Picture Arrangement, Block Design, and Object Assembly as well as Digit Symbol, which is similar to the Coding subtest of the WISC–III. These tests measure nonlinguistic cognitive skills such as problem solving, spatial perception, working memory, and visual-motor coordination. Subtest scores were combined to form a PIQ score that was used in the analyses.

Reading Outcome Measures

Word-level reading: The Word Identification (WI) and Word Attack (WA) subtests of the Woodcock Reading Mastery Tests—Revised (WRMT–R; Woodcock, 1987) were used to assess the participants' decoding of real and nonsense words (nonwords). The reading of real words (WI) may use phonological decoding skills as well as sight vocabulary. Nonword decoding (WA) presumably taps phonological skills because nonwords are novel to the reader and are not in his or her sight vocabulary. Standard scores were used in the analyses.

Reading comprehension: The Reading Comprehension subtest of the Wechsler Individual Achievement Test (WIAT; Wechsler, 1992) was used to assess the participants' comprehension of written passages. Standard scores were used in the data analyses.

Procedure

The participants were tested individually in two sessions. Tests were administered and scored by two licensed SLPs according to the instructions in the test manuals. Testing was carried out in a speech research laboratory at Case Western Reserve University or, at the parent's request, in a quiet and adequately lit room in the family's home. The speech productions from the GFTA were audio recorded. Responses were initially transcribed online using phonetic transcription. Ten percent of the responses were transcribed by a second SLP. Interrater reliability was >90%. The present study was approved by the Human Subjects Committee of University Hospitals Case Medical Center of Cleveland, OH. Informed consent was obtained from parents, and assent was obtained from participants prior to testing.

Design and Analyses

Using a cross-sectional design, an analysis of variance (ANOVA) was conducted to compare the TL, SSD-only, and SSD+LI groups on the predictor (Table 2) and reading outcome measures (Table 3) at each of the three literacy stages. To examine the influence of the predictor variables on the reading outcome measures, we conducted linear regressions. Regressions were conducted in a backward-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. At each iteration, the R^2 values were checked 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 ($p < 0.05$). Age, gender, and SES were employed as covariates in the analyses. Regression analyses were conducted for each group (TL, SSD only, and SSD+LI) within each of the three literacy stages (early elementary school, middle school, and high school). The results of the regression analyses are presented in Table 4.

In the present study, we examined whether the measures varied by literacy group ($n = 3$) and by clinical group ($n = 3$). Thus, to account for multiple testing, we corrected for six groups of statistical tests. For an overall $\alpha = 0.05$, statistical significance could be declared at $\alpha^* = 0.05/6 = 0.0083$.

Results

Participant Demographics

Demographics for the early elementary school, middle school, and high school literacy groups are presented in Table 1. The early elementary literacy group consisted of 170 students between the ages of 7;0 and 8;9. At early elementary school age, there were more males than females in both groups with SSD, $\chi^2(2, 169) = 25.68$, $p < .001$. All three early elementary groups (TL, SSD only, SSD+LI) differed on their scores on the GFTA, with the SSD+LI group scoring most poorly, followed by the SSD-only group, $F(2, 161) = 26.86$, $p < 0.001$. The SSD+LI group reported a lower SES than the TL group or the SSD-only group, $\chi^2(8, 162) = 28.37$, $p = .001$. As seen by the range of scores in the TL group, two students scored below the 50th percentile on the GFTA.

The middle school literacy group consisted of 196 students between the ages of 10;0 and 12;9. The middle school TL group and SSD-only group were older than the SSD+LI group, $F(2, 195) = 4.85$, $p = .009$. There were more males than females in the middle school SSD +LI group compared to the TL group, $\chi^2(2, 195) = 11.61$, $p = .003$. The middle school TL group also differed from the SSD-only and SSD+ LI groups on SES, $\chi^2(8, 189) = 23.06$, $p = .003$. The middle school TL and SSD-only groups scored higher on the GFTA than the SSD+LI group, $F(2, 152) = 10.96$, $p < .001$. Four students in the TL group scored below the 50th percentile on the GFTA.

The high school literacy group consisted of 95 students between the ages of 14;0 and 17;9. No significant differences were observed in age, gender, SES, or GFTA scores for the high school literacy group. However, at high school, 25% of the students in the SSD-only group and 29% of the students in the SSD+LI group made errors on the GFTA; no errors were observed for students in the TL group.

Group Comparisons on Measures

As shown in Table 2, significant group differences were observed on all of the predictor measures at the $p < 0.001$ significance level. The SSD+LI group performed significantly more poorly than the TL or SSD-only groups in all three literacy stages. No significant differences were found between the TL and SSD-only groups.

As shown in Table 3, significant group differences were observed on all of the reading outcome measures at the $p < 0.001$ significance level. The SSD+LI group performed more poorly than the TL or SSD-only groups in all three literacy stages. At middle school, the TL group performed significantly better than the SSD-only and SSD+LI groups on reading comprehension. However, none of the group means was 1 *SD* below the test mean, suggesting that these differences were not indicative of reading disability.

Regression Analyses

TL group: At early elementary school, performance on the phonological awareness measure accounted for 30.4% of the variance in the decoding of nonwords, and performance on the phonological awareness and vocabulary measures accounted for 41.4% of the variance in the decoding of real words. The overall language and vocabulary measures accounted for 48.6% of the variance in reading comprehension. At middle school, performance on the overall language measure accounted for 15.5% of the variance in nonword decoding and 36.0% in real word decoding, and performance on the vocabulary measure accounted for 44.5% of the variance in reading comprehension. At high school, no predictors reached significance for nonword decoding, and performance on the vocabulary measure accounted for 39.4% of the variance in real word decoding. The overall language measure accounted for 29.3% of the variance in reading comprehension. A summary of the data obtained from the regression analyses for TL students is presented in Table 4.

SSD-only group: At early elementary school, performance on the vocabulary measure accounted for 12.1% of the variance in nonword decoding, 9.8% of the variance in real word decoding, and 20.6% of the variance in reading comprehension. At middle school, performance on the overall language measure accounted for some of the variance in all of the reading skills (23.7 % of the variance in nonword decoding, 33.9% in the variance in real word decoding, and 39.0% of the variance in reading comprehension). At high school, performance on the overall language measure accounted for 23.2% of the variance in nonword decoding, and vocabulary accounted for 43.6 % of the variance in real word decoding. No significant predictors of reading comprehension were found for high school students with a history of SSD only.

SSD+LI group: At early elementary school, performance on the overall language measure accounted for 29.1% of the variance in nonword decoding, 45.1% of the variance in real word decoding, and 60.5% of the variance in reading comprehension. At middle school, performance on the overall language and phonological awareness measures accounted for 36.4% of the variance in nonword decoding and 39.1% of the variance in real word decoding. Performance on the overall language measure also explained 55.3% of the variance in reading comprehension. At high school, performance on the overall language measure accounted for 42.5% of the variance in nonword decoding and 55.5% of the variance in real word decoding, and performance on the vocabulary measure accounted for 63.8% of the variance in reading comprehension.

Discussion

The present study addressed two research questions. First, what linguistic and/or nonlinguistic cognitive skills of students with typically developing language predict reading (decoding and reading comprehension) at three stages during literacy development: early elementary school (Chall's Stage 2), middle school (Chall's Stage 3), and high school (Chall's Stage 4)? Second, would the pattern of these associations differ for students with SSD only and SSD and LI? Predictors included measures that were reported in the literature to be related to literacy skills: phonological awareness, overall language, vocabulary, and

nonlinguistic cognitive skills (PIQ). Outcome measures were decoding and reading comprehension. Our findings are somewhat consistent with the simple view of reading as predictors of decoding and reading comprehension differed for children with typical speech and language skills at early elementary school. At middle school and high school, unconstrained linguistic skills such as overall language and vocabulary predicted both decoding and reading comprehension. Our findings also demonstrated that some predictors such as overall language were consistent across literacy age groups, and other predictors such as phonological awareness and PIQ differed across literacy age groups. However, when predictors were common across the literacy age groups, they explained significantly different amounts of variance in the participants' literacy abilities. Similar to our previous reports and those of others (Bird et al., 1995; Lewis et al., 2000; Raitano et al., 2004), students with combined SSD+LI were at greater risk for reading difficulties than students with SSD only. SSD-only students were more similar to the TL students. Findings are discussed for each group separately, followed by an overall summary of major findings and implications.

Prediction of Reading in the TL Group

Early elementary school group: As expected, at early elementary school, the decoding of nonwords and real words was predicted by participants' phonological awareness skills. This is in agreement with previous reports that phonological awareness skills are used in order to decode unfamiliar words (Catts & Kamhi, 2005; Chall, 1983; Ehri, 1991; Hogan et al., 2005). Our findings are also consistent with the work of Lombardino et al. (1997), who found that scores on the CTOPP Elision subtest were most strongly related to performance on nonword reading in students with reading disabilities. In the present study, the student's vocabulary also predicted decoding of real words similar to other studies that have reported a relationship between vocabulary and real word reading abilities (Nation & Snowling, 2004; Wise, Sevcik, Morris, Lovett, & Wolf, 2007). It appears that at early elementary school, students are using both their semantic and phonological pathways to recognize words (Plaut, McClelland, Seidenberg, & Patterson, 1996). Reading comprehension scores were found to be predicted by vocabulary and overall language for the early elementary literacy group. Based on previous reports, overall language and vocabulary skills were expected to predict reading comprehension, as knowledge in the areas of receptive and expressive syntax, morphology, and semantics aid in the comprehension of text (Catts, 1993; Storch & Whitehurst, 2002).

Middle school group: At middle school, we found that overall language was the best predictor of decoding of both nonwords and real words. It was expected that vocabulary and other language skills may play a role in the decoding of real words. However, it was surprising that overall language and not phonological awareness predicted the decoding of nonwords (Hogan et al., 2005). One explanation is that when students reach the orthographic/automatic word recognition stage of reading development, they have mastered phonological decoding and instead use semantic memory to read (Ehri, 1991). It is possible that by middle school, students have stored letter and word patterns in their semantic memories and employ these patterns to assist them in the decoding of new real words. Nonwords may not be distinguished from unfamiliar real words as the nonwords were

patterned after real words, and therefore the child employs similar decoding strategies used in the identification of new words. Students might search for an analogy of the nonword in their lexicon that aids in decoding (Ehri & McCormick, 1998).

Vocabulary skills and PIQ predicted reading comprehension for the middle school group. The nonlinguistic cognitive skills such as reasoning, problem solving, and abstract thinking measured by PIQ may play more of a role for the middle school group as students at this age are beginning to be exposed to more abstract curricular materials, and they are expected to *read to learn.* Unlike previous studies that employed a full-scale IQ measure consisting of both verbal and performance subtests (Catts et al., 1999), in our study, only the PIQ subscale was used. As expected, PIQ was predictive of reading comprehension, suggesting that reading comprehension may be influenced by nonverbal skills such as memory, inference making, planning, and organization.

High school group: None of the predictors reached significance for the decoding of nonwords for the high school group. It may be that high school students employed different skills when decoding nonwords than those that we measured. For example, older students may rely more on morphology to decode nonwords. Another explanation may be that individual high school students differ in the skills they employ to decode nonwords, and thus a single predictor of nonword decoding was not identified at high school. As expected, the decoding of real words was best predicted by vocabulary, suggesting that high school students employ semantic pathways when reading single real words. Overall language predicted reading comprehension skills for the high school group, suggesting that as the complexity of text increases, unconstrained linguistic skills continue to be vital to reading comprehension abilities.

Prediction of Reading in the SSD-Only Group

Early elementary school group: At early elementary school, unlike with TL students, phonological awareness skills did not predict the decoding of nonwords and real words for students with isolated SSD; rather, vocabulary predicted decoding and reading comprehension for these students. A recent study by Overby, Trainin, Smit, Bernthal, and Nelson (2012) reported that phonological awareness skills mediated the effects of poor kindergarten speech sound production on reading and spelling skills in first grade, second grade, and third grade, yet vocabulary skills did not account for any of the variance. Although the SSD-only group did not differ significantly from the TL group on the CTOPP Elision subtest, the mean score was lower for the SSD-only group. In the present study, we did not distinguish between articulation disorders and phonological disorders. It is possible that students with phonological disorders had weaker phonological awareness skills than students with articulation disorders. Vocabulary skills may have been more uniform for students in the SSD-only group regardless of whether they presented with an articulation disorder or phonology disorder. Therefore, vocabulary skills may have been more predictive of reading than phonological awareness, as vocabulary skills were more uniform than elision skills in the SSD-only group.

Middle school group: For the middle school group, similar to the TL middle school group, overall language predicted both decoding and reading comprehension for students with a history of SSD only. However, unlike with the TL middle school group, PIQ was not predictive of reading comprehension for the students with isolated SSD. Students with SSD only scored significantly poorer on reading comprehension, but not on decoding, than TL students at middle school (see Table 3). This suggests that although middle school students with SSD may use language skills for reading comprehension, they may not be using higher cognitive skills such as executive functioning to aid reading comprehension. Alternatively, students with SSD only may have weaker language skills and vocabulary than TL students that resulted in poor reading comprehension. Students with SSD only scored lower than TL students on the language measures, although these differences did not reach significance. Overall, the SSD-only group was more similar to the TL group than different. Further research is needed to tease out the factors that influence reading comprehension for middle school students with a history of SSD.

High school group: At high school, the overall language measure predicted nonword decoding, and the vocabulary measures predicted real word decoding, whereas no significant predictors were identified for reading comprehension. Thus, similar to the TL high school students, vocabulary skills predicted real word decoding. High school students with SSD were similar to TL middle school students in predictors of nonword decoding. The lack of predictors for reading comprehension in the SSD-only group may be due to the heterogeneity of skills within this group.

Prediction of Reading in the SSD+LI Group

Early elementary school group: For early elementary students with combined SSD+LI, overall language predicted both decoding and reading comprehension. It appears that for students with LI, limitations in language skills impact reading more than limitations in phonological awareness skills. Students with combined SSD+LI scored significantly poorer on all measures (phonological awareness, overall language, vocabulary, PIQ, decoding, and reading comprehension) than both the TL students and the SSD-only students in all three literacy groups. This is in agreement with our previous reports and those of others (Bird et al., 1995; Lewis et al., 2000; Raitano et al., 2004) that students with combined SSD+LI are at greater risk for reading difficulties than students with isolated SSD.

Middle school group: At middle school, phonological awareness skills in addition to overall language contributed to the decoding of real words and nonwords. It is possible that middle school students with combined SSD+LI employed strategies for decoding that were similar to those used by younger TL early elementary students. Reading comprehension was predicted by overall language similar to the SSD-only group. The SSD-only group had significantly better overall language compared to the SSD+LI group, and therefore not surprisingly, significantly better reading comprehension scores. It appears that although the overall language skills of the SSD+LI group were poorer than those of the TL and SSD-only groups, students with SSD+LI still rely on language skills for reading comprehension.

High school group: Similar to the early elementary school and middle school SSD +LI groups, overall language predicted decoding for high school students with a history of combined SSD+LI, with vocabulary as the strongest predictor of reading comprehension. Little information is available on the literacy skills of high school students with a history of SSD with or without LI. Similar to TL high school students, overall language skills including vocabulary were strong predictors of decoding and reading comprehension for students with SSD. It is likely that many skills, verbal and nonverbal, contribute to literacy performance in adolescents. High school students are expected to read and comprehend technical material with complex vocabulary and to integrate material from multiple sources, make inferences, and synthesize material (Nippold, 2007).

Summary of Findings

The development of literacy relies on many skills; it is multifactorial and complex. Although similar skills contribute to reading proficiency across the age span, the relative importance of these skills changes with development. TL children use phonological awareness skills to decode real and nonwords and language and vocabulary skills for reading comprehension during early reading acquisition. Later, in middle school, students rely more on overall language and vocabulary for both decoding and reading comprehension. As reading skills mature, other factors such as nonlinguistic cognitive skills (PIQ) play a role. Students with SSD only may rely on vocabulary and overall language abilities for both decoding and reading comprehension. Students with combined SSD+LI may present with a double deficit as they have both limited phonological awareness skills and overall language essential for reading. Students with combined SSD+LI may also attempt to use their language skills for reading; however, due to their language deficits, they may fail to achieve expected literacy skills.

Clinical Implications

The prevention and treatment of literacy problems in children and adolescents has become a critical scope of the SLP's practice as he or she serves students with speech and language disorders that place them at risk for RD (American Speech-Language-Hearing Association, 2010). However, many school-based SLPs are not consistently providing written language services to students with poor literacy skills (Fallon & Katz, 2011). SLPs have the expertise to provide foundational language skills, such as vocabulary and oral language skills, and to implement strategies for reading for the older child and adolescent who struggles with literacy skills. Although most SLPs are aware of the relationships between speech and language deficits and reading skills, it is important to recognize that these skills change as students mature. It is critical for SLPs to have knowledge of the developmental trajectory of literacy skills from early elementary school to high school, the changing demands placed on literacy skills as students progress through school, and the skills required for competent reading at each level.

The present study has highlighted the contributions of phonological awareness, overall language, vocabulary, and nonlinguistic cognitive skills to decoding and reading comprehension at three stages of literacy development. In addition, the present study has provided evidence that students with SSD+LI differ in predictors of literacy skills from

SSD-only and TL students. Students with SSD with and without LI should be evaluated periodically to determine how their changing speech and language skills are impacting their reading development. For younger students, building vocabulary may aid in both decoding and reading comprehension skills. Older children and adolescents may need explicit instruction on text construction and linguistic cues for reading comprehension (Kamhi, 2012). Other non-linguistic cognitive skills, as demonstrated in the present study, also aid comprehension. The multifaceted nature of reading comprehension requires that SLPs be aware that nonlinguistic cognitive skills may also contribute to students' reading comprehension.

Limitations and Future Directions

Several limitations of the present study should be noted. The cross-sectional design did not allow the plotting of individual student's reading development trajectory. Future research may examine the predictive factors longitudinally for students with SSD to determine various developmental trajectories of literacy acquisition in this population. Articulation and phonological disorders were not differentiated. Furthermore, the severity of the SSD and the persistence or recovery of the SSD were not considered. A student whose SSD resolves by age 7 may differ from students whose SSD persists past the age of literacy acquisition (Bishop & Adams, 1990; Leitão & Fletcher, 2004; Lewis, Freebairn, & Taylor, 2002; Nathan et al., 2004).

Another limitation was the use of composite language scores rather than specific language skills as a predictor of reading. Specific language subsystems such as syntax or morphology skills may differentially predict reading outcomes. For example, students with SSD may present with morphological awareness deficits that impact reading skills. Apel and Lawrence (2011) examined 88 first graders (44 with and 44 without a history of SSD). Students with SSD scored lower than TL students on morphological awareness, phoneme awareness, word reading, and spelling. Morphological awareness predicted unique variance in spelling for both SSD groups and word-level reading for the TL group. Thus, a phonological deficit alone does not explain RD in students with SSD. Rather, the literacy skills of students with SSD are best explained by multiple linguistic and nonlinguistic cognitive variables.

We were not able to control for all of the factors that contribute to reading comprehension. Other nonlinguistic cognitive skills that influence literacy such as memory were not considered. Finally, the present study was unable to control for the effects of speech and language therapy or reading instruction, which may have affected the participants' literacy skills. Future studies should consider additional predictors, especially higher level linguistic and nonlinguistic cognitive skills, for high school students.

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Table 1

Participant demographics for the three clinical groups (i.e., typical language [TL], speech sound disorders only [SSD only], and SSD and language impairment [SSD+LI]) at the three literacy stages (i.e., early elementary school, middle school, and high school).

	Clinical group					
Demographic characteristic	**TL**	**SSD only**	**SSD+LI**	***F***	***df***	***p***
Early elementary school age						
Number of participants	52	58	60			
Mean age in years	7.99	8.03	8.03	0.07	2, 169	.937
SD	0.59	0.54	0.51			
Range	7.00–8.91	7.00–8.92	7.00–8.83			
No. of males/females[a,b] (χ^2)	15/37	34/24	46/14	26.11	2, 169	<.001
SES ranking[b,c] (χ^2)				28.37	8, 162	.001
1	0	0	5			
2	5	2	8			
3	6	10	17			
4	21	18	20			
5	19	25	7			
Mean GFTA percentile score	90.92	63.04	46.67	26.87	2, 161	<.001
SD[a,b,c]	16.39	36.24	35.46			
Range	25.0–99.0	1.0–99.0	1.0–99.0			
Middle school age						
Number of participants	74	50	72			
Mean age in years	11.41	11.53	11.08	4.85	2, 195	.009
SD[b,c]	0.93	0.81	0.78			
Range	10.00–12.92	10.08–12.92	10.00–12.91			
No. of males/females[b] (χ^2)	34/40	30/20	53/19	11.61	2, 195	.003
SES ranking[b,c] (χ^2)						
1	2	0	6	23.06	8, 189	.003
2	10	3	6			
3	7	7	20			

Demographic characteristic	Clinical group			*F*	*df*	*p*
	TL	**SSD only**	**SSD+LI**			
4	25	21	26			
5	27	19	11			
Mean GFTA percentile score	92.26	82.12	63.02	10.96	2, 152	<.001
SD[b,c]	20.83	32.96	40.66			
Range	14.0–99.0	2.0–99.0	1.0–99.0			
	High school age					
Number of participants	35	27	33			
Mean age in years	15.90	15.58	15.50	1.24	2, 152	.295
SD	1.13	1.16	1.05			
Range	14.00–17.92	14.00–17.50	14.08–17.50			
No. of males/females (χ^2)	14/21	16/11	20/13	3.56	2, 94	.169
SES ranking (χ^2)						
1	1	0	3	6.11	8, 91	.635
2	2	2	3			
3	7	3	7			
4	13	11	10			
5	11	11	8			
Mean GFTA percentile score	99.0	77.83	74.19	3.01	2, 49	.059
SD	0	38.57	40.51			
Range	**99.0**	2.0–99.0	1.0–99.0			

Note. SES = socioenomic status; GFTA = Goldman-Fristoe Test of Articulation (Goldman & Fristoe, 1986).

[a] The TL group differs from the SSD-only group at $p < .05$.

[b] The TL group differs from the SSD+LI group at $p < .05$.

[c] The SSD-only group differs from the SSD+LI group at $p < .05$.

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Table 2

Clinical group performance on the predictor measures at the three literacy stages.

	Clinical group								
	TL		SSD+LI		SSD only				
Measure	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	***df***	***p***
Early elementary school age									
Elision[b,c]	1.14	2.34	1.07	2.18	−1.14	3.37	10.23	2,129	<.001
CELF–3[b,c]	107.61	10.47	104.59	11.34	85.09	16.31	49.24	2,166	<.001
EOWPVT–R/PPVT–III[b,c]	6.76	6.32	6.07	6.64	−1.80	7.71	22.77	2,140	<.001
PIQ[b,c]	110.92	11.05	111.66	13.59	101.69	13.78	7.54	2,136	.001
Middle school age									
Elision[b,c]	1.04	2.77	2.14	3.05	−2.69	4.98	22.18	2,146	<.001
CELF–3[b,c]	111.40	14.90	106.98	15.28	80.87	16.42	75.11	2,185	<.001
EOWPVT–R/PPVT–III[b,c]	6.78	7.42	5.57	6.90	−2.66	10.35	22.66	2,173	<.001
PIQ[b,c]	113.07	13.37	110.74	13.63	96.05	15.91	22.38	2,148	<.001
High school age									
Elision[b,c]	2.62	1.86	1.38	3.62	−2.93	6.17	9.03	2, 62	<.001
CELF–3[b,c]	107.85	9.93	103.94	9.62	84.83	21.29	18.67	2, 74	<.001
EOWPVT–R/PPVT–III[b,c]	2.03	7.55	−1.23	5.73	−7.31	7.46	14.13	2, 87	<.001
PIQ[b,c]	110.82	13.83	109.07	15.68	88.94	17.21	11.35	2, 57	<.001

Note. Elision = Elision subtest of the Comprehensive Test of Phonological Processing (CTOPP; Wagner, Torgesen, & Rashotte, 1999); CELF–3 = Clinical Evaluation of Language Fundamentals—Third Edition (Semel, Wiig, & Secord, 1995); EOWPVT–R = Expressive One Word Picture Vocabulary Test, Revised (Gardner, 1990); PPVT–III = Peabody Picture Vocabulary Test—Third Edition (Dunn & Dunn, 1997); PIQ = performance IQ as assessed by the Wechsler Intelligence Scale for Children, Third Edition (Wechsler, 1991) or the Wechsler Adult Intelligence Scale—Revised (Wechsler, 1981).

[b]The TL group differs from the SSD+LI group at $p < .05$.

[c]The SSD-only group differs from the SSD+LI group at $p < .05$.

Table 3

Clinical group performance on the reading outcome measures at the three literacy stages.

	Clinical group								
	TL		SSD only		SSD+LI				
Measure	***M***	***SD***	***M***	***SD***	***M***	***SD***	***F***	***df***	***p***
Early elementary school age									
WRMT-WA[b,c]	107.27	12.91	101.57	14.57	85.24	18.54	30.28	2,168	<.001
WRMT-WI[b,c]	111.12	13.64	106.97	14.17	89.68	18.47	29.97	2,168	<.001
WIAT-RC[b,c]	108.58	11.05	106.16	12.15	91.98	15.37	21.75	2,137	<.001
Middle school age									
WRMT-WA[b,c]	109.89	11.57	103.55	11.66	84.13	20.82	50.90	2,188	<.001
WRMT-WI[b,c]	107.81	10.01	103.42	16.83	85.13	15.58	49.99	2,191	<.001
WIAT-RC[a,b,c]	113.70	12.21	106.52	14.72	89.21	14.10	52.58	2,167	<.001
High school age									
WRMT-WA[b,c]	107.57	11.53	101.48	9.42	88.36	18.70	16.52	2, 94	<.001
WRMT-WI[b,c]	107.23	11.24	102.07	10.13	84.73	19.44	22.31	2, 94	<.001
WIAT-RC[bc]	112.00	12.46	102.94	12.57	86.35	17.99	19.54	2, 94	<.001

Note. WRMT-WA = Word Attack subtest of the Woodcock Reading Mastery Test (Woodcock, 1987); WRMT-WI = Word Identification subtest of the WRMT; WIAT-RC = Reading Comprehension subtest of the Wechsler Individual Achievement Test (Wechsler, 1992).

[a]The TL group differs from the SSD-only group at $p < .05$.

[b]The TL group differs from the SSD+LI group at $p < .05$;

[c]The SSD-only group differs from the SSD+ LI group at $p < .05$.

Table 4

Summary of backward-stepwise regressions predicting reading outcomes for the three clinical groups at the three literacy stages.

Measure	Predictor	β	b (SE)	*p*	Total R^2
TL group					
Early elementary school age					
WRMT-WA	Elision	2.83	0.73	.001	0.304
WRMT-WI	Elision	2.71	0.75	<.001	0.414
	EOWPVT–R/PPVT–III	0.64	0.28		
WIAT-RC	CELF–3	0.54	0.15	<.001	0.486
	EOWPVT–R/PPVT–III	0.63	0.23		
Middle school age					
WRMT-WA	CELF–3	0.31	0.09	.001	0.155
WRMT-WI	CELF–3	0.40	0.07	<.001	0.360
WIAT-RC	EOWPVT–R/PPVT–III	0.60	0.20	<.001	0.445
	PIQ	0.37	0.11		
High school age					
WRMT-WA	No predictors	—	—	<.001	0.000
WRMT-WI	EOWPVT–R/PPVT–III	0.87	0.20	<.001	0.394
WIAT-RC	CELF–3	0.68	0.20	.002	0.293
SSD-only group					
Early elementary school age					
WRMT-WA	EOWPVT–R/PPVT–III	0.76	0.30	.013	0.121
WRMT-WI	EOWPVT–R/PPVT–III	0.64	0.28	.027	0.098
WIAT-RC	EOWPVT–R/PPVT–III	0.83	0.24	<.001	0.206
Middle school age					
WRMT-WA	CELF–3	0.37	0.10	<.001	0.237
WRMT-WI	CELF–3	0.39	0.08	<.001	0.339
WIAT-RC	CELF–3	0.61	0.12	<.001	0.390
High school age					
WRMT-WA	CELF–3	0.49	0.22	.043	0.232
WRMT-WI	EOWPVT–R/PPVT–III	1.20	0.29	<.001	0.436