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Investigating Predictors of Listening Comprehension in Third-, Seventh-, and Tenth-Grade Students: A Dominance Analysis Approach

Elizabeth L. Tighe, **Mercedes Spencer**, and **Christopher Schatschneider**
Florida State University

Abstract

This study rank ordered the contributive importance of several predictors of listening comprehension for third, seventh, and tenth graders. Principal components analyses revealed that a three-factor solution with fluency, reasoning, and working memory components provided the best fit across grade levels. Dominance analyses indicated that fluency and reasoning were the strongest predictors of third grade listening comprehension. Reasoning emerged as the strongest predictor of seventh and tenth grade listening comprehension. These findings suggest a shift in the contributive importance of predictors to listening comprehension across development (i.e., grade levels). The implications of our findings for educators and researchers are discussed.

Listening comprehension is defined as the ability to integrate, understand, and gain meaning from spoken input (Molloy, 1997) and can also be considered a component skill of more general oral language comprehension (Nation & Snowling, 2004). Research indicates that listening comprehension skills affect reading comprehension directly (Catts, Fey, Zhang, & Tomblin, 1999; Hedrick & Cunningham, 1990; Hoover & Gough, 1990; Nation, Cocksey, Taylor, & Bishop, 2010; Rost & Hartmann, 1992; Sears & Keogh, 1993) as well as indirectly via its interaction with other literacy-based skills such as vocabulary knowledge (i.e., oral language comprehension) (Kendeou, Van den Broek, White, & Lynch, 2009). For example, de Jong and van der Leij (2002) longitudinally investigated the relations between listening comprehension and reading comprehension for Dutch-speaking first and third graders and found that first grade listening comprehension skills predicted later reading comprehension skills. Moreover, the relationship between listening and reading comprehension is potentially subject to developmental influences (Cain & Oakhill, 2007). For instance, studies have demonstrated that listening comprehension and reading comprehension are moderately correlated (r = .3 to .9) (Caccavo, 1969; Joshi, Williams, & Wood, 1998; Molloy 1997) but that the relations between these skills tend to increase over time as a consequence of students' mastery of other literacy-based skills (e.g., decoding) (Diakidoy, Stylianou, Karefillidou, Papageorgiou, 2005; Hagtvet, 2003; Tilstra, McMaster, Van den Broek, Kendeou, & Rapp, 2009). Listening comprehension has also been identified as being crucial component to the development of pre-reading skills (Wise, Sevcik, Morris, Lovett, & Wolf, 2007).

Correspondence should be addressed to Elizabeth Tighe, Department of Psychology, Florida State University, 1107 W. Call St, Tallahassee, FL, 32306-4301, USA. tighe@psy.fsu.edu.

The importance of listening comprehension as it relates to reading skills is underscored by The Simple View of Reading (SVR), which asserts that reading comprehension is the product of word-level decoding abilities and language comprehension skills (R = D x C) (Gough & Tumner, 1986; Hoover & Gough, 1990). This theoretical view states that the relationship between decoding and language comprehension is multiplicative in nature so that if an individual displays mastery in decoding ability but poor language comprehension skills, they are likely to have poor reading comprehension as a result. Further, studies examining individuals with specific comprehension problems (Perfetti, 1985) support this notion because many of these studies have found that these individuals maintain normal decoding ability but have poor language comprehension skills and consequently have poorer reading comprehension than students without language comprehension deficits (Catts, Adlof, & Weismer, 2006; Nation, Adams, Bowyer-Crane, & Snowling, 1999; Nation, Clarke, Marshall, & Durand, 2004; Spencer, Quinn, & Wagner, 2014). Moreover, listening comprehension skills have been identified as being a better predictor of comprehension ability than intelligence (Stanovich, Cunningham, & Feeman, 1984).

Clearly, there is some consensus in the literature that listening comprehension plays an important role in an individual's reading comprehension ability; however, to date, there remains relatively little investigation of potential cognitive predictors of listening comprehension, particularly in the older grades. The present study seeks to fill a gap within the literature by examining several predictors of listening comprehension across the primary (i.e., third) and secondary (i.e., seventh and tenth) grade levels: working memory, verbal and nonverbal reasoning, and fluency. We introduce a regression-based statistical technique referred to as dominance analysis, which allowed us to rank order these predictors in terms of their contributive importance to listening comprehension at each grade level. This technique also allowed us to examine potential developmental shifts in the contributive importance of predictors to listening comprehension across three distinct developmental grade levels.

Predictors of Listening Comprehension

Predictors of listening comprehension have been extensively investigated in young children (Daneman & Blennerhassett, 1984; Daneman & Carpenter, 1980; Hannon & Frias, 2012; Hare & Devine, 1983; Keenan, Betjemann, Wadsworth, DeFries, & Olson, 2006; Florit, Roch, Altoè, & Levorato, 2009; Lepola, Lynch, Laakkonen, Silvén, & Niemi, 2012; Sénéchal, Ouellette, & Rodney, 2007), second language learners (Andringa, Olsthoorn, van Beuningen, Schoonen, & Hulstijn, 2012; Dunkel, 1991; Joiner, 1986; Li, Cheng, & Kirby, 2012; Rost, 1990), and skilled adult readers (Bell & Perfetti, 1994; Friedman & Johnson, 2006; Gernsbacher, Varner, & Faust, 1990; Nishino, 1992; Rubin, 1994; Van der Linden et al., 1999; Was and Woltz, 2007). Many of these studies consistently identify working memory and verbal abilities as the most important predictors of listening comprehension skills.

However, there exists a paucity of research on predictors of listening comprehension skills in middle and high school students. To date, Molloy (1997) has been the only investigation that has focused explicitly on identifying important predictors of listening comprehension in middle school students. Molloy (1997) examined the contribution of working memory capacity to listening comprehension skills in fifth and seventh grade students and found that a sentence span task, which required students to read sentences, verify the truthfulness of each sentence, and repeat back the last word of the sentence, was a significant predictor of listening comprehension. No studies have explored important predictors of listening comprehension skills in high school students. Thus, one of the primary goals of the current study was to better understand important predictors of listening comprehension across development. To accomplish this, we investigated the predictor contributions of working memory, verbal and nonverbal reasoning, and fluency to listening comprehension in third, seventh, and tenth grade students. Despite the limited amount of research on predictors of listening comprehension across grade levels, we discuss the available research on each of our included predictors and their relationship to listening comprehension skills below.

Working memory

Working memory is a memory system with a finite capacity that is responsible for storing, manipulating, and processing actively held information (Baddeley, 1986; Baddeley & Hitch, 1974; Daneman & Carpenter, 1980; Liberman, Shankweiler, & Liberman, 1989; Wagner & Torgesen, 1987). Working memory is a potentially important predictor of listening comprehension because listening comprehension tasks tend to place greater processing demands on working memory resources. For example, listeners are unable to control the speech rate, making listening comprehension experiences subject to rapid decay of information and therefore more taxing on working memory abilities (Daneman & Carpenter, 1980; Molloy, 1997). Characteristics of listening comprehension in conjunction with individual differences in working memory capacity subsequently lead to the observed differences in listening comprehension ability (see Daneman & Merikle, 1996). Florit et al. (2009) investigated the role of working memory, verbal intelligence, and receptive vocabulary in Italian-speaking preschoolers' listening comprehension skills. The results indicated that performance on all tasks accounted for significant variance in explaining listening comprehension over and above age. Working memory was found to contribute an additional 6% of the variance in listening comprehension over and above verbal abilities and short-term memory. It is also the case that individuals with verbal working memory deficits tend to exhibit impaired listening comprehension ability (e.g., McInnes, Humphries, Hogg-Johnson, & Tannock, 2003).

Verbal reasoning

Verbal reasoning or verbal intelligence is the ability to use language to solve and analyze problems. Past research has demonstrated that students' verbal ability impacts their listening comprehension performance (Florit, Roch, & Levorato, 2011, 2013a, 2013b; Thomas & Levine, 2006). For example, Florit, and colleagues (2013b) longitudinally investigated the relations between listening comprehension and verbal ability (i.e., receptive vocabulary[1]) in preschool children. The results indicated that verbal ability was directly and causally related

[1]Research has demonstrated strong correlations between measures of vocabulary knowledge and measures of verbal aptitude. For example, correlations between the Peabody Picture Vocabulary Test—Third Edition (Dunn & Dunn, 1997) and the Weschler Intelligence Scale for Children—Third Edition (Wechsler, 1991) are .90 (Dunn & Dunn, 1997), indicating that in most instances vocabulary knowledge can be considered a proxy for verbal aptitude.

to listening comprehension skills in these children; however, these relations were also determined to be reciprocal in nature. Furthermore, children who have specific language impairments have been found to have poorer listening comprehension skills (Kelso, Fletcher, & Lee, 2007; Vandewalle, Boets, Boons, Ghesquière, & Zink, 2012) and are also more likely to have vocabulary deficits than children without specific language impairments (Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998), which indicates that verbal reasoning ability may contribute to listening comprehension.

Nonverbal reasoning

Presently, only a single study has explicitly investigated the relations between nonverbal reasoning (i.e., the ability to use visual information rather than linguistic information to solve and analyze problems) and listening or language comprehension. Bishop and Adams (1992) examined the nonverbal reasoning abilities in children ages eight to 12 years old who had specific language impairments. Results indicated that these children had problems completing a sequence task when the stimuli were verbal as well as nonverbal, which suggests that language comprehension may rely, at least partially, on the mastery of some nonverbal reasoning skills. Although nonverbal reasoning has not been included as a predictor of listening comprehension skills, nonverbal reasoning has been consistently identified as an important contributor to reading comprehension skills across multiple grade levels (Adlof, Catts, & Lee, 2010; Tighe & Schatschneider, 2014; Tiu, Thompson, & Lewis, 2003). Because reading and listening comprehension skills are highly related and the relations between these two skills increases at higher grade levels (Diakidoy, et al., 2003; Tilstra et al., 2009), we wanted to investigate whether nonverbal reasoning may also be an important predictor of listening comprehension skills.

Fluency

Whether an individual is listening to a stream of speech or reading written text, the goal of comprehension remains consistent: to understand what is being communicated. As a result of the strong relations between reading and listening comprehension, some researchers argue that the only major distinction between reading and listening is that reading comprehension requires an individual to decode or recognize printed words via rapid identification of grapheme-phoneme correspondences (Perfetti & Hogaboam, 1975). Although, when we listen to a stream of speech, we are simultaneously engaging in top-down (e.g., inference-making) and bottom-up processes (e.g., decoding) (see Peterson, 2007). Bottom-up processing or decoding may be used during listening comprehension to distinguish between sounds within words and recognize word boundaries (Dahan & Magnuson, 2006), particularly for words that are less well known or unknown to the listener. Therefore, it is certainly possible that proficiency in accurately and automatically reading and decoding text (i.e., oral reading fluency) (Adams, 2000; National Institute of Child Health and Human Development [NICHD], 2000) may be positively associated with listening comprehension skills, especially when considering that both listening and reading comprehension require rapid word recognition. However, there is an absence of research that explicitly examines the extent to which fluency affects listening comprehension. Thus, given the potential similarities between listening and reading comprehension and the fact that fluency has been identified as a component skill of reading comprehension in various instances (NICHD, 2000), we sought to include this predictor within the current study.

Dominance Analysis

The current study wanted to rank order the contributive importance of several cognitive predictors to listening comprehension at three distinct developmental grade levels: third, seventh, and tenth grade. A traditional multiple regression approach allows researchers to estimate the relationships of several predictors to an outcome variable; however, it is difficult to interpret the importance of the predictors to an outcome variable if the predictors are highly correlated. Dominance analysis (DA), a regression-based technique that relies on bootstrapping, addresses the issue of rank ordering predictors by importance and eliminates the issue of high predictor multicollinearity. DA measures relative predictor importance by assessing the total and unique R^2 values for all possible combinations of predictors (subset models) as they relate to an outcome variable (i.e., listening comprehension) (Azen & Budescu, 2003; Budescu, 1993). For example, a predictor variable (i.e., fluency) is said to completely dominate a competitor variable (i.e., reasoning), if the contribution of fluency exceeds reasoning and exceeds that of other predictors in all subset models. Because of the strictness of establishing complete dominance, Azen and Budescu (2003) introduced weaker levels of dominance (conditional and general) as a means of minimizing undetermined dominance among predictors.

Several recent studies have demonstrated the utility of a DA approach to rank ordering predictors of various reading-related outcome variables: word-level skills (Compton, Olson, DeFries, & Pennington, 2002; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004), fluency (Mellard, Anthony, & Woods, 2012; Schatschneider et al., 2004; Vaessen & Blomert, 2010), and reading comprehension (Kim, Petscher, Schatschneider, & Foorman, 2012; Schatschneider et al., 2004; Tighe & Schatschneider, 2014). However, the majority of these studies have assessed the relative importance of predictors of reading-related outcomes in children at or below the sixth grade reading level (Kim et al., 2012; Schatschneider et al., 2004; Vaessen & Blomert, 2010) or in different populations: adults with low literacy skills (Mellard et al., 2012) and twins (Compton et al., 2002). In addition, none of the previous studies included listening comprehension as an outcome variable. Further, all of the past research has only evaluated complete dominance (the strictest level of dominance). The current study extended the body of literature on DA by: (a) investigating listening comprehension as an outcome variable; (b) assessing relative predictor importance across all dominance levels (complete, conditional, and general); and (c) including students at seventh and tenth grade reading levels.

The Present Study

The present study sought to use DA to investigate the relative importance of working memory, verbal and nonverbal reasoning, and fluency as predictors of listening comprehension in third, seventh, and tenth graders. Countless studies have investigated predictors of reading comprehension (for a review see Cain, Oakhill, & Bryant, 2004); yet, very few have examined the predictors of listening comprehension. Moreover, the majority of past research has focused on predictors of listening comprehension in preschoolers and early elementary-aged children (Florit et al., 2009, 2011, 2013a, 2013b). We wanted to extend past research by examining additional grade levels (e.g., middle and high school students) and applying a DA approach to rank order the contributive importance of the predictors to listening comprehension skills. First, we utilized a principal components analysis (PCA) at each grade level to determine an optimal set of predictors from our battery of assessments for our DAs. Second, we utilized the retained factors from the PCAs in DAs to rank order the predictors based on the total and unique R^2 estimates across all subset models by grade level. We addressed the following research questions:

1. What is the total listening comprehension variance accounted for by all of the predictors at each grade level?

2. What predictors emerge as the most important to third, seventh, and tenth grade listening comprehension skills?

Method

Participants

The participants included 215 third graders, 188 seventh graders, and 182 tenth graders (total $N = 585$) attending schools in three Florida educational districts. Participant demographic characteristics by grade level are presented in Table 1. Averaged across all grade levels, the sample was comprised of 54% females. The participants represented a range of ethnic backgrounds: 41% Caucasian, 38% African American, 17% Hispanic, 2% Asian, and 2% other/not specified. Approximately 36% of the sample qualified for free or reduced price lunch, which was used as a proxy for socioeconomic status. None of the participants qualified for having English language learner status and therefore, we considered all participants to be proficient in English. To be eligible to participate in the study, parental consent forms were sent out through classroom teachers. From the returned informed consent forms, our participants were drawn from 19 schools and 54 classrooms.

Measures

Listening comprehension—Three grade-specific orally presented passages from the Florida Comprehensive Assessment Test (FCAT) were utilized to assess listening comprehension skills. The passages were shortened in length so that each passage would not exceed two minutes in total read time. Following each passage, the examiner read aloud several multiple-choice questions and the participant marked down the answers on a score sheet. The participants answered 12 multiple-choice comprehension questions across the three passages. We utilized a composite score of the three FCAT passages in our analyses. The Cronbach's Alpha reliability estimates ranged from .82 to .88 across the three grade levels.

Fluency—Several measures were administered to assess a broad range of fluency skills: oral reading accuracy and fluency, word reading fluency, and comprehension.

Gray's Oral Reading Test-Fourth Edition (GORT-4): Accuracy and fluency scores from the GORT-4 (Wiederholt & Bryant, 2001) were utilized to assess oral reading accuracy and fluency. The GORT-4 is a norm-referenced measure of oral reading rate, accuracy, fluency, and comprehension. The measure consists of 14 passages with five multiple-choice comprehension questions following each passage. The accuracy score represents a student's ability to correctly pronounce words in the passages. The fluency score represents the rate at which a student reads a passage combined with the student's accuracy on the words in the passage. Reliability estimates for the GORT-4 are .94 for third grade, .91 for seventh grade, and .85 for tenth grade.

Oral reading fluency (ORF) passages: Nine ORF passages were administered to the participants. The participants read three grade-specific standardized ORF passages (AIMSweb, 2002). The exception to the grade-specific passages was for the tenth graders, who read eighth grade level passages, because AIMSweb does not provide passages above an eighth grade reading level. Three grade-specific passages extracted from textbooks on the state adoption list were also administered. Finally, the participants read three grade-specific passages from the practice items on the FCAT. Scores for all nine ORF passages were calculated based on the median number of words read correctly in one minute. Reliability was estimated using the average correlation between all passages within each grade and ranged from .88 to .91.

Reading comprehension: The Sunshine State Standards (SSS) Reading Comprehension subtest of the FCAT was administered as a comprehension measure. The FCAT-SSS is a group-administered, norm-referenced assessment, which includes six to eight informational and literary passages. The participants are prompted to read through the passages and answer the subsequent multiple-choice questions. The multiple-choice questions, which range from six to 11 per passage, assess words and phrases in context, the main idea of the passage, and comparison and cause/effect relationships. Scores on this measure range from 100 to 500 in which a score of around 300 indicates at grade-level reading comprehension performance. Internal reliabilities for the entire test battery are reported as .89, .90, and .85 for third, seventh, and tenth grade, respectively (Florida Department of Education, 2006).

Word reading fluency: Two subtests of the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999) were administered: the Phonetic Decoding Efficiency (PDE) subtest and the Sight Word Efficiency (SWE) subtest. The TOWRE is a norm-referenced, individually administered test designed to measure word reading accuracy and fluency. The PDE is a timed, 45-second subtest, which presents participants with a list of pseudo-words and prompts them to accurately read aloud as many pseudo-words as possible. The SWE is a timed, 45-second subtest, which presents participants with a list of real words and prompts them to read aloud as many real words as possible. Test-retest reliability is reported to be .90 for the PDE subtest and .97 for the SWE subtest.

Working memory—An adapted version of the Competing Language Processing Task (Gaulin & Campbell, 1994) was used to assess working memory, which included reading span and listening span measures. The reading span measure prompted participants to read groups of three-word sentences and to respond with true or false responses. The participants were also asked to recall the last word at the end of each sentence. For example, a participant might receive the following two sentences: “Candy is sweet. Triangles are round.” The participant would respond true or false to each sentence and then recall the final words: “sweet” and “round.” The groups of sentences increased in complexity, ranging from two sentences to up to six sentences per group, as the task proceeded. Testing continued until fewer than half of the final words were recalled. Both span measures included a total of 42 items. The listening span measure was identical in format to the reading span measure, except that each sentence was read aloud to the participant.

Verbal and nonverbal reasoning—Four subtests of the Wechsler Abbreviated Scale of Intelligence (WASI; Psychological Corporation, 1999) were used to assess reasoning skills: vocabulary, similarities, matrix reasoning, and block design. The first four items on the vocabulary subtest required the participants to verbally name presented pictures. The remaining 38 items asked the participants to define words aloud that were presented both orally and visually to the participants. The reliability coefficients for this subtest are .88 for third grade, .86 for seventh grade, and .83 for tenth grade. The similarities subtest measures abstract verbal reasoning abilities. Participants were asked to identify relationships between pairs of words that are either presented aloud or with pictures. The reliability coefficients for this subtest are .89, .85, and .83 for third, seventh, and tenth grade, respectively. The matrix reasoning subtest measures nonverbal fluid reasoning and general intellectual abilities. This task included a series of 35 incomplete patterns, each accompanied by five possible answer choices. Participants completed the task by either pointing to or stating the number of their answer choice. Reliability coefficients for this subtest are .93, .89, and .86 for third, seventh, and tenth grade, respectively. The block design subtest is a measure of perceptual organization and general intelligence that is designed to tap abilities related to spatial visualization, visuomotor coordination, and abstract conceptualization. Participants were asked to manipulate a set of blocks to match a pattern that was presented to them on a card by the examiner. Reliability coefficients for this subtest are .92 for third grade, .92 for seventh grade, and .89 for tenth grade.

Procedure

The two-hour battery of measures was individually administered to the participants after FCAT testing was completed in the spring 2003 academic year. Three forms of counterbalanced assessments were randomly assigned to participants. All examiners underwent rigorous training and reached an acceptable level of proficiency in test administration prior to assessing participants.

Results

Descriptive Statistics

The means and standard deviations of all measures are listed by grade level in Table 2. Correlations among the measures for each grade are provided in Tables 3, 4, and 5. Across all grade levels, the measures were low to moderately correlated with each other. All of the assessments were positively correlated with our composite listening comprehension scores (ranging from .28 to .63 in third grade, .25 to .65 in seventh grade, and .15 to .51 in tenth grade, *p*s < .05).

Principal Components Analyses (PCAs)

PCAs, using oblique promax rotations, were conducted at each grade level to reduce the number of measures (n = 12) into common constructs to create the predictors for our dominance analyses (DAs). Oblique promax rotation was chosen because it assumes that the factors are intercorrelated. To determine the number of factors to retain for our subsequent DAs, we employed three criteria: (1) Kaiser's Rule (all eigenvalues greater than 1.0); (2) examination of scree plots; and (3) a minimum of 70% of the variance accounted for by the 12 entered variables (Cattell, 1966; Stevens, 1992). The factors were interpreted based on the zero-order correlations of the individual measures with the factors. The measures with the highest correlations (factor loadings) comprised and labeled each of our retained factors. We present the results of our PCAs by grade level below.

Third grade—We entered 12 measures into our PCA: TOWRE PDE, TOWRE SWE, FCAT, GORT-4 Fluency, GORT-4 Accuracy, a composite ORF passage score, WASI similarities, WASI vocabulary, WASI matrix reasoning, WASI block design, listening span, and reading span. The scree plot and Kaiser's Rule (eigenvalues of 6.56, 1.39, 1.01, and .84 for the four largest components) indicated a 3-factor solution. Thus, we retained three factors, which accounted for 75% of the covariation among the measures in third grade.

Table 6 presents the factor loadings and factor intercorrelations. We labeled our first retained factor as fluency because the highest loadings were from measures used to assess speed and accuracy in reading connected text or recognizing single words or pseudo-words (composite ORF passage score, two TOWRE subtests, and two GORT-4 subtests). We labeled the second retained factor as reasoning because the highest loadings were from the four WASI subtests. These subtests all assess verbal and nonverbal higher-order reasoning and inferential abilities. The WASI vocabulary and similarities subtests also cross-loaded on our fluency factor (loadings of .69 and .60, respectively). In addition, the FCAT, a measure of reading comprehension, cross-loaded on both the fluency (.79) and reasoning (.65) factors. We labeled the third factor working memory because the highest loadings were the two working memory measures (listening and reading span). The factors were moderately correlated with each other (ranging from .43 to .57) and moderately correlated with our composite listening comprehension score (ranging from .43 to .57).

Seventh grade—A PCA with the same 12 measures as in the third grade analyses was conducted for seventh grade. Similarly, a scree plot and Kaiser's Rule (eigenvalues of 6.13, 1.53, 1.24, and .69 for the four largest components) indicated a 3-factor solution. Thus, we retained three factors, which accounted for 74% of the covariation among the measures in seventh grade.

Table 7 presents the factor loadings and factor intercorrelations. The three factors retained in seventh grade were identical to those retained in third grade. The first retained factor was labeled fluency and was comprised of the ORF composite score, GORT-4 subtests, and TOWRE subtests. The second retained factor was labeled reasoning and consisted of the four WASI subtests. Once again, the FCAT cross-loaded on the fluency (.65) and reasoning (.73) factors. Our third retained factor was labeled working memory and consisted of the listening and reading span measures. The factors were low to moderately correlated with each other (ranging .20 to .56) and with listening comprehension (ranging from .26 to .63).

Tenth grade—We utilized the same 12 variables from the third and seventh grade analyses in a PCA for tenth grade. Identical to our previous analyses, a scree plot and Kaiser's Rule (eigenvalues of 5.87, 1.71, and 1.18, and .71 for the four largest components) indicated that a three-factor solution provided the best fit. Thus, we retained three factors, which accounted for 73% of the covariation among the measures in tenth grade.

Table 8 presents the factor loadings and the factor intercorrelations. The three factors retained for tenth grade were identical to those retained in third and seventh grade. The first factor was labeled fluency and consisted of the GORT-4 subtests, the ORF composite score, and the TOWRE subtests. The second factor was labeled reasoning and was comprised of the four WASI subtests. Again, the FCAT cross-loaded on the fluency (.58) and reasoning (.84) factors; however, by this grade level the FCAT loaded much higher with the reasoning component. This finding was not surprising given that the proportion of FCAT items that require complex reasoning and inferential skills increases from 30% in third grade to 70% in tenth grade (Torgesen, Nettles, Howard, & Winterbottom, 2005). The final factor was labeled working memory, which was comprised of the listening and reading span tasks. The three factors were low to moderately correlated with each other (ranging from .25 to .53) and low to moderately correlated with listening comprehension (ranging from .20 to .57).

Dominance Analyses

We utilized our retained factors from the PCAs in our DAs to rank order the predictors by contributive importance to listening comprehension at each grade level. To establish predictor importance, DA relies on bootstrapping and computes total and unique R^2 estimates for all possible combinations of predictors as they relate to a criterion variable (i.e., listening comprehension). As previously discussed, a predictor (i.e., reasoning) is considered completely dominant over a competitor predictor (i.e., fluency) if the predictor (i.e., reasoning) contributes additional unique variance to listening comprehension in both the pairwise comparison as well as in the presence of all other possible combinations of predictors (subset models). In other words, complete dominance (the strictest dominance level) is only achieved if a variable's predictive utility exceeds that of all other competitor variables in all possible subset models (Budescu, 1993).

We utilized the combinatorial rule of probability to calculate the total number of subset models (combinations of predictors) needed for our DAs (Hays, 1994). Because all of our grade levels contained three predictors (fluency, reasoning, and working memory), we needed seven different regression models per grade: 3 single predictor models, 3 combinations of two predictor models, and 1 three-predictor model. Thus, we estimated 21 subset models across our three grade levels. Our analyses were conducted using the DA macro in SAS 9.2 (Azen & Budescu, 1993; Budescu, 1993; SAS Institute Inc., 2012). The DA macro allowed us to generate complete dominance estimates (the strictest level of dominance) (Budescu, 1993) as well as conditional and general dominance estimates (less stringent levels of dominance) (Azen & Budescu, 2003). The weaker levels of dominance (conditional and general) operate on an "on average" basis and were introduced as a means to reduce undetermined dominance between predictors (Azen & Budescu, 2003). Conditional dominance is achieved when a predictor contributes additional unique variance within each model size (i.e., averaging over subset models with only a single predictor) as compared to a competitor predictor. Similarly, general dominance is achieved if a predictor's unique contribution is greater across the average of all subset models as compared with the competitor predictor. It is important to note that significant comparisons at the complete level would also account for all significant comparisons at the conditional and general level because the dominance levels operate in a hierarchical fashion. Similarly, conditional dominance would also imply general dominance (Azen & Budescu, 2003). Although reporting the strictest level of dominance is best, we decided to report all pairwise predictor pairwise comparisons across all dominance levels to minimize the chance of undetermined dominance between predictors.

Finally, it is important to note that DA relies on bootstrapping in which we used 1,000 iterations for each grade level DA. Thus, there are not *p*-values associated with DA. Instead, a predictor is defined as statistically "dominant" if the predictor contributed more unique variance than the competitor predictor and in the presence of all subset models at least 950 out of 1,000 times. Likewise, a predictor would be statistically "dominated" by a competitor predictor if that predictor were least dominant at least 50 or fewer times out of 1,000. The number of times a predictor dominants another predictor is referred to as the D_{ij_mean}, where $_i$ and $_j$ represent the competing predictors. We present the predictor total and unique R^2 values for the seven subset models (Tables 9, 11, and 13), the predictor pairwise comparison results (D_{ij_mean}) by dominance level (Tables 10, 12, and 14), and graphs of the predictor on average (within each model size) variance estimates (Figures 1, 2, and 3) by grade level below.

Third grade—The three factors of fluency, reasoning, and working memory from the PCA were entered into our third grade DA. The total and unique R^2 estimates from the seven subset models (all possible combinations of the three predictors) are presented in Table 9. The first column in this table (*Subset Models*) specifies which predictor(s) were entered into the subset models. The second column (R^2) delineates the total R^2 value accounted for by the subset models. The remaining three columns (*Fluency, Reasoning, Working Memory*) present the unique R^2 estimates of these predictors in the presence of all other predictors in the model. For example, the first row of Table 9 demonstrates that the single predictor subset model of fluency accounted for 26% of the third grade listening comprehension variance. After controlling for fluency, reasoning contributed an additional 12% unique variance and working memory accounted for an additional 5% unique variance to listening comprehension.

Total R^2 estimates of subset models with two or more predictors (i.e., fluency-reasoning) are interpreted as the joint contribution of these predictors to listening comprehension. For example, the fluency-reasoning subset model suggests that both predictors jointly accounted for 37.6% of the listening comprehension variance and that working memory contributed an additional 2% unique variance. A subset model with all three predictors jointly accounted for 39.7% of the variance in third grade listening comprehension skills.

Table 10 presents the predictor pairwise comparisons by dominance level in third grade. An asterisk in our dominance table indicates that dominance was established ($D_{ij\_mean} \geq 0.950$ or ≤ 0.050). The results indicated that reasoning ($_i$) completely dominated working memory ($_j$) ($D_{ij\_mean} = 0.955$). Pairwise comparison dominance could not established at any of the other levels.

Figure 1 presents the on average (within model size) variance estimates for each predictor to listening comprehension. For example, reasoning contributes 32.5% variance to listening comprehension in a model with no other included predictors, an additional 15% variance on average with any one other predictor in the model, and an additional 8% variance with all other included predictors (unique variance). Although dominance could not be established between fluency and reasoning, reasoning contributes the most unique variance (8%) as compared to fluency (3%) and working memory (2%). Thus, in third grade, reasoning and fluency emerged as the most important predictors of listening comprehension.

Seventh grade—Similar to third grade, the three predictors of fluency, reasoning, and working memory from the PCA were entered into our seventh grade DA. Table 11 presents the total and unique predictor R^2 estimates from the seven subset models. A model with all three predictors accounted for 42.7% of the variance in listening comprehension skills. The pairwise comparisons by dominance level are listed in Table 12. Reasoning ($_i$) completely dominated fluency ($_j$) and working memory ($_j$) (D_{ij_mean} = .999 and 1.000, respectively). Additionally, fluency ($_i$) generally dominated working memory ($_j$) (D_{ij_mean} = .976). Reasoning emerged as the strongest listening comprehension predictor, accounting for 39.7% of the variance in a model by itself, an average of 27% of the variance in conjunction with any other included predictor, and 18% unique variance (Figure 2). Thus, these findings suggest that reasoning is the most important predictor of seventh grade listening comprehension skills. Working memory emerged as the least important predictor of listening comprehension at this grade level.

Tenth grade—Identical to the previous grade levels, the three predictors of fluency, reasoning, and working memory from the PCA were entered into our tenth grade DA. Table 13 presents the total and unique predictor R^2 estimates from the seven subset models. Jointly, the three predictors accounted for 33.1% of the listening comprehension variance. The pairwise comparisons by dominance level are presented in Table 14. Similar to seventh grade, reasoning ($_i$) completely dominated fluency ($_j$) and working memory ($_j$) (D_{ij_mean} = .999 and 1.000, respectively). In addition, fluency generally dominated working memory (D_{ij_mean} = .954). It is evident that reasoning is the strongest predictor, accounting for 32.5% of the variance in a model by itself, an average of 24% of the variance in conjunction with any other included predictor, and 18% unique variance (Figure 3). Moreover, by tenth grade, fluency only contributed an additional 1% unique variance to listening comprehension and working memory did not account for additional variance in listening comprehension. Thus, reasoning emerged as the most important predictor and working memory emerged as the least important predictor of tenth grade listening comprehension skills.

Discussion

The purpose of the current study was to examine and rank order by contributive importance the predictors of listening comprehension skills in third, seventh, and tenth graders. Our PCAs revealed that a 3-factor solution, with fluency, reasoning, and working memory components, provided the best fit at all grade levels. The retained PCA factors were entered into a separate DA at each grade level. The three predictors accounted for a moderate amount of the total listening comprehension variance (ranging from 33.1% to 42.7%) across the grade levels. In third grade, reasoning and fluency emerged as the most important predictors of listening comprehension, with unique variance estimates of 8% and 3%, respectively. In seventh and tenth grade, reasoning emerged as the single strongest predictor of listening comprehension, capturing 18% unique variance in both of the grade levels. Working memory was the least predictive of listening comprehension skills across all grade levels. These findings indicate a developmental shift in the predictive utility of cognitive predictors to listening comprehension: fluency and reasoning are more important in the primary school grade levels whereas higher-order reasoning skills are more important in the secondary school grade levels. The implications of our findings for educators and researchers and suggestions for future research are discussed.

Predictors of Listening Comprehension

Reasoning and fluency—Past research has identified verbal reasoning (Florit et al., 2011, 2013a, 2013b) as an important predictor of preschoolers' and early elementary school students' listening comprehension skills. Consistent with the previous literature, reasoning (comprised of verbal and nonverbal reasoning and comprehension) emerged as an important predictor across all of our grade levels. We also identified fluency (comprised of oral and word reading fluency and comprehension) as an important predictor of listening comprehension, particularly in third grade students. Our reading comprehension measure, the FCAT, cross-loaded on the fluency and reasoning factors; however, the FCAT loaded more highly with fluency in third grade and loaded more highly with reasoning in seventh and tenth grade. Thus, reading comprehension may be an important predictor of listening comprehension across development (grade levels). Future research should explore reading comprehension as a separate predictor of listening comprehension skills across a range of grade levels.

Beyond identifying fluency and reasoning as important predictors, we found that the contributive importance of these predictors to listening comprehension varied as a function of grade level: fluency was more important in third grade whereas reasoning emerged as most important in seventh and tenth grade. Studies have reported that higher-order inferential and reasoning abilities increase during the secondary grade levels (Cain & Oakhill, 1998); however, none of the research has directly assessed the impact of reasoning skills to listening comprehension at the secondary grade levels. These findings mirror those found in the predictors of reading comprehension literature (Schatschneider, Harrell, & Buck, 2007; Tighe & Schatschneider, 2014). For example, Tighe and Schatschneider (2014) utilized a DA approach to investigate predictors of individual differences in reading comprehension in third, seventh, and tenth graders. Similar to our findings, Tighe and

Schatschneider (2014) reported a developmental shift in the contributive importance of predictors: fluency and verbal reasoning were most important to third grade reading comprehension whereas general reasoning skills were most important to tenth grade reading comprehension. Results from the current study in conjunction with Tighe and Schatschneider's (2014) findings lend support to rauding theory (Carver, 1977), in which Carver illustrates through a series of mathematical equations that reading comprehension (i.e., reading level, A_L) and listening comprehension (i.e., verbal knowledge level, V_L) may both utilize similar underlying cognitive processes (Carver, 2000, 2003). However, given the limited amounts of research on predictors of listening comprehension and exploratory nature of the present study, future research needs to further examine the relationship between listening and reading skills and the predictors of listening comprehension across development.

Working memory—Working memory is one of the most frequently investigated predictors of children's listening comprehension skills (Daneman & Carpenter, 1980; Daneman & Merikle, 1996; Florit et al., 2009; Molloy, 1997). Inconsistent with the past research, working memory emerged as the least important predictor of listening comprehension across all of our grade levels. There are a couple reasons to explain why working memory was the least important predictor of listening comprehension. First, the majority of the past research has assessed the predictive utility of working memory to listening comprehension in young children. It may be the case that working memory is central to listening comprehension only in pre-readers and early elementary school children. In third grade, our working memory factor accounted for 18.5% of the listening comprehension variance in a model by itself and 2% unique variance. Pairwise dominance could not be established between fluency and working memory, suggesting that working memory is still considered a component of listening comprehension at this grade level. By seventh and tenth grade, working memory was completely dominated by reasoning and generally dominated by fluency, indicating that working memory is not an important component of listening comprehension at these grade levels. Moreover, working memory contributed an additional 1% unique variance to seventh grade listening comprehension skills and contributed no unique variance to tenth grade listening comprehension skills. These findings suggest that working memory may only be an important predictor to listening comprehension in the earlier grade levels.

Second, there exist few norm-referenced assessments of working memory and substantial variability in the types of working memory measures administered across studies. For instance, research has differentiated between "low level" versus "high level" working memory tasks (Molloy, 1997). These measures differ in terms of the amount of storage capacity and processing demands placed on working memory. Molloy (1997) found that "high level" tasks, which are considered more taxing on processing demands, were more predictive of listening comprehension than "low level" tasks in fifth and seventh grade students. In addition, studies have distinguished between verbal, numerical, and/or visuospatial working memory tasks. Thus, it may be the case that particular types of working memory tasks are better predictors of listening comprehension skills.

Implications of Findings

Our findings have several practical implications. Because various skills are differentially predictive of listening comprehension across varying grade levels, it is important to consider this when implementing targeted instruction and/or interventions for students who have weaknesses in their listening comprehension skills. For instance, because fluency and verbal reasoning are influential predictors of listening comprehension in third grade, third graders with poor listening comprehension skills would benefit from instruction and/or interventions that incorporate a fluency component (i.e., activities that necessitate simultaneous decoding and comprehension ability; NICHD, 2000), such as choral reading or partner reading, and activities that tap verbal reasoning skills as opposed to activities that target general reasoning ability (e.g., nonverbal reasoning). However, for seventh and tenth graders, more general reasoning ability was highly predictive of listening comprehension; thus, instruction and/or interventions that target these students' reasoning skills would be more likely to positively impact their listening comprehension skills. Furthermore, contrary to previous research investigating listening comprehension in pre-readers and early elementary-aged children, the results of the present study indicate that targeting working memory skills may not be beneficial to listening comprehension in the older grades. Therefore, classroom activities that focus on improving working memory skills specifically with the goal of increasing listening comprehension ability may not result in significant student gains.

The current results also have implications for researchers. Consistent with past studies (e.g., Schatschneider et al., 2004), DA is a promising statistical tool for researchers who are interested in determining whether certain skills are predictive of an overall ability as well as allowing for a rank ordering of multiple predictors based on their contributive importance. Thus, DA is useful for any investigation of complex cognitive processes (e.g., reading comprehension) that rely on an integration of multiple skills. Additionally, the present study extended the past literature on DAs by incorporating Azen and Budescu's (2003) revision on additional levels of dominance to resolve undetermined predictor dominance. By including additional levels of dominance (i.e., conditional and general), we were able to establish further rank orderings of our predictors to listening comprehension (i.e., fluency vs. working memory in seventh and tenth grade).

Limitations and Future Directions

A few limitations should be addressed. First, the dearth of research on predictors of listening comprehension, especially in the later grades, made it difficult to determine an optimal set of predictors to include. With the current set of predictors, we were only able to account for a moderate amount of the variance in listening comprehension at each grade level (ranging from 33.1% to 42.7%). Additional reading-related predictors should be considered to account for this unexplained variance. For example, some research has suggested that linguistic knowledge, more specifically measures of vocabulary knowledge, grammatical accuracy, segmentation accuracy, and metacognitive awareness have all been found as important predictors of listening comprehension skills (Andringa et al., 2012; Mecartty, 2000; Vandergrift, Goh, Mareschal, & Tafaghodtari, 2006). In the current study, vocabulary was included in our reasoning factor; however, future research should explore the separate contributions of vocabulary and reasoning to listening comprehension as well as additional predictors to better understand the construct of listening comprehension.

Second, there is considerable variability in defining and assessing the construct of listening comprehension. Listening comprehension falls under the umbrella terms of oral language comprehension (Nation & Snowling, 2004) and linguistic comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). Thus, research has considered the construct of listening comprehension separately and in conjunction with vocabulary knowledge and verbal reasoning skills. Moreover, there are few norm-referenced assessments of listening comprehension. The current study utilized orally presented FCAT passages with multiple-choice questions to assess listening comprehension. Future research should examine additional broader oral language assessments and vary the types of texts (i.e., narrative and expository texts) and response formats (i.e., multiple-choice and open-ended questions) to better understand the construct of listening comprehension.

Finally, the data presented in this study is cross-sectional and therefore, it is difficult to assess developmental changes in the contributions of the predictors to listening comprehension. This study is the first to investigate the predictors of listening comprehension at three distinct developmental grade levels, and more specifically, to extend the research to the secondary grade levels. However, future research needs to investigate the predictor contributions to listening comprehension longitudinally.

Conclusion

The present study illustrated the utility of dominance analyses to rank order predictors of listening comprehension by contributive importance in third, seventh, and tenth grade students. The results indicated that the predictors of fluency, reasoning, and working memory accounted for a moderate amount of the listening comprehension variance (ranging from 33.1% to 42.7%) across the three grade levels. Fluency and reasoning skills were the most important predictors of third grade listening comprehension skills. Reasoning emerged as the single strongest predictor of seventh and tenth grade listening comprehension skills. These findings suggest a developmental shift in the importance of component listening comprehension skills as a function of grade level. This study presents an initial attempt at understanding important predictors of listening comprehension across development. Future studies should determine an optimal set of predictors and investigate these predictors longitudinally to better understand the construct of listening comprehension.

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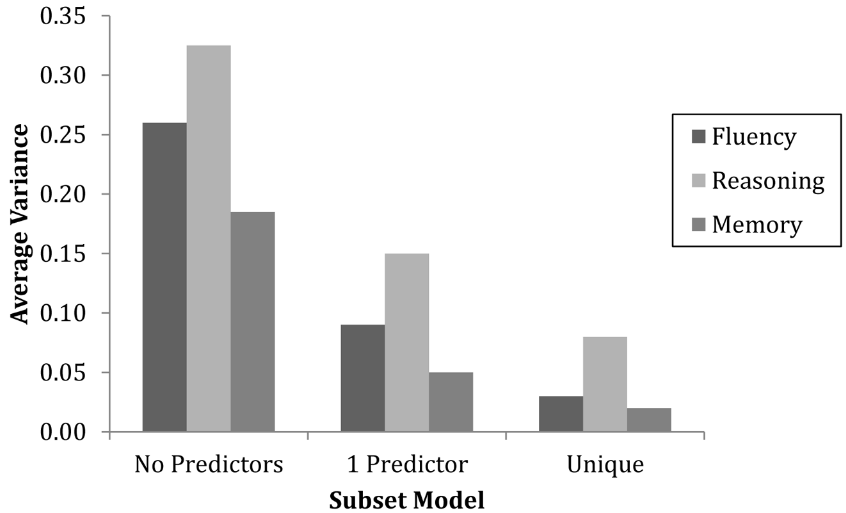

Figure 1.
Average Variance Accounted for in 3rd Grade Listening Comprehension by all Subset Models

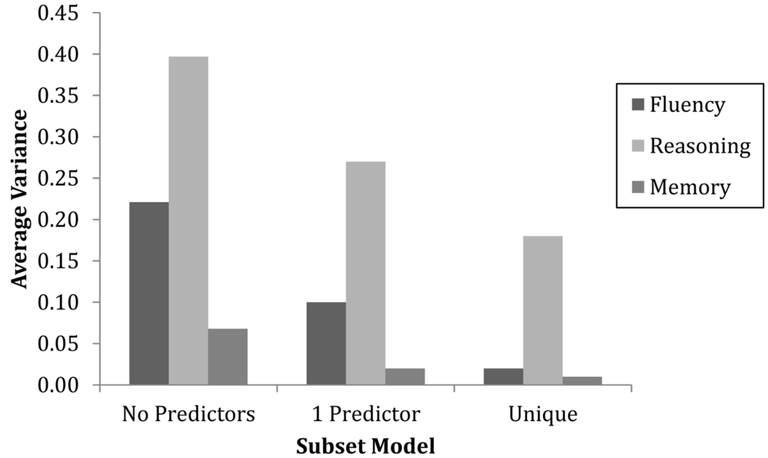

Figure 2.
Average Variance Accounted for in 7th Grade Listening Comprehension by all Subset Models

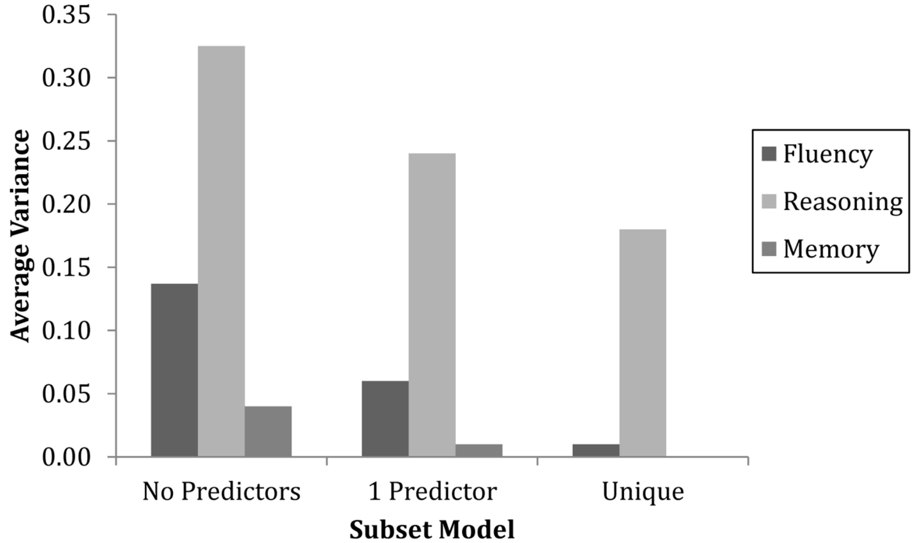

Figure 3.
Average Variance Accounted for in 10th Grade Listening Comprehension by all Subset Models

Table 1

Percentages of Participant Demographic Information by Grade Level

Demographic Characteristic	3rd Grade (*N* = 215)	7th Grade (*N* = 188)	10th Grade (*N* = 182)
Gender			
Male	43%	37%	49%
Race/Ethnicity			
Caucasian	39%	47%	37%
African American	42%	34%	36%
Hispanic	15%	13%	24%
Asian	1%	4%	2%
Other	3%	2%	1%
Free/Reduced Lunch			
Did Not Qualify	55%	60%	76%
Free Lunch	40%	34%	20%
Reduced Lunch	5%	6%	4%

Table 2

Means and Standard Deviations for all Measures by Grade Level

Measure	3rd Grade		7th Grade		10th Grade	
	N	**M(SD)**	**N**	**M(SD)**	**N**	**M(SD)**
Reading Comprehension						
GORT-4 Accuracy	213	9.77(3.23)	187	9.98(3.70)	178	9.42(3.34)
GORT-4 Fluency	213	9.88(3.67)	187	10.02(4.42)	178	8.88(4.46)
FCAT	207	310.59(62.63)	184	319.89(50.80)	180	307.63(43.28)
Reading Fluency						
TOWRE SWE	215	103.34(14.56)	188	102.05(11.87)	182	91.96(10.33)
TOWRE PDE	215	100.49(16.03)	188	100.60(14.81)	182	91.17(16.19)
ORF Textbook 1	215	103.85(46.84)	188	112.15(25.22)	182	121.79(27.97)
ORF Textbook 2	214	95.89(41.88)	188	129.07(33.81)	181	136.84(28.73)
ORF Textbook 3	214	68.16(34.24)	188	132.82(32.41)	182	149.17(32.13)
ORF FCAT 1	214	91.07(39.81)	188	129.01(30.40)	180	140.29(27.61)
ORF FCAT 2	214	93.91(39.62)	187	116.81(33.03)	181	161.06(36.46)
ORF FCAT 3	214	104.32(38.97)	187	126.11(31.57)	181	158.31(34.57)
ORF Aimsweb 1	215	99.46(41.77)	187	154.96(37.46)	181	164.04(34.60)
ORF Aimsweb 2	214	108.64(42.41)	187	152.03(34.71)	180	155.10(34.30)
ORF Aimsweb 3	214	106.55(41.44)	187	156.08(44.24)	180	153.40(36.62)
Working Memory						
Reading Span	214	19.22(8.05)	186	25.80(6.54)	182	24.87(7.16)
Listening Span	215	19.68(7.89)	187	25.18(7.19)	182	24.94(7.85)
Listening Comprehension						
Listening Passage 1	214	4.86(1.60)	187	3.71(1.21)	182	2.20(1.00)
Listening Passage 2	215	2.48(1.28)	187	3.37(1.46)	182	2.05(0.82)
Listening Passage 3	214	2.84(1.14)	186	4.23(1.45)	182	3.53(1.17)
Reasoning						
WASI Vocabulary	210	48.71(11.81)	184	48.53(9.25)	177	46.40(9.27)
WASI Similarities	210	53.28(11.15)	186	49.39(11.34)	182	47.34(9.60)
WASI Matrix Reasoning	210	52.05(10.87)	186	49.93(8.98)	182	47.03(8.97)

Measure	3rd Grade		7th Grade		10th Grade	
	N	M(SD)	N	M(SD)	N	M(SD)
WASI Block Design	213	49.81(10.62)	186	49.48(10.94)	182	47.43(10.35)

Note: GORT-4 = Gray Oral Reading Test-Fourth Edition. FCAT = Florida Comprehensive Assessment Test. TOWRE = Test of Word Reading Efficiency. SWE = Sight Word Efficiency. PDE = Phonemic Decoding Efficiency. ORF = Oral Reading Fluency. WASI = Wechsler Abbreviated Scale of Intelligence.

Table 3

Correlations Among Third Grade Measures

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Oral Reading Fluency	--	.57	.36	.48	.39	.25	.40	.76	.79	.84	.78	.86	.51
2. WASI Vocabulary	--	--	.38	.74	.39	.35	.39	.63	.52	.52	.54	.56	.62
3. WASI Block Design	--	--	--	.32	.56	.26	.28	.43	.39	.36	.42	.43	.34
4. WASI Similarities	--	--	--	--	.42	.27	.28	.56	.46	.47	.47	.49	.56
5. WASI Matrix Reasoning	--	--	--	--	--	.25	.35	.47	.38	.42	.37	.41	.44
6. Reading Span	--	--	--	--	--	--	.50	.30	.23	.19	.32	.29	.28
7. Listening Span	--	--	--	--	--	--	--	.40	.30	.34	.38	.41	.40
8. FCAT	--	--	--	--	--	--	--	--	.62	.64	.65	.69	.63
9. TOWRE PDE	--	--	--	--	--	--	--	--	--	.84	.78	.82	.32
10. TOWRE SWE	--	--	--	--	--	--	--	--	--	--	.79	.86	.41
11. GORT-4 Accuracy	--	--	--	--	--	--	--	--	--	--	--	.96	.41
12. GORT-4 Fluency	--	--	--	--	--	--	--	--	--	--	--	--	.44
13. Listening Comprehension	--	--	--	--	--	--	--	--	--	--	--	--	--

Note: N = 192. WASI = Wechsler Abbreviated Scale of Intelligence. FCAT = Florida Comprehensive Assessment Test. TOWRE = Test of Word Reading Efficiency. PDE = Phonemic Decoding Efficiency. SWE = Sight Word Efficiency. GORT-4 = Gray Oral Reading Test-Fourth Edition. All correlations are significant at $p < .01$.

Table 4

Correlations Among Seventh Grade Measures

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Oral Reading Fluency	--	.56	.35	.50	.34	.21	.19	.67	.78	.76	.75	.86	.48
2. WASI Vocabulary	--	--	.50	.73	.45	.14[a]	.28	.63	.43	.40	.59	.61	.57
3. WASI Block Design	--	--	--	.57	.57	.17	.26	.46	.26	.25	.45	.43	.49
4. WASI Similarities	--	--	--	--	.45	.09[a]	.22	.53	.44	.33	.56	.55	.53
5. WASI Matrix Reasoning	--	--	--	--	--	.26	.31	.41	.30	.31	.40	.39	.39
6. Reading Span	--	--	--	--	--	--	.46	.19	.22	.24	.25	.24	.25
7. Listening Span	--	--	--	--	--	--	--	.25	.20	.21	.21	.21	.32
8. FCAT	--	--	--	--	--	--	--	--	.47	.41	.61	.63	.65
9. TOWRE PDE	--	--	--	--	--	--	--	--	--	.79	.74	.78	.34
10. TOWRE SWE	--	--	--	--	--	--	--	--	--	--	.63	.71	.35
11. GORT-4 Accuracy	--	--	--	--	--	--	--	--	--	--	--	.95	.51
12. GORT-4 Fluency	--	--	--	--	--	--	--	--	--	--	--	--	.52
13. Listening Comprehension	--	--	--	--	--	--	--	--	--	--	--	--	--

Note: N = 174. WASI = Wechsler Abbreviated Scale of Intelligence. FCAT = Florida Comprehensive Assessment Test. TOWRE = Test of Word Reading Efficiency. PDE = Phonemic Decoding Efficiency. SWE = Sight Word Efficiency. GORT-4 = Gray Oral Reading Test-Fourth Edition. Correlations are significant at $p < .05$.

[a] correlations are not significant ($p > .05$).

Table 5

Correlations Among Tenth Grade Measures

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Oral Reading Fluency	--	.47	.31	.36	.34	.26	.24	.62	.76	.80	.76	.86	.43
2. WASI Vocabulary	--	--	.49	.60	.45	.21	.25	.64	.33	.40	.44	.45	.46
3. WASI Block Design	--	--	--	.45	.60	.27	.24	.51	.26	.26	.36	.35	.42
4. WASI Similarities	--	--	--	--	.43	.18	.19	.65	.25	.27	.40	.39	.42
5. WASI Matrix Reasoning	--	--	--	--	--	.24	.25	.51	.20	.25	.41	.39	.36
6. Reading Span	--	--	--	--	--	--	.43	.27	.19	.22	.21	.24	.26
7. Listening Span	--	--	--	--	--	--	--	.19	.19	.16	.26	.25	.15
8. FCAT	--	--	--	--	--	--	--	--	.41	.43	.56	.60	.51
9. TOWRE PDE	--	--	--	--	--	--	--	--	--	.80	.72	.77	.26
10. TOWRE SWE	--	--	--	--	--	--	--	--	--	--	.64	.73	.28
11. GORT-4 Accuracy	--	--	--	--	--	--	--	--	--	--	--	.95	.28
12. GORT-4 Fluency	--	--	--	--	--	--	--	--	--	--	--	--	.35
13. Listening Comprehension	--	--	--	--	--	--	--	--	--	--	--	--	--

Note: N = 172. WASI = Wechsler Abbreviated Scale of Intelligence. FCAT = Florida Comprehensive Assessment Test. TOWRE = Test of Word Reading Efficiency. PDE = Phonemic Decoding Efficiency. SWE = Sight Word Efficiency. GORT-4 = Gray Oral Reading Test-Fourth Edition. All correlations are significant at $p < .05$.

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Table 6

Third Grade Factor Loadings and Factor Intercorrelations

Measures	Fluency	Reasoning	Working Memory
Oral Reading Fluency	**.92**	.48	.38
WASI Vocabulary	**.69**	**.66**	.53
WASI Block Design	.40	**.82**	.29
WASI Similarities	**.60**	**.67**	.41
WASI Matrix Reasoning	.43	**.85**	.34
Reading Span	.24	.31	**.86**
Listening Span	.39	.35	**.84**
FCAT	**.79**	**.65**	.48
TOWRE PDE	**.90**	.49	.31
TOWRE SWE	**.91**	.48	.28
GORT-4 Accuracy	**.91**	.48	.39
GORT-4 Fluency	**.95**	.52	.40
Inter-correlations			
Fluency	1.00		
Reasoning	.57	1.00	
Working Memory	.43	.45	1.00

Note: N = 192. Bolded loadings indicate the measures comprising each factor. WASI = Wechsler Abbreviated Scale of Intelligence. FCAT = Florida Comprehensive Assessment Test. TOWRE = Test of Word Reading Efficiency. PDE = Phonemic Decoding Efficiency. SWE = Sight Word Efficiency. GORT-4 = Gray Oral Reading Test-Fourth Edition.

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Table 7

Seventh Grade Factor Loadings and Intercorrelations

Measures	Fluency	Reasoning	Working Memory
Oral Reading Fluency	**.93**	.58	.16
WASI Vocabulary	.57	**.82**	.15
WASI Block Design	.33	**.80**	.26
WASI Similarities	.52	**.85**	.10
WASI Matrix Reasoning	.32	**.72**	.40
Reading Span	.27	.20	**.86**
Listening Span	.23	.36	**.81**
FCAT	**.65**	**.73**	.13
TOWRE PDE	**.90**	.42	.19
TOWRE SWE	**.85**	.34	.27
GORT-4 Accuracy	**.88**	.64	.20
GORT-4 Fluency	**.94**	.63	.20
Inter-correlations			
Fluency	1.00		
Reasoning	.56	1.00	
Working Memory	.20	.24	1.00

Note: N = 174. Bolded loadings indicate the measures comprising each factor. WASI = Wechsler Abbreviated Scale of Intelligence. FCAT = Florida Comprehensive Assessment Test. TOWRE = Test of Word Reading Efficiency. PDE = Phonemic Decoding Efficiency. SWE = Sight Word Efficiency. GORT-4 = Gray Oral Reading Test-Fourth Edition.

Table 8

Tenth Grade Factor Loadings and Factor Intercorrelations

Measures	Fluency	Reasoning	Working Memory
Oral Reading Fluency	**.93**	.53	.26
WASI Vocabulary	.49	**.80**	.23
WASI Block Design	.33	**.75**	.36
WASI Similarities	.37	**.80**	.13
WASI Matrix Reasoning	.34	**.76**	.36
Reading Span	.24	.28	**.83**
Listening Span	.23	.27	**.83**
FCAT	.58	**.84**	.21
TOWRE PDE	**.90**	.37	.19
TOWRE SWE	**.88**	.39	.22
GORT-4 Accuracy	**.89**	.56	.27
GORT-4 Fluency	**.94**	.56	.27
Inter-correlations			
Fluency	1.00		
Reasoning	.53	1.00	
Working Memory	.25	.32	1.00

Note: N = 172. Bolded loadings indicate the measures comprising each factor. WASI = Wechsler Abbreviated Scale of Intelligence. FCAT = Florida Comprehensive Assessment Test. TOWRE = Test of Word Reading Efficiency. PDE = Phonemic Decoding Efficiency. SWE = Sight Word Efficiency. GORT-4 = Gray Oral Reading Test-Fourth Edition.

Table 9

R^2 Contributions Across Subset Models of Third Grade Predictors of Listening Comprehension

		Unique Contribution of Predictor		
Subset Model	***R^2***	**Fluency**	**Reasoning**	**Memory**
Models with 1 Predictor				
Fluency	.260	---	.12	.05
Reasoning	.325	.05	---	.04
Memory	.185	.13	.18	---
1 Predictor Average		**.09**	**.15**	**.05**
Models with 2 Predictors				
Fluency-Reasoning	.376	---	---	.02
Fluency-Memory	.315	---	.08	---
Reason-Memory	.363	.03	---	---
Unique Contribution		**.03**	**.08**	**.02**
Model with all 3 Predictors				
Fluency-Reasoning-Memory	.397	---	---	---

Note: N =192.

Table 10

All Dominance Levels for Pairwise Comparisons of Third Grade Predictors

I	J	Dij_mean	PIJ	PJI	Pijno
Complete					
Reason	Fluency	0.808	0.777	0.161	0.062
Reason	Memory	0.955*	0.923	0.014	0.063
Fluency	Memory	0.821	0.737	0.095	0.168
Conditional					
Reason	Fluency	0.808	0.777	0.161	0.062
Reason	Memory	0.955	0.923	0.014	0.063
Fluency	Memory	0.821	0.737	0.095	0.168
General					
Reason	Fluency	0.810	0.810	0.190	0.000
Reason	Memory	0.975	0.975	0.025	0.000
Fluency	Memory	0.864	0.864	0.136	0.000

Note: I and J = variables that are competing; Dij_mean = average number of times variable I dominated variable J over all bootstrap samples; PIJ = proportion of bootstrap samples in which I dominated J; PJI = proportion of bootstrap samples in which J dominated I; Pijno = proportion of bootstrap sample sin which no dominance was established.

* indicates the highest level of dominance achieved and implies all subsequent levels of dominance are also achieved.

Table 11

R^2 Contributions Across Subset Models of Seventh Grade Predictors of Listening Comprehension

		Unique Contribution of Predictor		
Subset Model	R^2	**Fluency**	**Reasoning**	**Memory**
Models with 1 Predictor				
Fluency	.221	---	.20	.03
Reasoning	.397	.02	---	.01
Memory	.068	.18	.34	---
1 Predictor Average		**.10**	**.27**	**.02**
Models with 2 Predictors				
Fluency-Reasoning	.417	---	---	.01
Fluency-Memory	.250	---	.18	---
Reason-Memory	.409	.02	---	---
Unique Contribution		**.02**	**.18**	**.01**
Model with all 3 Predictors				
Fluency-Reasoning-Memory	.427	---	---	---

Note: N =174.

Table 12

All Dominance Levels for Pairwise Comparisons of Seventh Grade Predictors

I	J	Dij_mean	PIJ	PJI	Pijno
Complete					
Reason	Fluency	0.999*	0.999	0.001	0.00
Reason	Memory	1.000*	1.000	0.000	0.00
Fluency	Memory	0.815	0.640	0.010	0.35
Conditional					
Reason	Fluency	0.999	0.999	0.001	0.00
Reason	Memory	1.000	1.000	0.000	0.00
Fluency	Memory	0.815	0.640	0.010	0.35
General					
Reason	Fluency	0.999	0.999	0.001	0.00
Reason	Memory	1.000	1.000	0.000	0.00
Fluency	Memory	0.976*	0.976	0.024	0.00

Note: I and J = variables that are competing; Dij_mean = average number of times variable I dominated variable J over all bootstrap samples; PIJ = proportion of bootstrap samples in which I dominated J; PJI = proportion of bootstrap samples in which J dominated I; Pijno = proportion of bootstrap sample sin which no dominance was established.

* indicates the highest level of dominance achieved and implies all subsequent levels of dominance are also achieved.

Table 13

R^2 Contributions Across Subset Models of Tenth Grade Predictors of Listening Comprehension

		Unique Contribution of Predictor		
Subset Model	R^2	**Fluency**	**Reasoning**	**Memory**
Models with 1 Predictor				
Fluency	.137	---	.19	.01
Reasoning	.325	.01	---	.00
Memory	.040	.11	.29	---
1 Predictor Average		**.06**	**.24**	**.01**
Models with 2 Predictors				
Fluency-Reasoning	.331	---	---	.00
Fluency-Memory	.149	---	.18	---
Reason-Memory	.325	.01	---	---
Unique Contribution		**.01**	**.18**	**.00**
Model with all 3 Predictors				
Fluency-Reasoning-Memory	.331	---	---	---

Note: N =172.

Table 14

All Dominance Levels for Pairwise Comparisons of Tenth Grade Predictors

I	J	Dij_mean	PIJ	PJI	Pijno
Complete					
Reason	Fluency	0.999*	0.999	0.000	0.001
Reason	Memory	1.000*	1.000	0.000	0.000
Fluency	Memory	0.830	0.693	0.033	0.274
Conditional					
Reason	Fluency	0.999	0.999	0.000	0.001
Reason	Memory	1.000	1.000	0.000	0.000
Fluency	Memory	0.830	0.693	0.033	0.274
General					
Reason	Fluency	0.999	0.999	0.000	0.000
Reason	Memory	1.000	1.000	0.000	0.000
Fluency	Memory	0.954*	0.954	0.046	0.000

Note: I and J = variables that are competing; Dij_mean = average number of times variable I dominated variable J over all bootstrap samples; PIJ = proportion of bootstrap samples in which I dominated J; PJI = proportion of bootstrap samples in which J dominated I; Pijno = proportion of bootstrap samples in which no dominance was established.

* indicates the highest level of dominance achieved and implies all subsequent levels of dominance are also achieved.