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Examining the contributions of syntactic awareness and syntactic knowledge to reading comprehension

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Purpose: The purpose of this study was to examine the effect(s) of syntactic knowledge and syntactic awareness on adolescents' reading comprehension.
Method: One hundred and seventy-nine, 9th and 10th grade students' syntactic awareness, syntactic knowledge and reading comprehension skills were assessed. In addition, other known contributors to reading comprehension were assessed including word level reading, short-term memory and vocabulary knowledge skills.
Results: Path analysis was used to analyse the direct and indirect effects of syntactic awareness and syntactic knowledge on reading comprehension. Students' syntactic knowledge directly accounted for significant variance in reading comprehension. Syntactic awareness indirectly accounted for significant variance in reading comprehension through syntactic knowledge.
Conclusions: This study confirmed the significant effects of syntactic knowledge and syntactic awareness on reading comprehension among adolescent students. This is one of the very few studies to examine both knowledge and awareness of syntax simultaneously and to determine that syntactic knowledge mediates the contribution of syntactic awareness to adolescent students' reading comprehension.

Reading comprehension, an important academic, economic and social skill (RAND Reading Study Group, 2002), is the process of building mental representations of written language by deciphering the meaning of written text at the word, sentence and text levels (Perfetti, Landi, & Oakhill, 2005). Language skills, specifically syntax, contribute to reading comprehension abilities (e.g., Catts, Adolf, & Weismer, 2006; Catts, Fey, Tomblin, & Zhang, 2002; Catts & Hogan, 2003; Stothard & Hulme, 1992). Syntactic skills are driven by two related but different constructs: syntactic knowledge and syntactic awareness (Cain, 2007; Cain & Oakhill, 2007). Although some studies have found that syntactic

awareness does not contribute to early elementary-age students' reading comprehension (Bowey & Patel, 1988; Cain, 2007), it is possible that the contribution of syntactic awareness to reading comprehension depends on students' age or grade level. The relation between syntactic awareness and reading comprehension may change as students progress academically because the academic text being read draws more heavily on the linguistic system. Kintsch (1998) proposed the construction integration theory that states that reading comprehension is composed of the simultaneous interaction of word recognition skills and higher-level linguistic and conceptual knowledge.

Although word recognition skills are important to reading comprehension, the focus of the current study was to identify skills that support sentence and text comprehension. Within the construction integration theory, Kintsch (1998) identified levels of representation that are necessary to construct meaning from written language: structural knowledge (i.e., syntactic and semantic knowledge), propositional knowledge (i.e., constructing idea-units) and world knowledge (i.e., knowledge of specific content). Semantic knowledge, one component of structural knowledge, has been found to contribute to reading comprehension among elementary and adolescent students (e.g., Beck, Mckeown, & Kucan, 2002; Biemiller & Boote, 2006; Gough & Tunmer, 1986; Nation & Snowling, 1998; Ouellette, 2006). Far less research has been conducted on the contributions of syntactic knowledge or syntactic awareness to reading comprehension. Therefore, the purpose of this study was to examine how syntactic knowledge and syntactic awareness contribute to adolescent students' reading comprehension.

Contributions of syntax to reading comprehension

Syntax is one skill that supports structural knowledge. Syntax refers to the rule system that governs how words are combined into larger meaningful units, such as phrases, clauses and sentences (Catts & Kamhi, 1999). Syntactic knowledge is a student's ability to comprehend or produce different grammatical structures within the context of a sentence (Catts et al., 2006; Cutting& Scarborough, 2006). For example, a student would be required to listen to a sentence and identify a picture that represents that sentence or a student would be required to produce sentences during an oral language sample or written language sample. Syntactic awareness is a student's 'ability to manipulate and reflect on the grammatical structures of language' (Cain, 2007). For example, a student would be required to listen and/or read a series of words presented out of order and create a grammatical sentence using the words provided. Syntactic awareness is a related but a distinct construct from syntactic knowledge because syntactic awareness assesses students' metalinguistic awareness or ability to manipulate language as if it were an object (Roth, Speece, Cooper, & De La Paz, 1996; Zipke, Ehri, & Cairns, 2009). Bowey and Patel (1988) hypothesised that students' syntactic knowledge supports their syntactic awareness. Bowey and Patel (1988) reported a correlation of 0.73 and Cain (2007) reported a correlation of 0.24 and 0.35 between syntactic knowledge and syntactic awareness.

Syntactic knowledge and syntactic awareness have been found to relate and contribute to reading comprehension (Cutting & Scarborough, 2006; Demont & Gombert; 1996; Muter, Hulme, Snowling, & Stevenson, 2004; Shiotsu & Weir, 2007). Cutting and Scarborough (2006) found that syntactic knowledge uniquely contributed 1–3% of the variance in reading comprehension. Among early elementary-age students, Demont and Gombert (1996) and Muter et al. (2004) found that syntactic awareness predicted later reading

comprehension after controlling for other known literacy factors such as phonological awareness, word-level reading and receptive vocabulary. Muter et al. (2004) found that syntactic awareness was moderately correlated with word-level reading and reading comprehension; 0.56 and 0.61, respectively. Gaux and Gombert (1999) and Guo, Roehrig and Williams (2011) explored the contributions of syntactic awareness to reading comprehension among adolescent students and adults. Gaux and Gombert (1999) found that syntactic awareness significantly contributed 4–5% of the variance in reading comprehension over reasoning, memory and linguistic competency. Guo et al. (2011) found that syntactic awareness contributed significant variance to vocabulary and reading comprehension. Although there are few experimental studies suggesting a causal relation between syntax and reading comprehension (Layton, Robinson, & Lawson, 1998; Weaver, 1979), some researchers have suggested that syntactic knowledge aids reading comprehension because a student must comprehend different grammatical structures within and across sentences to comprehend the overall text (i.e., text integration; Nation & Snowling, 2000). It also has been suggested that syntactic awareness can aid students ability to detect and correct word recognition errors, which may enhance their comprehension monitoring abilities (e.g., Bowey, 2005; Cain, 2007; Oakhill, Cain, & Bryant, 2003; Nation & Snowling, 2000).

Researchers usually include either a measure of syntactic knowledge or syntactic awareness when examining reading comprehension (Catts et al., 2006; Cutting & Scarborough, 2006; Demont & Gombert, 1996; Gaux & Gombert, 1999; Nation & Snowling, 2000). Unfortunately, this method does not illuminate the more complex multivariate relations between these constructs and their effect on reading comprehension. Only two studies have investigated both syntactic knowledge and syntactic awareness in one model of reading comprehension; these were conducted with elementary-age students (Cain, 2007; Bowey & Patel, 1988).

Bowey and Patel (1988) examined how 60 first grade students' language awareness (i.e., syntactic awareness and phonemic awareness) and language knowledge (i.e., syntactic knowledge and vocabulary knowledge) were related to their word-level reading and reading comprehension abilities. Syntactic awareness was measured with two tasks: error imitation and error correction tasks. For the error imitation task, students were required to imitate orally presented sentences that contained a grammatical error. For the error correction tasks, students were required to correct sentences that contained a grammatical error. Additionally, syntactic knowledge was measured with the sentence imitation subtest from the Test of Oral Language Development-Primary (Newcomer & Hammill, 1982). Reading comprehension was significantly correlated with syntactic knowledge ($r = 0.54$) and syntactic awareness ($r = 0.40$). Hierarchical multiple regression analysis revealed that a composite variable of phonemic awareness and syntactic awareness did not contribute to reading comprehension after controlling for receptive vocabulary and syntactic knowledge. Contrastively, when phonemic and syntactic awareness were controlled, receptive vocabulary and syntactic knowledge abilities contributed 12.48% of the variance to reading comprehension. Bowey and Patel (1988) concluded that syntactic awareness and syntactic knowledge are not independent of each other because when analysed in separate regression analyses, both contributed a substantial amount of variance to reading comprehension (i.e., 29.3% and 17.4%, respectively). These results suggest that syntactic awareness and syntactic knowledge are related constructs, and for younger students, syntactic knowledge is a significant predictor of reading comprehension. Bowey and Patel (1988) went on to explain that syntactic awareness, a metalinguistic skill, does not develop apart from syntactic knowledge, a language knowledge skill and that students with more advanced syntactic knowledge may also develop more advanced syntactic awareness.

Cain (2007) examined 196, 7- to 10-year-old children's word-level reading, reading comprehension, memory, vocabulary, syntactic knowledge and syntactic awareness skills. Syntactic knowledge was measured with the Test of Reception of Grammar (TROG; Bishop, 2003). This task required students to match orally presented sentence stimuli varied in grammatical complexity with pictures that best depicted the sentences (four choices). Syntactic awareness was measured by two tasks: (a) a grammatical correction task, which required students to correct an orally-presented sentence that contained errors on subject-verb agreement and (b) a word-order correction task, which required students to rearrange words to create a grammatically correct sentence. In a hierarchical regression analysis, neither the grammatical correction task nor the word order correction task contributed additional variance after controlling for vocabulary, grammatical knowledge and memory, similar to Bowey and Patel (1988). Cain did not analyse whether syntactic knowledge contributed additional variance after controlling for syntactic awareness.

Overall, we draw two relevant conclusions from Bowey and Patel (1988) and Cain (2007) results. First, syntactic knowledge plays a significant role in reading comprehension in elementary students whether measurement taps expressive or receptive skills. Second, syntactic awareness does not contribute to elementary students' reading comprehension. However, it remains unknown whether the same conclusions can be generalised to adolescent students. Reading passages appropriate for early elementary students include less complex vocabulary and syntax than reading passages for adolescent students. Adolescent students encounter more complex syntactic constructions in the expository text presented in core academic courses, which requires higher levels of metalinguistic skill to monitor their comprehension (Scott, 2009). It is hypothesised that syntactic knowledge and syntactic awareness have a different impact on reading comprehension depending on the age of students and the differing demands of the written text.

Therefore, the purpose of this study was to examine the effects of syntactic knowledge and syntactic awareness on adolescents' reading comprehension. Also, included in the analysis of reading comprehension were word-level reading, vocabulary knowledge and short-term memory, which are other abilities known to contribute to reading comprehension (Beck et al., 2002; Catts, et al., 2005; Hoover & Gough, 1990). Specifically, the following questions were addressed:

1. What is the direct effect of adolescent students' syntactic knowledge and syntactic awareness on reading comprehension above other known contributing factors?
2. What is the indirect effect of adolescent students' syntactic awareness on reading comprehension through syntactic knowledge above other known contributing factors?
3. What is the indirect effect of adolescent students' syntactic knowledge on reading comprehension through syntactic awareness above other known contributing factors?
4. What is the total effect of adolescent students' syntactic awareness and syntactic knowledge on reading comprehension above other known contributing factors?

Method

Participants

Participants were 193 9th and 10th grade students who attended a high school located in a southeastern state. Of the 193, 14 students were excluded from the data set and analysis because they were receiving special services, resulting in 179 students. Parental consent

and student assent were obtained for each participating student as approved by the local institutional review board. The sample included 51.1% women, and the sample mean age was 15 years 7 months (1 year 3 months). Ethnicity information, gathered from students' school records, revealed: 52.2% Caucasian, 33.3% African American, 5.6% Hispanic, 2.2% Asian and 6.7% other. The school-wide (i.e., elementary through secondary) percentage of students on free and reduced lunch was 20.6%. All students spoke English as their primary language. According to teacher report, none of the students were classified as having a learning disability or speech/language disorder.

Measures

A battery of assessments was administered to measure reading comprehension and known contributors to reading comprehension. Additionally, syntactic awareness and syntactic knowledge were assessed.

Reading comprehension

Reading comprehension was measured with the subtest from the Gates-MacGinitie Reading Test, fourth Ed. (MacGinitie, MacGinitie, Maria, & Dreyer, 2000), a group-administered measure. Students read passages and answered multiple-choice questions related to each passage. Some questions required the students to recall information stated in the text, whereas other questions required that students make inferences from the text. The comprehension test included 11 narrative and expository passages and 48 questions, and participants were allowed 35 minutes to complete the test. Students read the questions from a test booklet and marked their response on an answer sheet. Raw scores were used in the analysis. Test-retest reliability for the reading comprehension subtest was reported by the test authors' manual at 0.87 for 9th grade and 0.81 for 10th grade.

Predictor variables

Syntactic word-order task. Syntactic awareness was measured using a group administered, criterion-referenced syntactic word-order correction task. The structure of this task has been used previously to assess syntactic awareness (e.g., Cain, 2007; Cain & Oakhill, 2007; Demont & Gombert, 1996; Gaux & Gombert, 1999). Most researchers use an oral only presentation structure that relies heavily on students' working memory (Cain, 2007; Gaux & Gombert, 1999). To decrease working memory demands, the syntactic word-order task was structured so that students had the items in writing via an easel booklet in addition to having the items presented orally via a prerecorded CD.

In a previous study, the items on the syntactic word-order correction task were analysed using item response theory analysis. Of the original 20 items, 12 items displayed difficulty parameters within the range of −3 and 3 and discrimination parameters between 0 and 3 (Brimo, Apel, & Petscher, in review). The 12 items that were retained ranged in difficulty from −3.37 (Item 15) to 1.88 (Item 6) with a mean of −.27 and a median of 0.18 (25th, 50th and 75th quartiles were −1.44, 0.18 and 0.81). Discrimination parameters ranged from 0.34 (Item 13) to 1.16 (Item 8) with a mean of 0.65 and a median of 0.58 (25th, 50th and 75th quartiles were 0.48, 0.58 and 0.84). Even though the difficulty parameter for item 15 was not in the selected range, it was retained because the discrimination parameter was

in the selected range (i.e., 0.51). Item 15 also was retained because it was constructed to include a prepositional phrase, which is a phrase frequently used by late-elementary students to expand their sentence complexity (Nippold, 1998; Scott, 2004).

During administration of the word-order correction task, students completed two practice items and were given the correct answers. After presentation of two examples, students were presented the 12 test items. For each item, students were presented with a series of words that were out of order. They were required to rearrange the words and write a grammatically correct sentence on their answer sheet. Students were given 90 seconds to complete each item. Items were scored as correct (1) and incorrect (0). The raw score represented the total number of correct items. See Appendix A for examples.

Syntactic knowledge. Syntactic knowledge was measured by the listening comprehension subtest from the Group Reading Assessment Diagnostic Evaluation (GRADE; Williams, 2001). This was group-administered and measured students' ability to comprehend complex sentences. Students listened to 16 orally presented sentences and chose one of four pictures that best corresponded to the sentence presented. According to the examiner's manual, the sentences on the subtest were created to assess oral language comprehension; therefore, the inclusion of technical or advanced vocabulary and proper names were excluded. The internal reliability coefficient reported in the examiner's manual was 0.74. Items were scored as correct (1) and incorrect (0). The raw score represented the total number of correct items. See Appendix B for examples.

The syntactic knowledge and syntactic awareness tasks were composed of complex sentences with one independent clause and at least one dependent clause, noun phrase or verb phrase (Nippold, 1998). Complex constructions were used because older students expand their sentence complexity by including phrases and clauses into their oral and written language (Nippold, 1998; Scott, 1988; 2004). The complexity of the tasks may provide different results than previous research where simple syntactic constructions were used.

Control variables. Vocabulary knowledge, word-level reading skills and short-term memory have been shown to contribute to reading comprehension (Beck et al., 2002; Catts, Hogan, & Adolf, 2005; Cutting & Scarborough, 2006; Gathercole & Baddeley, 1993; Hoover & Gough, 1990; Muter et al., 2004). Thus, these areas were assessed to isolate the specific effects of syntactic awareness and syntactic knowledge on reading comprehension. Vocabulary knowledge was assessed with the vocabulary subtest of the GMRT. Reliability for this task was reported by the authors' manual at 0.92 for 9th grade and 0.88 for 10th grade. Word-level reading was assessed using the sight word efficiency subtest of the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, & Rashotte, 1999), which assessed students' ability to read as many words as possible in 45 seconds. Test-retest reliability for the TOWRE was reported by the authors' manual at 0.88 for adolescent students. Lastly, short-term memory was assessed with the nonword repetition subtest of the Comprehensive Test of Phonological Processing (Wagner et al., 1999). The nonword repetition subtest assessed students' ability to repeat nonsense words. Test-retest reliability was reported by the authors' manual at 0.83.

Procedure

Undergraduate and graduate students were trained to administer and score each measure. They were given a tutorial on each measure and their execution of the measures was

assessed. Examiners had to pass the training to begin data collection. The same procedure was implemented for data scoring. For norm-referenced assessments, examiners were trained based on the author's manual. For the researcher-created syntactic awareness task, examiners used scoring sheets created from Brimo et al. (in review). During data collection, participating students were administered all but the word-level reading and short-term memory tasks over three 50-minute group-testing sessions during their English course. The word-level reading and short-term memory measures were administered individually during the students' elective periods.

Methodology

Students' data were entered into the statistical programme PASW 18 (SPSS Inc., Chicago, IL, USA) to examine the data descriptively. A path analysis model was fitted to the data with Mplus Version 6 (Muthén & Muthén, 2010), using maximum likelihood estimation, to investigate the direct and indirect effects of syntactic awareness and syntactic knowledge on reading comprehension. A path analysis model was selected for data analysis because the results provide estimates of the magnitude and significance of the hypothesised relation between constructs simultaneously, and direct and indirect effects can be estimated in the model. Additionally, a model of adolescent reading comprehension including syntactic knowledge and syntactic awareness has not been evaluated. Therefore, a path analysis model was created to understand the relations between these variables before creating a multiple-indicator approach to construct latent variables (i.e., unobserved variables created by multiple observed variables).

When creating path models, assumptions must be met. Primarily, the inclusion of constructs in the model and specification of directionality of presumed causal effects must be addressed (Tate, 1992). The predictor variables in the current study were measured concurrently; therefore, the inclusion and directionality of vocabulary, short-term memory, word-level reading, syntactic knowledge and syntactic awareness were based on theory and previous literature (i.e., construction integration theory; Beck et al., 2002; Catts et al., 2005; Cutting & Scarborough, 2006; Hoover & Gough, 1990; Kintsch, 1998; Muter et al., 2004). Additionally, the assessments selected to measure the constructs were deemed to have good psychometric characteristics (e.g., discrimination and difficulty values and reliability coefficients). Lastly, identification of the path analysis models was met by including less observed variables than estimates (i.e., the degrees of freedom is greater than 0). The path models in the current study were composed of five observed variables and 21 estimates, which met the identification criteria.

After assumptions were met, two path models were created to examine the direct effects of vocabulary, short-term memory, word-level reading, syntactic awareness and syntactic knowledge on reading comprehension. Two path analysis models were created to analyse the indirect effects of syntactic knowledge and syntactic awareness because no previous research was available to hypothesise whether syntactic awareness or syntactic knowledge served as the mediating variable. Neither Cain (2007) nor Bowey and Patel (1988) analysed mediating effects in their regression analyses. Therefore, Model 1 utilised syntactic knowledge as the mediating variable, and Model 2 utilised syntactic awareness as the mediating variable. Indirect effects for Model 1 were estimated by creating a direct effect from syntactic awareness to syntactic knowledge and a direct effect from syntactic knowledge to reading comprehension. For Model 2,

indirect effects were estimated by creating a direct effect from syntactic knowledge to syntactic awareness and a direct effect from syntactic awareness to reading comprehension.

Inter-rater reliability

To obtain an inter-rater reliability score, 25% of the students' measures were rescored by the primary investigator. Any discrepancy between scores was changed by discussing the difference with the primary scorer, secondary scorer and a third person (i.e., second author). The reliability measure, prior to changing any discrepancy scores, was calculated by dividing the number of agreements by the number of disagreements and multiplying by 100. Inter-rater reliability for all assessments ranged from 93% to 99%.

Results

Descriptive statistics

Descriptive statistics for all variables are presented in Table 1. Prior to analysing the data using path analysis modelling, preliminary analyses revealed that the data were normally distributed based on the skewness and kurtosis values for each variable and linear function of the criterion variables and the predictor variables based on a plot diagram of the unstandardized residuals against each predictor variable. Bivariate scatterplots with residuals plotted against predictor variables also ruled out homoscedasticity.

T tests were computed to analyse grade level and gender differences for all predictor and control variables. Bonferroni correction was used to adjust the alpha level to .01 to correct for possible Type 1 errors. No gender differences were found among vocabulary, working-memory, syntactic awareness, syntactic knowledge or word-level reading. Grade level differences were found for vocabulary, $t(176) = 2.79$, $p = .006$, on which 9th grade scored higher than 10th grade. Grade level differences were not the primary focus of this study; however, to ensure that grade level differences did not affect the results, separate regression analyses were computed for 9th and 10th grade with reading comprehension as the dependent variable and vocabulary, word-level reading, short-term memory, syntactic knowledge and syntactic awareness as predictor variables. For both grades, the overall model fit was significant ($9\text{th} = F(5,\ 179) = 17.160,\ p < .001$; $10\text{th} = F(5,179) = 17.983$,

Table 1. Descriptive statistics.

Variables (total items)	Mean	*SD*	Skewness	Kurtosis
Nonword repetition (18)	11.30	3.12	−0.547	0.162
Word-level reading (104)	89.69	9.38	−0.830	2.660
Vocabulary (40)	30.61	7.25	−0.217	−0.586
Syntactic knowledge (17)	12.42	1.99	−0.746	0.762
Syntactic awareness (12)	5.91	2.21	0.049	−0.109
Reading comprehension (48)	32.16	9.61	−0.475	−0.715

Note: Means represent average of raw scores; *SD*, standard deviation.

$p < .001$). Although differences were found, they were judged not to affect the purpose of the study. Inter-correlations are reported in Table 2. Performance on the syntactic knowledge task was moderately correlated with vocabulary, syntactic awareness and reading comprehension (i.e., 0.32, 0.41 and 0.40, respectively). Performance on the syntactic awareness task also was moderately correlated with vocabulary and reading comprehension (i.e., 0.42 and 0.44, respectively).

Path analysis model

The first step to analysing path analysis models is the evaluation of model fit indices to determine which model best fit the data and thus reflect how adolescent students' syntactic awareness and syntactic knowledge contribute to reading comprehension (Yuan, 2005). Crowley and Fan (1997) suggest that it is best practice to report several measures of fit. These included goodness-of-fit index (chi-squared; ratio of chi-square to degrees of freedom), the comparative fit index (CFI; >0.90), Tucker-Lewis index (TLI; >0.90), root mean square error of approximation (RMSEA; <0.08) and standardised root mean residual (SRMR; <0.09). However, because the sample size was less than 250, the CFI and SRMR were used predominately to analyse and explain model fit (Hu & Bentler, 1999).

The SRMR and CFI indices indicated that Model 1 had the better fit to the data where syntactic knowledge served as the mediating variable. Akaike information criterion (AIC; Akaike, 1987) was used to compare Model 1 and Model 2, which were considered nonhierarchical models (Kline, 2005). The AIC value for Model 1 was lower when compared with Model 2, which suggested that Model 1 was a better fit to the data over Model 2. Thus, Model 1 was used to explore specific path coefficients and Model 2 was not pursued further. See Table 3 for fit indices.

The second step to analysing path modelling was to evaluate the significance of direct and indirect paths in Model 1. The direct path estimate is the direct effect of a predictor variable on a criterion variable. The indirect path estimate, or mediating effect, is the indirect effect of a predictor variable through another predictor variable on a criterion variable. Detailed direct and indirect estimates for the Model 1 are described in the next two sections.

Table 2. Summary of inter-correlations.

Measure	1	2	3	4	5	6
1. Nonword repetition	1	0.05	0.14	0.11	0.17*	0.11
2. Word-level reading		1	0.27**	0.15*	0.35**	0.24**
3. Vocabulary			1	0.32**	0.42**	0.67**
4. Syntactic knowledge				1	0.41**	0.40**
5. Syntactic awareness					1	0.44**
6. Reading comprehension						1

Note: **$p < .01$. *$p < .05$.

Table 3. Model fit indices for standard error of the mean models.

Model	χ^2	*df*	χ^2/df	CFI	TLI	RMSEA	SRMR	AIC
Model 1	5.497	3($p = .14$)	1.83	0.984	0.953	0.068	0.033	1937.48
Model 2	20.216	3($p < .001$)	6.74	0.900	0.701	0.179	0.070	1981.76

Note: χ^2, chi-square; *df*, degrees of freedom; CFI, comparative fit index; TLI, Tucker-Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean residual; AIC, Akaike information criterion.

Direct effects of syntactic awareness and syntactic knowledge on reading comprehension

To determine the direct effects of syntactic awareness and syntactic knowledge, standardised paths estimates were analysed. Final standardised estimates for Model 1 are displayed in Figure 1. The path from syntactic knowledge to reading comprehension was significant and the standardised estimate was 0.15. The standardised path estimate is interpreted like beta weight; so for every one standard deviation increase in syntactic knowledge, a 0.15 increase in reading comprehension is expected, holding vocabulary, word level reading, and short-term memory constant. Syntactic awareness did not contribute significant, direct variance to reading comprehension.

Indirect and total effects of syntactic awareness through syntactic knowledge on reading comprehension

In addition to analysing the direct effects of syntactic awareness and syntactic knowledge on reading comprehension, indirect and total effects were analysed. The indirect path from syntactic awareness through syntactic knowledge on reading comprehension was significant.

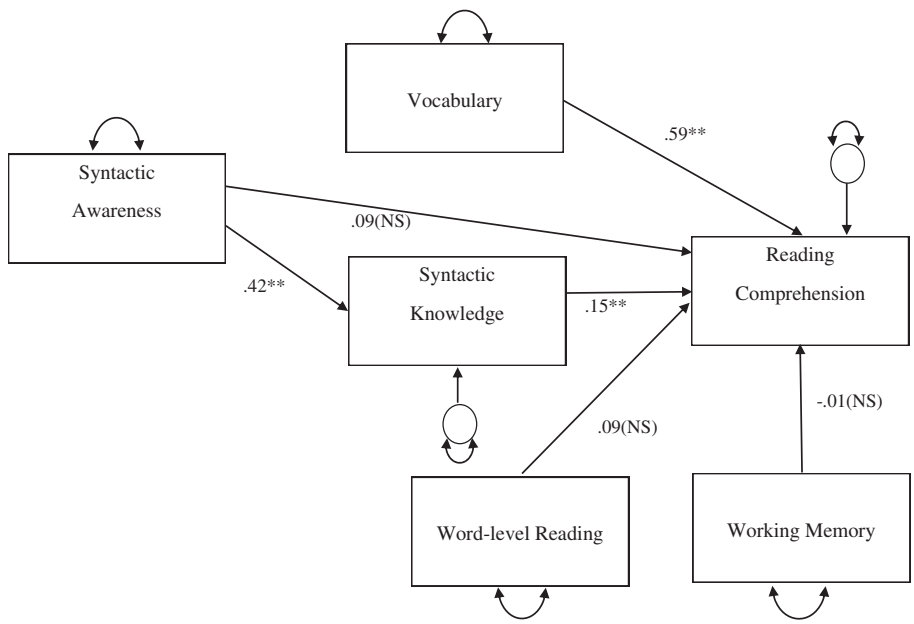

Figure 1. Path analysis model 1 examining the direct and indirect effects of syntactic awareness and syntactic knowledge to reading comprehension.**$p < .01$. NS, nonsignificant.

The indirect effect estimate is calculated by multiplying the direct effect of syntactic awareness on syntactic knowledge (i.e., 0.42) and the direct effect of syntactic knowledge on reading comprehension (i.e., 0.15). The indirect effect estimate of syntactic awareness on reading comprehension was 0.064. The total effect estimate is calculated by summing the direct and indirect effects of syntactic awareness. The total effect estimate for syntactic awareness could not be calculated because syntactic awareness did not significantly contribute any variance directly to reading comprehension. This suggests that syntactic awareness contributes significant variance to reading comprehension through syntactic knowledge.

Discussion

The purpose of this study was to examine the effects of syntactic knowledge and syntactic awareness on adolescents' reading comprehension. Syntactic awareness and syntactic knowledge were examined simultaneously to determine the indirect effects of each on reading comprehension. Adolescent students' syntactic knowledge and syntactic awareness contributed significant variance to reading comprehension, and syntactic knowledge served as the mediating variable between syntactic awareness and reading comprehension.

Direct effects of syntactic knowledge on reading comprehension

When investigating the effects of syntactic knowledge and syntactic awareness among adolescent students, syntactic knowledge, not syntactic awareness, directly contributed significant variance to reading comprehension. Catts et al. (2006) found that students with poor reading comprehension and poor decoding scored significantly lower than typical readers on a syntactic knowledge measure. Cutting and Scarborough (2006) found that 9–15% of the variance in reading comprehension was uniquely accounted for by vocabulary and syntactic knowledge. Alone, syntactic knowledge uniquely contributed 1–3% of the variance in reading comprehension. However, Catts et al. (2006) did not analyse the contributions of syntactic knowledge to reading comprehension; instead, they analysed the difference between syntactic knowledge among good and poor comprehenders. Cutting and Scarborough (2006) did examine the unique contribution of vocabulary and syntactic knowledge separately to reading comprehension but their results were not specified by age or grade. The reported mean grade of the students was 4.4, but no other information was provided for the number of adolescent students included in the sample. The current study has confirmed that with syntactic awareness, word-level reading, and vocabulary accounted for, syntactic knowledge contributed significant variance to adolescent students' reading comprehension. Interestingly, regardless of how syntactic knowledge was measured across studies, it remained a significant contributor to reading comprehension. For example, Catts and his colleagues (2006) utilised a task that required students to listen and follow oral directions and Cutting and Scarborough (2006) utilised several tasks that required students to formulate sentences, recall sentences, comprehend sentences by answering questions related to the sentences. The current study utilised a task where students have to listen to a sentence and choose one of four pictures that best represented the sentence.

The majority of research has focused on identifying factors that contribute to reading comprehension as opposed to explaining how factors function in the process of reading comprehension. Tunmer and Hoover (1993) described this type of research as attempting to model reading rather than describing the reading process. Very few researchers have described how

syntactic knowledge contributes to reading comprehension but have confirmed that it relates and contributes significant variance to successful reading comprehension. It has been suggested, though, that syntactic knowledge, a language comprehension measure, is needed to understand the linguistic information presented in written text (Catts, et al., 2006). It may be that students who can comprehend syntactic structures, such as the relative pronouns who or that in a relative clause, can parse the meaning of the sentence and thus develop more meaning of the overall text. More research is needed to determine whether students with higher syntactic knowledge skills perform differently on reading comprehension or sentence-level comprehension tasks than students with lower syntactic knowledge.

Another important consideration presented initially by Cutting and Scarborough (2006) was to analyse syntactic knowledge separately from other language skills such as vocabulary. Many researchers investigating reading comprehension analyse language skills as a combined factor and do not isolate specific language skills much like Cain (2007) and Bowey and Patel (1988) who entered syntactic knowledge simultaneously with vocabulary knowledge and working memory in their regression analyses. This type of analysis makes it difficult to identify which components of language should or can be intervened (Oakhill et al., 2003). Cutting and Scarborough (2006) also suggested that by analysing language skills separately, researchers can determine the specific magnitude of the effect of each language skill. Overall, from the current results and previous research, we can confirm that syntactic knowledge (i.e., the ability to comprehend sentences or recall sentences) contributes significantly to reading comprehension across a wide age range.

Direct effects of syntactic awareness on reading comprehension

Very few studies have analysed both syntactic knowledge and syntactic awareness simultaneously in one model of reading comprehension. The current study expands on the work of Cain (2007) and Bowey and Patel (1988) by examining these two abilities in adolescent students. Cain (2007) found that even among the younger and older elementary-age students in her sample, differences among the relations between syntactic knowledge and syntactic awareness were evident, and after controlling for syntactic knowledge and other skills, syntactic awareness did not directly contribute to reading comprehension. Because Cain found differences among the small age range in her sample, it was important to determine whether similar or different results would hold true for older students. Our results revealed that syntactic awareness did not directly contribute to reading comprehension among adolescent students.

These are very interesting findings given the moderate correlation found between syntactic awareness and reading comprehension (i.e., 0.44) and the significant contribution of syntactic awareness to reading comprehension found in other studies (e.g., Gaux & Gombert, 1999; Demont & Gombert, 1996). Cain (2007) suggested that there is an indirect relation between syntactic awareness and reading comprehension and syntactic awareness may not directly relate to reading comprehension because of the shared variance between syntactic knowledge and vocabulary. Bowey and Patel (1988) found that 29.9% of the variance in reading comprehension was jointly explained by syntactic awareness (i.e., metalinguistic awareness) and syntactic knowledge (i.e., general language ability), but syntactic awareness did not uniquely contribute to reading comprehension. The current findings from this study support what Cain (2007) and Bowey (1986a, 1986b) concluded. When syntactic knowledge and syntactic awareness are examined simultaneously, syntactic knowledge is a

significant predictor of reading comprehension. In our study, syntactic awareness and syntactic knowledge were moderately correlated, supporting Bowey's (1986a, 1986b) 'general language ability account' hypothesis stating that syntactic awareness does not develop apart from syntactic knowledge.

Another possible explanation for the nonsignificant direct effect of syntactic awareness on reading comprehension relates to the students' syntactic awareness skills. Students in the current study displayed a higher mean on the syntactic knowledge task (i.e., 12.42) when compared with the mean on the syntactic awareness task (i.e., 5.91). Students' lower syntactic awareness skills could have affected the direct relation of their syntactic awareness to reading comprehension. Future research studies should investigate whether syntactic awareness directly or indirectly contributes to reading comprehension among groups of students with low and high syntactic awareness skills.

Indirect effect of syntactic awareness through syntactic knowledge on reading comprehension

To further investigate the contribution of syntactic awareness to reading comprehension, we analysed the indirect effect of syntactic awareness through syntactic knowledge and found that syntactic awareness made a significant, indirect effect on reading comprehension. This is the only study to date to examine the indirect effects of syntactic awareness on adolescent reading comprehension. The results confirm that syntactic awareness and syntactic knowledge do share a considerable amount of variance and that students' explicit awareness of their syntactic knowledge contributed to the comprehension of written text. Gaux and Gombert (1999) suggested that students who exhibit better syntactic awareness may comprehend grammatical constructions more efficiently while reading, which then assists with comprehension. The syntactic awareness task used in our study required students to rearrange words to create a complex sentence. During this process, students had to find words to create the main clause and then determine how the rest of the words related to the main clause to create the dependent clause or vice versa. Students who can efficiently reorder words to create a complex sentence may better comprehend or parse the meaning of a complex sentence to integrate information across sentences and create meaning of the overall text. Bowey and Patel (1988) indicated that although metalinguistic awareness, specifically syntactic awareness, does not contribute unique variance to reading comprehension, it should not be interpreted that metalinguistic awareness does not impact reading comprehension. For example, a large body of research has confirmed that training phonemic and morphological awareness, metalinguistic skills, lead to improvements in word-level reading and reading comprehension (Cunningham, 1990; Bowers, Kirby, & Deacon, 2010; Goodwin & Ahn, 2010).

Very few studies have examined whether training of syntactic awareness leads to improvement of reading comprehension. Weaver (1979) found that an explicit sentence organisation intervention improved third grade students' reading comprehension when compared with a control group. Weaver suggested that reading comprehension instruction should include skills beyond decoding and vocabulary such as explicitly instructing syntactic awareness. Contrary to Weaver (1979), however, Layton et al. (1998) found that syntactic awareness intervention did not improve reading comprehension; their treatment, though, did improve students' syntactic awareness. Students in this study received six 30-minute lessons that may not have been enough treatment to have an effect on reading comprehension, which can be considered a distal measure.

Additional findings

In our study, we examined the contributions of syntactic awareness and syntactic knowledge along with vocabulary knowledge, word-level reading and short-term memory. In addition to the direct effect of syntactic knowledge and indirect effect of syntactic awareness, vocabulary knowledge was the only other significant predictor of adolescent reading comprehension. Vocabulary knowledge has been a leading contributing construct in reading comprehension among elementary and adolescent students (e.g., Beck et al., 2002; Biemiller & Boote, 2006; Gough & Tunmer, 1986; Nation & Snowling, 1998; Ouellette, 2006). Word-level reading has been found to contribute to reading comprehension in previous research (Cutting & Scarborough, 2006; Muter et al., 2004); therefore, it may be the small sample size that contributed to the nonsignificant effect in the current study. Additionally, vocabulary was assessed in whole groups, and students were asked to read the words and select another word that had a similar meaning. This type of vocabulary assessment may have assessed students' ability to read the words in addition to assessing vocabulary knowledge. Thus, the vocabulary task used may have subsumed the variance of the word-level reading task. Lastly, the results support previous researchers who found that word-level reading and language comprehension impact reading comprehension differently across the age-span (Catts et al., 2005; Demont & Gombert, 1996). Like these studies, language comprehension ability (i.e., vocabulary and syntactic knowledge) predicted adolescent students' reading comprehension over word-level reading ability. Short-term memory also did not play a significant role in adolescent reading comprehension. Previous research has found that short-term memory accounts for a small percentage of variance in reading (Swanson, Trainin, Necoechea, & Hammill, 2003). Again, this finding might have been due to the small sample size or the use of a short-term memory task instead of a working memory task (i.e., nonword repetition versus a digit or word span task used in the other studies).

Limitations

This study had several limitations. First, a larger sample size would likely have led to other significant path coefficients. In the future, researchers may include a larger sample size to determine those possible effects. Second, the syntactic knowledge task used in this study may have been affected by the students' vocabulary knowledge. The listening comprehension subtest from the GRADE (Williams, 2001) contained items that assessed vocabulary over comprehension of grammatical structures. Researchers may wish to analyse various tasks to measure syntactic knowledge to determine whether different tasks affect the outcome (e.g., TROG; Bishop, 2003).

Further, this model of reading comprehension does not address all factors that impact reading comprehension. To further evaluate reading comprehension, researchers should include measures of discourse-level listening comprehension, inference generation and text structure identification. It remains unknown whether syntactic awareness and syntactic knowledge would contribute to a discourse-level measure; although, discourse listening-comprehension is a contributing factor to reading comprehension (Kershaw & Schatschneider, 2012). Lastly, this study's findings are limited to 9th and 10th grade students. To obtain a more comprehensive understanding of the effect of syntactic awareness and syntactic knowledge on reading comprehension among adolescent students, researchers could assess students in other middle and high school grades.

Summary and implications

Our study was the first to investigate the direct and indirect contributions of syntactic knowledge and syntactic awareness to adolescent students' reading comprehension. We found that syntactic knowledge made a significant direct contribution to reading comprehension, solely, while syntactic awareness indirectly contributed to adolescent students' reading comprehension through their syntactic knowledge skills. These results support Cain's (2007) and Bowey and Patel's (1988) suggestions that syntactic awareness and syntactic knowledge share variance and both skills are important for early elementary readers and, now, adolescent readers. Overall, researchers and practitioners should consider measuring both awareness and knowledge of syntax when examining reading comprehension. Further, because syntactic awareness and syntactic knowledge are related constructs and syntactic knowledge made a significant direct effect on reading comprehension, practitioners may consider providing instruction on syntactic awareness to increase students' syntactic knowledge and thus improve their reading comprehension. Many intervention studies have confirmed that training other metalinguistic skills such as phonemic and morphological awareness improve word-level reading and reading comprehension. However, intervention research is needed to determine whether syntactic awareness instruction may lead to increased syntactic knowledge and thus better text integration skills (Bowey & Patel, 1988).

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Appendix A. 'Syntactic awareness example items'

Example item	Correct answers	Syntactic construction
In compartment the was microphone placed the repaired glove	The repaired microphone was placed in the glove compartment. **OR** The microphone was placed in the repaired glove compartment.	Prepositional phrase
As the presentation is soon refreshments will be over served as	Refreshments will be served as soon as the presentation is over. **OR** Will refreshments be served as soon as the presentation is over? **OR** As soon as the presentation is over, refreshments will be served.	Adverbial clause
Children perfectly watching while the we were behaved them	The children behaved perfectly while we were watching them. **OR** While we were watching them, the children behaved perfectly. **OR** While the children behaved perfectly, we were watching them.	Adverbial clause

Appendix B. 'Syntactic knowledge example items'

Example item	Correct answer	Syntactic construction
Already late for his interview, Derrick was frustrated when he had to stop for a train.	The picture that represents the correct answer is a man in a car stopped in front of a moving train. Other pictures depict a man at an interview, a man getting on a train, and a man looking at a toy train.	Adjective clause
After moving furniture all day, Janine insisted that her friends move the television out of the kitchen before she would order pizza.	The picture that represents the correct answer is a woman on the phone while her friends are moving a TV. Other pictures depict a woman sitting at a table eating pizza while her friends move the TV, a picture of a woman on the phone while her friends look at a TV, and a picture of a woman and her friends eating pizza with a TV on the table.	Adverbial clause

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