Who Did What to Whom? The Relationship Between Syntactic Aspects of Sentence Comprehension and Text Comprehension

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ABSTRACT

This study investigated the relationship between syntactic comprehension at the sentence level and text-level comprehension. The study isolated the specific contribution of syntax by asking whether sentence comprehension efficiency of difficult syntactic constructions explained variance in text comprehension after controlling for sentence comprehension efficiency of basic constructions with similar semantic complexity. Seventy-three Grade 5 students completed assessments of text comprehension; basic and difficult written sentence comprehension efficiency; and control measures of decoding fluency, vocabulary, and verbal memory. Efficiency measures were used to assess individual differences in basic sentence comprehension with accuracy near ceiling. Difficult sentence comprehension efficiency explained 6% unique variance in text comprehension after controlling for basic sentence comprehension efficiency and other controls. Thus, the results show that individual differences in the ability to establish sentence meaning from syntactic information are related to text comprehension.

Introduction

The simple view of reading provides a general theory of reading and states that text comprehension is the product of word decoding and language comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). Language comprehension can be subdivided into lower level and higher level language factors (e.g., Perfetti, Landi, & Oakhill, 2005). Lower level factors such as vocabulary, morphology, and syntax allow the reader to activate word meanings and connect them into propositions. Higher level factors such as inferencing, comprehension monitoring, and sensitivity to story structure help integrate information across sentences and paragraphs into a coherent situation model (Kintsch, 1998; Perfetti et al., 2005). The importance of decoding, some lower level factors (vocabulary and morphology), and some higher level factors (inferencing) has been established (e.g., Deacon, Kieffer, & Laroche, 2014; Kendeou, van den Broek, White, & Lynch, 2009; National Reading Panel, 2000; Oakhill & Cain, 2012; Silva & Cain, 2015; Tong, Deacon, Kirby, Cain, & Parrila, 2011). But few studies have focused specifically on the possible importance of individual differences in using syntactic information to establish literal propositional meaning.

Syntactic information is crucial because it guides the integration of word meanings into propositional meanings on which the situation model of the text is based. In the sentence *John teased Bob*, the syntax conveys that *John* is the actor; in English, the subject (marked by the preverbal position) of active constructions conveys the agent role for verbs like *tease*. Thus, syntax explicitly conveys information about how the word meanings should be integrated into a proposition so that the reader does not have to infer who did what to whom. There is good evidence that readers also use higher level skills to make suitable inferences to successfully understand texts (e.g., Oakhill & Cain, 2012;

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Silva & Cain, 2015). But the present study investigated the importance for text comprehension of individual differences in deriving literal meaning accurately and fast from sentence syntax. Failure to use the syntactic information could lead to misunderstanding of the sentence meaning. Even slow processing of syntactic information could limit integration of propositional information across sentences. In this way, syntactic knowledge has the potential to be a very important source of individual differences in language comprehension skills.

Even though syntactic knowledge is crucial for understanding sentences and text, it does not follow that lack of syntactic knowledge is a problem in practice. It is possible that most children master relevant syntactic knowledge by the time they start in school, or at least when they are able to decode words with sufficient accuracy for text comprehension. However, there is evidence that syntax is a problem for at least some children, including some children with specific language impairment (Bishop & Snowling, 2004; Leonard, 2014). Furthermore, there is evidence that performance on sentence-level tasks is related to text comprehension (Adlof & Catts, 2015; Adlof, Catts, & Lee, 2010; Brimo, Apel, & Fountain, 2015; Catts, Adlof, & Weismer, 2006; Ecalle, Bouchafa, Potocki, & Magnan, 2011; Muter, Hulme, Snowling, & Stevenson, 2004; Nation & Snowling, 2000; Potocki, Ecalle, & Magnan, 2013; Silva & Cain, 2015). For example, Catts et al. (2006) found that students who were categorized as poor comprehenders in Grade 8 performed poorly on tests of complex sentence comprehension in kindergarten, Grade 2, and Grade 4. Adlof et al. (2010) showed that tests of sentence imitation and completion were unique longitudinal predictors of students' text comprehension difficulties. In another study, Grade 9 and 10 students' oral sentence comprehension performance explained variance in text comprehension after controlling for vocabulary and reading fluency (Brimo et al., 2015). However, other studies have failed to find unique contributions from sentence comprehension to text comprehension (Florit, Roch, & Levorato, 2013; Oakhill & Cain, 2012). For example, Oakhill and Cain (2012) found that despite significant cross-sectional correlations, sentence comprehension was not a unique predictor of text comprehension after controlling for other measures. But the number of other measures was sizable, so it is not clear what mediated the relationship.

Aspects of grammatical knowledge

Sentence comprehension tasks typically use stimuli that could measure a broad range of grammatical skills, from comprehension of simple to complex syntax, inflectional morphology, and knowledge of grammatical words such as connectors and prepositions. This is suitable for measuring general language skill level. But it makes it difficult to specifically assess syntactic knowledge and thus possible correlations between individual differences in syntactic knowledge and text comprehension.

For example, some studies use the Test for Reception of Grammar (TROG; Bishop, 2003) to assess grammatical knowledge (Cain, 2007; Oakhill & Cain, 2012; Silva & Cain, 2015). The test items test morphological, syntactic, and possibly semantic knowledge and processing. Some items assess knowledge of prepositions, others logical words (e.g., *neither … nor*), syntactic constructions (e.g., passive or relative clauses construction), and yet other items plural morphology. Although the TROG is clearly sensitive to grammatical knowledge broadly, one study found that a school-age group of children with specific language impairment performed more poorly on a syntactic awareness task than a younger control group matched on, among other things, the TROG (van der Lely, Jones, & Marshall, 2011). This suggests that the TROG may not fully capture syntactic difficulties in school-age children. Other studies have used sentence comprehension tasks with sentences of high complexity to avoid floor and ceiling effects (Brimo et al., 2015; Ecalle et al., 2011). For example, Brimo et al. (2015) used sentences such as *After moving furniture all day, Janine insisted that her friends move the television out of the kitchen before she would order pizza.* The task was to match the sentence with one of four pictures. Comprehension accuracy on such stimuli could be sensitive to a number of factors beyond syntactic knowledge, including the ability to build, maintain, or compare complex mental models. Thus, such tasks are difficult to interpret for the purpose of evaluating the specific role of syntactic knowledge in text comprehension.

Some studies have investigated grammatical awareness instead of or in addition to grammatical knowledge. Grammatical knowledge concerns the ability to produce and comprehend grammatical features, for example, when using syntax to comprehend sentence meanings. Grammatical awareness concerns the ability to reflect on grammar, for example, when correcting word order or morphological deviations. Syntactic awareness has been shown to correlate with text comprehension (Brimo et al., 2015; Cain, 2007; Muter et al., 2004; Nation & Snowling, 2000; Potocki et al., 2013; Tong, Deacon, & Cain, 2014). But the correlation could be due to differences in metalinguistic sentence comprehension or memory issues, as syntactic awareness has failed to explain variance in text comprehension when memory and grammatical knowledge have been taken into account (Brimo et al., 2015; Cain, 2007).

In summary, there is evidence that sentence-level tasks are correlated with text comprehension, but few studies have attempted to isolate the role of syntactic comprehension. One exception is Nation and Snowling (2000), who found that poor comprehenders had particular difficulties with passive constructions compared to active constructions. This is direct evidence that syntactic skills are specifically related to poor comprehension. The present study in a similar vein examined the difference between basic and more difficult syntactic constructions to isolate the role of syntax in text comprehension in a cross-sectional study without oversampling poor comprehenders.

Basic and difficult syntax

Some syntactic structures have been shown to cause difficulty for both children and adults, notably constructions with noncanonical ordering of agents and patients, such as passive constructions, object relative constructions, and constructions with object–verb–subject ordering in languages where this ordering is acceptable, albeit infrequent (Dabrowska & Street, 2006; Ferreira, 2003; Kristensen, Engberg-Pedersen, & Poulsen, 2014; Thomsen & Poulsen, 2015). For example, Ferreira (2003) found that college students were less precise and slower when interpreting passive sentences compared to active sentences (81% vs. 99% accuracy), as in *The girl was kicked by the boy* versus *The boy kicked the girl*.

Some types of relative clauses have also been shown to cause difficulties for both children and adults (Booth, MacWhinney, & Harasaki, 2000; MacWhinney & Pléh, 1988; Wells, Christiansen, Race, Acheson, & MacDonald, 2009). For example, object extracting relative clauses (henceforth object relatives) take longer to process than subject extracting relative clauses (henceforth subject relatives). In the relatively easy subject relatives, the relative clause modifies a noun that acts as the subject of the relative clause, as in *Emma saw the cat that kissed the pig*, where *the cat* is the subject of the relative clause. In the more difficult object relative clauses, on the other hand, the modified noun acts as the object of the relative clause, as in *Emma saw the cat that the pig kissed*, where *the cat* is the object of the relative clause.

It has also been found that sentences comprehension is difficult when centrally embedded relative clauses separate the subject and the verb, as in *The boy who sees the girl chases the policeman*. The reason may be that the relative clause *who sees the girl* interrupts the subject–verb relationship between the subject *the boy* and the verb phrase *chases the policeman* (Booth et al., 2000; MacWhinney & Pléh, 1988; Slobin, 1973).

In summary, some syntactic structures pose difficulties both in terms of accuracy and reaction time, even into adulthood. It is possible that the ability to deal with these difficult sentence structures is a limiting factor in text comprehension. Previous studies have demonstrated correlations between sentence and text comprehension, but most of these studies have assessed sentence comprehension by means of materials that challenge morphology, syntactic knowledge, and semantic processing. Thus it is has not been possible to isolate the effect to knowledge of syntactic structure.

The present study

The aim of the present study was to investigate how sentence comprehension is related to text comprehension in Grade 5, where decoding is less of a limiting factor for text comprehension compared to beginning grades (cf. Florit & Cain, 2011; Tilstra, McMaster, Van den Broek, Kendeou, & Rapp, 2009). At this grade level, students are expected to read with the purpose of acquiring academic knowledge (e.g., Danish Ministry of Education, 2014). Academic language may contain syntactic constructions that are infrequent in everyday language, including passive and embedded relative constructions (Fang, 2006; Snow & Uccelli, 2009). Therefore, it is worth investigating whether individual differences in the ability to comprehend difficult structures are related to the comprehension of academic texts.

Specifically, the study was designed to isolate the effects of syntactic knowledge by investigating whether the comprehension of difficult syntactic constructions explained variance in reading beyond the comprehension of basic syntactic constructions. The rationale was that comprehension of basic sentences would provide a strict control for the possibility that effects of the difficult sentence comprehension measure could be due to nonsyntactic task-related factors, such as inattention, memory, semantic processing, or decoding skills. To this end we designed an experimental measure of sentence comprehension with matched basic and difficult items, for example, matched active and passive constructions. In anticipation of ceiling effects on sentence comprehension accuracy measures, the task measured response latency in addition to accuracy. Accuracy and speed were combined into efficiency measures. The assumption was that even though students are able to comprehend sentence structures correctly, they may have more or less difficulty in doing so.

In addition, the study included control measures of memory, vocabulary, and decoding.

Method

Participants

Eighty Grade 5 students from five classrooms in two different public schools in Copenhagen, Denmark, participated in this study. The schools are located in well-functioning urban neighbourhoods with mixed socioeconomic backgrounds. Six students reported not speaking Danish at home. This percentage (7.5%) indicates lower school proportions of immigrants or children of immigrants compared to the national average of 11% in public schools in the year of the study (2012) and a much lower percentage than the Copenhagen average of 27% (Danish Ministry of Education, 2016). Schools with low proportions of students with Danish as second language were selected on purpose to avoid a strong influence of second-language issues on the key variables of sentence comprehension. The students that did not speak Danish at home were left out of the analyses. The remaining 74 students (50% boys) had a mean age of 11 years 11 months (SD = 4.36 months). In Denmark, all children are typically included in general classrooms unless they have severe behavioural difficulties, and we did not select or exclude children based on special education needs.

The official curriculum guidelines for Danish in Grade 5–6 (or previous grade levels) do not mention syntax (Danish Ministry of Education, 2014). In contrast, other well-known aspects of text comprehension are mentioned: decoding, vocabulary, inferencing, and text structure. Morphology is mentioned, but only in relation to decoding, spelling, and vocabulary.

Danish is a relatively deep orthography (Elbro, 2005; Seymor, Aro, Erskine, & COST Action A8 network, 2003).

Materials and procedures

All of the following tests were administered individually, except for the text comprehension test, which was administered as a group test in the students' classrooms. Trained university students specializing in speech and language therapy administered all tests.

Vocabulary

Vocabulary was assessed with an expressive picture naming task (Gellert & Christensen, 2012; Gellert & Elbro, 2013). The students were asked to name 54 different pictures, one at a time. The target words represented a broad range of semantic fields but not specific academic fields. If the students did not produce an answer for a picture within 5 s, the test administrator would ask them to move on to the next picture. Cronbach's alpha was .74.

Decoding fluency

The students read two lists of 20 words and two lists of 20 nonwords (Elbro, 1990). The words were common, largely regular words of increasing difficulty from *ti* (ten) to *kedeligt* (boring). The items on the nonword lists matched the items on the word lists in length. Responses were recorded and scored later for accuracy and completion time. Decoding fluency was measured in correct words per minute. The correlation between word and nonword fluency was .92 (Spearman-Brown corrected). The two measures were z-score transformed and averaged into a decoding fluency composite.

Verbal memory

An adaption (Elbro, Borstrøm, & Petersen, 1998; Elbro & Petersen, 2004) of the forward and backward digit span tasks from Wechsler Intelligence Scale for Children–Revised (Wechsler, 1974) was used to measure verbal short-term and working memory. In the forward span task, the students had to repeat series of digits, increasing in length from two to nine digits. There were two items at each level of difficulty. Testing stopped if a student made two errors at a given level. The procedure for the backward span task was the same, except that the students had to repeat the digits in reverse order. The score for each task was the number of correct answers. The adapted format matches Wechsler Intelligence Scale for Children–IV (Wechsler, 2003), which reports split-half reliabilities between .79 and .85 in the relevant age groups. The two measures were z-score transformed and averaged into a verbal memory composite.

Text comprehension

LÆS5 (Nielsen, Møller, & Pøhler, 2000) was administered as a group test to measure the students' text comprehension. *LÆS5* is a standardized cloze-test designed for Grade 5. It consists of two separate subtests, both of which are expository texts on a particular subject (an archaeological finding and a Swedish railroad line). The first text is approximately 1.100 words long and contains 19 cloze items. The second is approximately 650 words long and contains 15 cloze items. In each item, a word was missing in the sentence. The students had to choose the most appropriate word out of four different possibilities. In most items, choosing the correct word required using information from outside the sentence from which the word was missing, for example, by using background knowledge or information from previous sentences in the text. The distractor words were of the same word class as the target word and did not violate grammatical restrictions of the sentence context (e.g., through agreement). Thus the items could not be solved by purely formal grammatical awareness. Interpretation of the sentence meaning was necessary. In the second text, five of the sentences containing the cloze items included passive constructions. All of these were nonreversible, that is, semantic information supported the correct interpretation, for example, "Everyone is impressed by the spectacular [environmental_protection, prize, animal_park, nature]," where the context established "nature" as the only plausible answer (all the choices are single words in Danish). The score was the number of correct cloze items. The students were given 20 and 13 min to complete the first and the second subtest, respectively. In each subtest, fewer than five students did not answer the last question. Thus the scores should mainly be interpreted to represent text comprehension accuracy rather than reading speed. The correlation between the two subtests was .85 (Spearman-Brown corrected).

Basic and difficult sentence comprehension

This experimental, computer-based task was designed to measure sentence comprehension accuracy and speed of comprehension of basic and difficult syntactic constructions. Every trial consisted of an introductory sentence, a target sentence, and a two-alternative forced choice comprehension question about the literal, syntactically coded meaning of the target sentence. The introductory sentences were used to establish a new scene and thus to clearly mark the transition from one target sentence to the next completely unrelated target sentence. The introductions did not include clues to the sentence meaning of the target sentence; for example, *Jonas and Simon are waiting for the bus* was presented as an introduction to the target sentence *Simon is kicked by Jonas*.

The target sentences and associated questions were constructed in pairs of basic and difficult items. We chose three difficult syntactic constructions on the basis that they have been shown to cause processing difficulty (cf. the introduction) and that they have corresponding basic constructions that can convey a similar state of affairs: active versus passive voice, premodified noun versus embedded relative clause, and subject versus object relative clause. Table 1 exemplifies target sentences and questions in an English translation. A full list of materials can be found in the Appendix.

Each sentence in a pair was constructed around the same verb (and the same adjective in the premodified noun/embedded relative clause conditions). The meanings of the target sentences in a pair were designed to have similar truth conditions to balance the semantic complexity of the basic and difficult conditions. There were no negations of any kind to keep semantic complexity low. To minimize influence from vocabulary and decoding skills, we chose common words, predominantly with regular orthography. The sentences were reversible in the sense that the sentence meaning could not be established from context or world knowledge.

These sentence construction principles allowed identical wording of the comprehension questions for both of the items in a pair (cf. Table 1). But the two response options differed between the basic and difficult items in a pair to match the target sentence.

There were five stimuli pairs for each of the three basic/difficult constructions, for a total of 30 items. After data collection, we found that two pairs contained errors. They were excluded from data analysis.

The test was administered on a laptop computer using E-Prime 2.0 experiment software (Schneider, Eschman, & Zuccolotto, 2002). The order of items alternated between basic and difficult sentences, and different constructions were distributed evenly across the list. In each trial, the introductory sentence appeared on the computer screen first. By pressing a key on the keyboard, the students replaced the introductory sentence with the target sentence. By pressing the key again, the sentence would be replaced by a comprehension question (*Who is kicking?*). The possible answers (e.g., *Simon* and *Jonas*) were displayed below the question. The students answered by pressing a key corresponding to their chosen answer. The left/right location of the correct answer was balanced between conditions. The computer recorded the response latency as the time in milliseconds from when the question was presented on the screen to when the student responded on the keyboard. For each student we computed separate efficiency scores of correct per second for the basic and the difficult conditions. These efficiency scores were computed by dividing the

Table 1. Approximate translations from Danish of example stimuli from the sentence comprehension task.

Basic Structures		Difficult Structures		
Syntactic Structure	Target Sentence	Syntactic Structure	Target Sentence	Question
Active voice	*John kicks Christian.*	Passive voice	*Simon is caught by Jonas.*	*Who is the kicker?*
Premodified noun	*The hat is on the red chair.*	Embedded relative clause	*The book, which the pencil is on, is red.*	*Which one is red?*
Subject relative clause	*Maja finds Victor, who chases Martin.*	Object relative clause	*Mads finds Ida, who Nanna chases.*	*Who is the chaser?*

proportion of correct answers with the mean response latencies on correct answers (cf. de Jong, 2011, for similar transformation). This transformation had several benefits. It reduced the number of separate predictor measures. It balanced differences in how the students approached the speed/accuracy trade-off to some degree, such that, for example, a fast-response strategy would be penalized if it led to incorrect responses. Finally, the transformation made the distributions of the basic and difficult sentences more comparable and normal, where especially the accuracy scores for the basic sentences were expected to have strong ceiling effects. Split-half reliability for efficiency was .77 and .79 for basic and difficult items (Spearman-Brown corrected).

Results

All analyses were conducted in SPSS version 23.

Data cleaning

Latencies from the sentence comprehension task were trimmed according to the following principles to prevent extreme values from influencing mean latencies from individual students unduly: Latencies from incorrect responses or responses shorter than 800 ms were deleted as invalid. Furthermore, latencies above or below 2.5 standard deviations of the mean for the student were replaced with the cutoff value. For computing these standard deviations, values above 12,000 ms were left out. On average, this affected 2.6% of the latencies in the basic condition and 1.6% of the latencies in the difficult condition. As mentioned in the Method section, the efficiency scores were computed as the proportion of correct answers divided by the mean latencies for each child for each condition (basic/difficult). Data trimming of individual item response latencies is widespread practice. But there are many ways to do so, and the way of doing it can influence the results (Ulrich & Miller, 1994). The central regression analyses presented next have also been conducted with nontrimmed latencies with no important differences in the results.

One univariate outlier (i.e., a student scoring more than 3.29 standard deviations from the mean) was identified on the text comprehension test. This student was excluded from the following analyses. No students were identified as multivariate outliers based on Mahalanobis distance with a significance level of .001 (Tabachnick & Fidell, 2007). Thus the following analyses were conducted on 73 students—36 girls and 37 boys with a mean age of 11;11 (SD = 4.38 months).

Descriptive statistics and intercorrelations

Table 2 presents descriptive statistics for the key variables in the study. There was a limited ceiling effect on the text comprehension measure, with 15% of the students scoring at ceiling. The two parts

Table 2. Descriptive statistics.

	M	SD	Range
Text comprehension accuracy (%)	85.86	12.50	47.06 – 100
Word decoding fluency (correct per min)	86.90	26.39	17.71 – 146.15
Nonword decoding fluency (correct per min)	53.50	18.46	8.61 – 99.19
Vocabulary (correct out of 54)	39.05	4.91	27 – 52
Forward digit-span (correct out of 16)	8.05	1.29	5 – 11
Backward digit-span (correct out of 16)	4.47	1.44	2 – 8
Basic sentence question accuracy (%)	93.78	7.66	69.23 – 100
Difficult sentence question accuracy (%)	85.99	12.71	53.85 – 100
Basic sentence question latency (ms)	2,254.72	535.84	1,298 – 3,703
Difficult sentence question latency (ms)	2,566.20	794.71	1,535 – 4,457
Basic sentence question efficiency (correct per s)	0.44	0.11	0.26 – 0.72
Difficult sentence question efficiency (correct per s)	0.37	0.13	0.14. – 0.65

of the text comprehension test have been normed separately (Nielsen et al., 2000). The present sample was 0.13 and 0.35 standard deviations above the means of the first and the second part of the test, respectively. For the purpose of the following analyses, the skewed distribution of the text comprehension scores was normalized through reflection, square-root transformation, and rereflection (Tabachnick & Fidell, 2007). The transformed scores had a skew of –0.22, with high scores indicating good performance, as on the original scale.

As expected, there was a strong ceiling effect on the accuracy of basic sentence comprehension, with 51% of the students at ceiling. There was also a ceiling effect on the difficult sentence comprehension questions, with 26% of the scores at ceiling. This was expected on the assumption that Grade 5 students with Danish as a first language would be able to understand fairly short sentences. There was no meaningful way of improving the distributional properties of the accuracy measures, but the derived sentence comprehension efficiency measures did not suffer from these distributional problems.

Differences between the basic and difficult sentence comprehension conditions were analysed to validate the syntax difficulty manipulation. Performance on the basic sentences was significantly more accurate and efficient than on the difficult sentences: A Wilcoxon's signed rank test showed that sentence comprehension accuracy was higher in the basic (94%) compared to the difficult condition (86%), $T = 222$, $p < .001$. The students were also more efficient in the basic conditions (26.30 correct per min) compared to the difficult condition (22.25 correct per min), $t(72) = 5.24$, $p < .001$, $d = 0.57$.

Table 3 presents the zero-order correlations between the central variables of interest. Age was not correlated significantly with any measure and was therefore left out of the table and further analyses. Basic sentence comprehension accuracy was not significantly correlated with text comprehension, possibly due to the limited variance in the measure. But difficult sentence comprehension accuracy was correlated with text comprehension despite the ceiling effect ($r = .47$, $p < .001$). Both basic ($r = .40$, $p < .001$) and difficult ($r = .47$, $p < .001$) sentence comprehension efficiency were significantly correlated with text comprehension. Thus the basic sentence comprehension measure benefitted from taking latency into account, whereas latency did not seem to add information relevant for text comprehension to the difficult sentence comprehension measure.

As is often seen, decoding fluency was also significantly correlated with text comprehension ($r = .25$, $p < .05$). Decoding fluency did not correlate significantly with either of the sentence comprehension accuracy measures. But basic sentence comprehension efficiency was significantly correlated with decoding fluency ($r = .31$, $p < .01$), indicating the necessity to control for decoding fluency in evaluating the contribution of sentence comprehension efficiency to text comprehension.

Vocabulary was also significantly correlated with text comprehension ($r = .38$, $p < .001$) and most of the sentence comprehension measures (rs between .16 and .32). Verbal memory was significantly correlated with the sentence comprehension accuracy measures ($r = .25$ and .37, $p < .05$ and .001) but not text comprehension or the sentence comprehension efficiency measures (rs < .17).

Table 3. Zero-order correlations.

	1	2	3	4	5	6	7	8	9
1. Reading comprehension accuracy	—								
2. Decoding fluency	.25*	—							
3. Vocabulary	.38**	.06	—						
4. Verbal memory	.08	.15	−.12	—					
5. Basic sentence accuracy	.10	.12	.16	.25*	—				
6. Difficult sentence accuracy	.47**	.12	.27*	.38**	.27*	—			
7. Basic sentence latency (inv. transf)	.37**	.29*	.20	.07	−.13	.25*	—		
8. Difficult sentence latency (inv. transf)	.36**	.18	.24*	.00	−.19	.31**	.63**	—	
9. Basic sentence efficiency	.40**	.31**	.26*	.17	.23	.34**	.93**	.55**	—
10. Difficult sentence efficiency	.47**	.19	.32**	.15	−.03	.63**	.60**	.93**	.58**

*$p < .05$. **$p < .01$.

Table 4. Hierarchical regressions with text comprehension as dependent variable.

Step	Variable	R^2	ΔR^2	Final β
1	Decoding fluency composite	.06	.06*	.14, ns
2	Vocabulary	.20	.13**	.25*
3	Basic sentence efficiency	.26	.06*	.12, ns
4	Difficult sentence efficiency	.32	.06*	.30*

Note. ns = not significant.
*$p < .05$. **$p < .01$.

Does sentence comprehension predict variance in text comprehension beyond decoding fluency and vocabulary?

Both decoding fluency and vocabulary measures were related to text comprehension and sentence comprehension. It is thus possible that the correlation between sentence comprehension and text comprehension simply reflects basic word-level decoding or vocabulary skills. This possibility was investigated with a fixed-order hierarchical regression analysis with text comprehension as the dependent variable. Decoding and vocabulary were entered in the first two steps as control variables. To save degrees of freedom, the verbal memory tasks were not entered as control variables because they were not correlated with text comprehension or sentence comprehension efficiency measures. Basic and difficult sentence comprehension efficiency were entered in the next two steps. Table 4 presents the results. Basic sentence comprehension efficiency explained 6% variance in text comprehension when entered in Step 3 after decoding fluency and vocabulary. Difficult sentence comprehension efficiency explained an additional 6% variance in text comprehension in Step 4. The total model explained 32% of the variance in text comprehension. The standardized residuals of the final model did not deviate from normality, $D(73) = .09$, $p > .20$. The standardized beta coefficient of basic sentence comprehension efficiency in the final model was not significant. Thus basic sentence comprehension efficiency on its own explained variance in text comprehension after taking decoding and vocabulary into account, but the difficult sentence comprehension condition could carry the entire effect of both sentence comprehension tasks.

The correlational analyses suggested that latency added little over accuracy to difficult sentence comprehension as a predictor of reading comprehension (cf. earlier). This was confirmed in follow-up analyses with difficult sentence comprehension latency (inverse transformed) and accuracy as separate predictors. Latency did not contribute significantly after controls (final β = .11, $p = .40$), whereas accuracy did (final β = .32, $p < .01$).

It could be argued that verbal memory should be included in the regression models despite nonsignificant p values because they were planned control variables in the study. Rerunning the analyses in Table 4 with additional control for a composite measure of the two memory tasks made no noticeable difference to the results. The correlation between the two subtasks turned out to be low ($r = .24$, $p < .05$). Therefore, a composite measure could be considered inappropriate. Using either control measure separately as control measures did not make noticeable impact either.

Discussion

The present study investigated whether difficulties with establishing literal meaning representations at the sentence level could explain individual differences in the ability to understand written texts. The main result was that even into Grade 5 there is a relationship between sentence comprehension efficiency and text comprehension. Furthermore, difficult sentence comprehension efficiency explained 6% unique variance beyond basic sentence comprehension efficiency and other control variables. Basic sentence comprehension was a strong control for the possibility that task-related factors, such as sentence reading efficiency, memory, attention, or semantic processing, carried the contribution of difficult sentence comprehension to text comprehension. The difficult sentences

differed from the basic sentences in syntactic structure, rather than semantic complexity. Thus, the results show that individual differences in the ability to derive propositional meaning from difficult syntactic structure are related to text comprehension. This result provides some support for the idea that difficulties with syntactic processing carry over to poor text comprehension, but different causal interpretations of the correlational results will be discussed next. Together, the sentence comprehension measures explained 12% variance in text comprehension beyond controls, but the difficult sentence measure alone could carry most of this effect.

Previous studies have found correlations between sentence-level and text-level comprehension in similar age groups (Brimo et al., 2015; Ecalle et al., 2011), but those studies primarily tested complex sentences and associated complex sentence meanings because older students typically are at ceiling in accuracy on basic sentence structures. Thus, it was not possible to isolate the effect of syntax. One exception is Nation and Snowling (2000), who found that poor comprehenders had particular difficulties with correcting word order in passive compared to active sentences. The present study extended this finding to an unselected group of Grade 5 students with Danish as their first language by showing that comprehension efficiency of difficult syntactic structures predicted variance in text comprehension beyond comprehension of basic syntactic structures. The basic sentence comprehension measure provided a strong control for the possibility that nonsyntactic aspects of the sentence comprehension task could explain the effect of the difficult sentence comprehension measure.

The fact that basic sentence comprehension efficiency explained variance in text comprehension suggests that even basic sentence comprehension presents a challenge for some students with poor text comprehension skills. This correlation should be interpreted with considerable caution, however. It is possible that the basic sentence comprehension task measured aspects of decoding fluency that were not measured by the control measure of oral list reading fluency. There are indications that oral and silent reading fluency are partially separable (van den Boer, van Bergen, & de Jong, 2014), and thus that there is decoding variance that was not picked up by our measure of oral decoding fluency, despite good reliability of the measure. On the other hand, sentence reading fluency could be different from word decoding because it is influenced by broader language comprehension abilities (Kim & Wagner, 2015), for example, syntactic comprehension. Further studies are needed to directly investigate whether the relationship between sentence reading fluency and text comprehension is mediated by syntactic comprehension.

The demographics and reading comprehension scores suggest that the sample should be interpreted to represent students from classrooms where socioeconomic or second-language factors are not academically limiting challenges. The benefit of the homogenous sample is that second-language factors are ruled out as a cause of the sentence comprehension effects. But the homogeneity may also have naturally limited the variation in the reading and language measures, which could explain why the total explained variance in text comprehension was somewhat low (31%–37%). The low correlation between reading fluency and text comprehension ($r = .25$) was noteworthy. It could be explained by the fact that, by far, the most students completed the text comprehension tests within the time frame, which probably limited the influence of reading speed on the text comprehension measure. Reading comprehension accuracy has been shown to be less dependent on decoding fluency than text comprehension rate (Rønberg & Petersen, 2015).

Limitations

The cross-sectional design of the present study cannot determine the direction of causality. It is therefore possible that poor sentence comprehension is a consequence, not a cause, of poor text comprehension. Knowledge of difficult syntactic constructions could, for example, be established in part through experience with successful text comprehension. Further studies are needed to establish causality. Furthermore, the validity of the claim that comprehension of difficult sentence structures are a specific challenge could be further investigated in studies that vary the syntactic difficulty of the

text comprehension task. Comprehension of difficult sentences should be more highly correlated with texts that contain many difficult syntactic structures.

We did not measure general reasoning ability, so we cannot rule out that general reasoning ability was involved in the sentence comprehension task. But the sentence comprehension test was constructed to be independent of general complex reasoning skills. All the questions simply required the students to determine the agent/patient roles or who possessed a certain characteristic. This information was conveyed only by the sentence structure and could not be extracted by general reasoning. However, an anonymous reviewer suggested that some students could have taken advantage of the self-paced format of presentation. This format was intended to reduce the influence of individual differences in decoding speed but could be used for rereading difficult sentences to improve question answering efficiency. Individual differences in the tendency to use such a strategy could be related to text comprehension through general problem solving rather than syntactic knowledge. Thus, future studies should reduce student control of the task.

There was some ceiling effect on the text comprehension measure. This may have depressed correlations with the independent variables. We see no strong reasons to believe that this influenced some predictors more than others.

The text comprehension test was a cloze-format task. The cloze-questions in the test appear to have been constructed to assess comprehension outside the sentence boundary, and such tests have been shown to correlate highly with tests that ask more global comprehension question (Gellert & Elbro, 2012). However, taken together with the ceiling effect it is important to replicate the present results with a wider range of text comprehension measures to determine the generality of the results across different levels of text comprehension.

Implications for practice and future directions

The main implication of the present results is that educators should be aware that students who have difficulties with comprehending texts may have difficulties with establishing literal, propositional meaning from syntax. Sentences with difficult syntactic structures can be expected to cause the biggest difficulties. However, the exact causal role of syntactic comprehension is unclear, and it is therefore not possible to make strong recommendations for intervention. Intervention studies are also needed to completely establish a direct causal role and to evaluate the utility of targeting sentence comprehension in intervention. Some grammar-focused interventions for children with specific language impairment have been promising (cf. Ebbels, 2013, for review). But it remains to be seen whether the effects of such interventions carry over to reading comprehension. Another outstanding question is whether sentence comprehension problems are limited to the difficult syntactic structures, or whether some students have general difficulties with establishing literal sentence meaning. The answer to this question could qualify decisions about whether to pursue instruction that focuses on difficult syntax, rather than intervention that targets sentence comprehension more broadly.

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Appendix

Table A1. A full list of target sentences and questions in Danish (italics) with approximate English translation in quotes.

Target Sentence		Question
Basic construction	Difficult construction	
Active voice	**Passive voice**	
Julie fanger Clara	*Sara bliver fanget af Kasper*	*Hvem fanger?*
('Julie catches Clara')	('Sara is caught by Kasper')	('Who is the catcher?')
Rasmus sparker Christian	*Simon bliver sparket af Jonas*	*Hvem sparker?*
('Rasmus kicks Christian')	('Simon is kicked by Jonas')	('Who is the kicker?')
Drengen skubber pigen	*Drengen bliver skubbet af pigen*	*Hvem skubber?*
('The boy pushes the girl')	('The boy is pushed by the girl')	('Who is the pusher?')
Daniel puffer Anja	*Jesper bliver puffet af Katrine*	*Hvem puffer?*
('Daniel shoves Anja')	('Jesper is shoved by Katrine')	('Who is the shover?')
Mikkel driller Anton	*Anne bliver drillet af Sofie*	*Hvem driller?*
('Mikkel teases Anton')	('Anne is teased by Sofie')	('Who is the teaser?')
Premodified noun	**Embedded relative clause**	
Hatten ligger på den røde stol	*Bogen, som blyanten ligger på, er rød*	*Hvilken en er rød?*
('The hat is on the red chair')	('The book, which the pencil is on, is red')	('Which one is red?')
Æsken er i den sorte spand	*Posen, som tasken er i, er sort*	*Hvilken en er sort?*
('The box is in the black bucket')	('The bag, which the briefcase is in, is black')	('Which one is black?')
Gaflerne er i de nye skabe	*Kasserne, som knivene ligger i, er nye*	*Hvilke er nye?*
('The forks are in the new cabinets')	('The boxes, which the knives are in, are new')	('Which ones are new?')
Subject relative	**Object relative**	
Lasse så katten, som kyssede hunden.	*Emma så katten, som grisen kyssede.*	*Hvem kyssede?*
('Lasse saw the cat, who kissed the dog')	('Emma saw the cat, who the pig kissed')	('Who was the kisser?')
Maria ser Lucas, som klapper Jeppe.	*Tobias ser Anna, som Line klapper.*	*Hvem klapper?*
('Maria sees Lucas, who pats Jeppe')	('Tobias sees Anna, who Line pats')	('Who is the patter?')
Pigen kender hesten, som slikker koen.	*Pigen kender hunden, som katten slikker.*	*Hvem slikker?*
('The girl knows the horse, who licks the cow')	('The girl knows the dog, who the cat licks')	('Who is the licker?')
Pigen elsker kaninen, som bider en gris.	*Frøen elsker pigen, som drengen bider.*	*Hvem bider?*
('The girl loves the rabbit, who bites a pig')	('The frog loves the girl, who the boy bites')	('Who is the biter?')
Maja finder Victor, som jagter Martin.	*Mads finder Ida, som Nanna jagter.*	*Hvem jagter?*
('Maja finds Victor, who chases Martin')	('Mads finds Ida, who Nanna chases')	('Who is the chaser?')

Note. Target sentences were constructed in pairs, but presented separately, each followed by the comprehension question.