UNIVERSITY OF COPENHAGEN

Remembering sentences is not all about memory: Convergent and discriminant validity of syntactic knowledge and its relationship with reading comprehension

Poulsen, Mads; Nielsen, Jessie Leigh; Christensen, Rikke Vang

Published in:
Journal of Child Language

DOI:
10.1017/S0305000921000210

Publication date:
2021

Document version
Peer reviewed version

Citation for published version (APA):
Poulsen, M., Nielsen, J. L., & Christensen, R. V. (2021). Remembering sentences is not all about memory: Convergent and discriminant validity of syntactic knowledge and its relationship with reading comprehension. *Journal of Child Language*. https://doi.org/10.1017/S0305000921000210

Download date: 13. jun.. 2021

Remembering Sentences is not all About Memory: Convergent and Discriminant Validity of Syntactic Knowledge and its Relationship With Reading Comprehension

Mads POULSEN, Jessie Leigh NIELSEN and Rikke VANG CHRISTENSEN
University of Copenhagen

Mads POULSEN, PhD, Department of Nordic Studies and Linguistics University of Copenhagen, Copenhagen, Denmark, m.poulsen@hum.ku.dk; Jessie Leigh NIELSEN, MA, Department of Nordic Studies and Linguistics University of Copenhagen, Copenhagen, Denmark, mgk690@hum.ku.dk; Rikke VANG CHRISTENSEN, PhD, Department of Nordic Studies and Linguistics University of Copenhagen, Copenhagen, Denmark, rikkec@hum.ku.dk

This version of the paper has been accepted for publication in Journal of Child Language: POULSEN, M., NIELSEN, J., & VANG CHRISTENSEN, R. (advance online). Remembering sentences is not all about memory: Convergent and discriminant validity of syntactic knowledge and its relationship with reading comprehension. *Journal of Child Language,* 1-17. doi:10.1017/S0305000921000210

Acknowledgements: This research was supported by grant 8091-00021B from the Independent Research fund Denmark. We are also indebted to the student assistants who helped with data collection, and the schools and students who participated in the study.

Correspondence concerning this article should be addressed to Mads POULSEN, Department of Nordic Studies and Linguistics, Mads Poulsen, Emil Holms Kanal 2, Copenhagen S. DK-2300, Denmark. E-mail: m.poulsen@hum.ku.

Abstract

Recent studies have found correlations between sentence-level tests and reading comprehension. However, the task demands of sentence-level tests are not well understood. The present study investigated syntactic knowledge as a construct by examining the convergent and discriminant validity of two sentence-level tasks, sentence comprehension and sentence repetition, designed to test syntactic knowledge and their relation with reading comprehension. Results from 86 Grade 6 students showed that the syntax tests were more highly correlated with each other than with tests of working memory and vocabulary. This suggests that the syntax measures tap into a set of skills that are at least partially separate from these other cognitive constructs. Furthermore, syntactic knowledge explained unique variance in reading comprehension beyond controls. The syntax tasks were working memory dependent, but working memory was not the primary reason why syntax tasks are correlated with reading comprehension.

Keywords: syntax, sentence comprehension, reading comprehension

Remembering Sentences is not all About Memory: Convergent and Discriminant Validity of Syntactic Knowledge and its Relationship With Reading Comprehension

To understand discourse or a written text the comprehender needs to – among other things – establish sentence meaning based on knowledge of syntactic cues such as word order and case marking. In a sentence such as *John sees her,* the preverbal position of *John* and the accusative personal pronoun *her* signal that John is doing the seeing. It is well established that it takes some years for children to acquire the syntactic cues in oral language (Ambridge & Lieven, 2015), but there has been less focus on possible individual differences in such syntactic knowledge once children progress beyond the first years of schooling. Yet, such individual differences may have relevance for children's possibilities for benefitting from school activities, both when engaging in spoken discourse, and perhaps especially when they are expected to learn from written texts of increasing complexity more or less on their own. Persons with developmental language disorder are known to struggle with acquiring and using syntactic knowledge at school entry (Owen & Leonard, 2006), into adolescence (Nippold, 2017), and in adulthood (Poll, Betz, & Miller, 2010). But it is less clear whether there are individual differences in syntactic knowledge of practical importance beyond what can be found in the minority of students with developmental language disorder. Our goal was to investigate syntactic knowledge as a construct in two ways: First, through demonstrating the convergent and divergent validity of two syntax measures compared to measures of other cognitive constructs. Second, by investigating the relationship between syntax and reading comprehension as an indication of the practical relevance of individual differences in syntactic knowledge construct in ordinary classrooms.

The Role of Syntactic Knowledge in Reading Comprehension

According to the influential Simple View of Reading, reading comprehension relies on two partially separable components: decoding and language comprehension (Gough & Tunmer, 1986; Hoover & Gough, 1990). Whereas decoding is narrowly defined as identifying words on the basis of letters, language comprehension is a broader cover term, which includes language components that are shared between reading and listening comprehension, such as vocabulary, morphology, and inferencing. Syntactic knowledge, like vocabulary and morphological knowledge, can be viewed as a lower order comprehension skill, which is used for establishing propositional meaning. Higher order skills integrate propositional meanings with background knowledge, for example through inferencing (Kintsch & Rawson, 2005; Perfetti, Landi, & Oakhill, 2005). From the perspective of linguistics, syntactic knowledge clearly plays a role in the comprehension process by signaling the propositional relationship between word meanings. But it is not clear whether individual differences in syntactic knowledge in practice constitute a separable or important bottleneck in children's reading comprehension. Beyond the first years of language acquisition, differences could be too small to have relevant impact on real world activities such as reading. (cf. Perfetti et al., 2005, pp. 237-238 for discussion).

Recent studies have found sizable correlations between sentence-level tasks and reading comprehension (Brimo, Apel, & Fountain, 2017; Deacon & Kieffer, 2018; Language and Reading Research Consortium & Logan, 2017; Poulsen & Gravgaard, 2016; Silva & Cain, 2015; Sorenson Duncan, Mimeau, Crowel, & Deacon, advance online publication). To the extent that sentence-level tasks measure syntactic knowledge, this suggests that the individual differences are sufficiently large to have practical importance. But sentence-level tasks are complex, and the relation with reading comprehension could be confounded with several sources of individual differences other than syntactic knowledge, for example morphological knowledge, vocabulary, working memory, and background knowledge and expectations. Indeed, LARRC and Logan (2017, pp. 460-461) suggested that their grammar latent variable, which was based on sentence-level tasks and word morphology, was a strong predictor of reading comprehension exactly because the indicator tasks drew on a wide range of language skills from the word to the text level. The present study was specifically concerned with isolating syntactic knowledge from other levels of language knowledge and working memory in the prediction of individual differences in reading comprehension.

Assessment of Syntactic Knowledge

Researchers have used different terms to cover various notions that children may differ in the ability to process sentence-level information. This article focuses on the concept *syntactic knowledge*, that is knowledge about how meaning relations are signaled by word order and some inflectional morphology (e.g. case and verb morphology) according to learned conventions of a particular language, including the use of this knowledge to comprehend and produce sentences (e.g. Brimo, Lund, & Sapp, 2018). Syntactic knowledge can be distinguished from syntactic awareness: the ability to reason about sentence structure, for example in word order correction tasks. Brimo and colleagues found indications in their meta-analysis that syntactic knowledge is a stronger correlate of reading comprehension difficulties than syntactic awareness. Furthermore, syntactic knowledge may be relevant in a broader range of communicative activities, where reflecting on the structure of language is rarely applied.

A number of different test formats have been used to measure syntactic knowledge, for example sentence repetition, multiple choice sentence-picture matching, sentence-animation verification, and multiple choice comprehension questions (e.g. Bishop, 2003; Brimo et al., 2017; Frizelle, Thompson, Duta, & Bishop, 2019; Poulsen & Gravgaard, 2016; Semel, Wiig, & Secord, 2006). One central difficulty with interpreting children's performance on these assessment tools is that performance may rely on other factors than syntactic knowledge. Frizelle and colleagues (Frizelle, O'Neill, & Bishop, 2017; Frizelle et al., 2019) recently pointed out the heavy processing load in sentence-picture matching tests such as the TROG where the child needs to decide which of four different pictures represents the correct mapping of the syntactic structure of a sentence.

Another frequently used method is sentence repetition, where children are asked to repeat back sentences of varying difficulty (e.g. Semel et al., 2006). It is well established that the task is solved by comprehension into a meaning structure followed by regeneration of the sentence from this structure (Kidd, Brandt, Lieven, & Tomasello, 2007; Lombardi & Potter, 1992; Polišenská, Chiat, & Roy, 2015; Nick G. Riches, 2012; N. G. Riches, Loucas, Baird, Charman, & Simonoff, 2010). However, it is still not clear to what extent sentence repetition is *also* dependent on more general memory resources. LARRC and Logan (2017) reported that sentence repetition loaded equally high on grammar and memory latent variables, suggesting that there is a sizeable memory component to sentence repetition.

To separate general task demands from syntactic demands, Poulsen and Gravgaard (2016) developed a self-paced sentence comprehension task that required the participants to read sentences and answer two-choice comprehension questions addressing literal information encoded by the syntactic structures in the stimuli. The materials consisted of semantically matched basic and difficult syntactic constructions, for example active vs. passive. They found that performance on the sentences with difficult syntax predicted variance in reading comprehension beyond performance on basic syntax (on which there was little variance), decoding, vocabulary, and verbal working memory. Thus, the correlation between the syntactically demanding items and reading comprehension could not be explained by the general task demands or the other control measures. This result supports the idea that sentence-level tasks measure a construct that is important for reading comprehension for reasons that cannot be reduced to for example vocabulary or working memory. An important limitation was that the self-paced format of the task could have allowed the test to be sensitive to individual differences in how children strategically solve problems, for example by rereading difficult items. The present study aimed to replicate the results using an oral, non-self-paced format of the task to reduce the possible confounds of decoding skills and strategic rereading.

Any task designed to assess syntactic knowledge will potentially draw on other cognitive resources as well. This situation raises two questions of validity: Is there substantial common variation between different task formats that can reasonably be said to measure syntactic knowledge (convergent validity)? And is this common variance separable from variance in tasks that do not draw on syntactic knowledge (discriminant validity)? With regard to convergent validity, the correlations between syntax measures vary considerably. Frizelle et al. (2017) reported a correlation of .08 between a TROG style sentence-picture matching task and a parallel sentence repetition measure in a sample of five-year-olds. Hjetland et al. (2019) reported a correlation of .30 in a sample of seven-year-olds between TROG-2 and sentence repetition, and The Language and Reading Research Consortium and Jiang (2018) reported cross-sectional correlations between .52 and .66 from pre-kindergarten to Grade 3. Aside from the fact that different samples may have differing baseline correlations, another explanation for the differences across studies might be differences in task characteristics, possibly including differences in demands for syntactic knowledge relative to other task demands. Frizelle et al. (2017) assessed various types of relative clauses using the same target sentences in the two formats, whereas Hjetland et al. (2019) employed a sentence memory task with increasing sentence length, but with no apparent syntactic selection criteria (see examples in Klem et al., 2015). Finally, Recalling Sentences from the CELF test battery (Semel et al., 2006) was used in the LARRC study. In Recalling Sentences, sentence length, syntactic complexity, and vocabulary are confounded, and it is unclear how exactly syntactic knowledge is involved.

To sum up, there is evidence that there are individual differences in school-aged children's ability to extract information from sentences, but it is still unclear whether this is due to differences in syntactic knowledge or in other cognitive constructs involved in specific sentence-level tests.

The Present Study

The goal of the present study was to investigate the construct validity of the notion of syntactic knowledge, whether it differs from verbal working memory, and to what extent the correlation between syntactic knowledge and reading comprehension can be explained by working memory in middle-school aged children. The relationship with reading comprehension serves as an indication of whether individual differences in syntactic knowledge are sufficiently large to have practical relevance. The study evaluated the correlational properties of two syntactic knowledge tasks designed to maximize syntactic load and minimize dependence on decoding, vocabulary, morphology, and problem solving. It is difficult to remove memory load from verbal syntactic tasks since syntactic comprehension involves processing and integrating multiple elements over time. Instead, the study controlled for verbal working memory with tasks that – like the syntax tasks – require the participants to store and process multiple linguistic units, but without syntactic cues to guide encoding and retention.

The syntactic knowledge tasks were sentence repetition and an oral version of the multiple-choice sentence comprehension task used by Poulsen and Gravgaard (2016). Both tasks used syntactic stimuli that were deemed challenging at least into adolescence based on previous research (Dabrowska & Street, 2006; Ferreira, 2003; Kristensen, Engberg-Pedersen, & Poulsen, 2014; Slobin, 1973), such as passives and non-canonical word order. The inclusion of two syntactic knowledge tasks allowed analyses of their convergent and discriminant validity compared to the other measures of decoding, vocabulary, and verbal working memory.

More specifically, the research questions were:

1) whether the two syntax measures were more highly correlated with each other than with working memory and vocabulary (convergent and discriminant validity).
2) to what extent working memory explained variance in the syntax measures.
3) to what extent the two syntax measures predicted variance in reading comprehension beyond measures of verbal working memory. Controls for decoding and vocabulary were also included to evaluate the independence of syntactic knowledge from these constructs.
4) whether comprehension accuracy on difficult items in the sentence comprehension task would predict unique variance beyond control variables including performance on basic items.

The last question was included as replication of Poulsen and Gravgaard (2016). A positive answer to the last question would indicate that the ability to handle syntactic load plays a role in reading comprehension.

Method

Participants

One hundred and twenty-one grade 6 students from two schools in relatively affluent neighborhoods in the Copenhagen area participated in the study. Some of these were excluded from the analyses, 10 due to missing assessment of reading comprehension and an additional 24 to remove confounds concerning second-language learning. One student had cochlear implant and difficulties with completing the receptive language tasks. This student was also left out of the analyses. The remaining 86 children (32 girls, 54 boys) had a mean age of 12;10 (*SD* = 0;4). They all spoke the majority language, Danish, at home. Parents were required to give written consent before their child could participate.

Measures

Syntactic Knowledge

Syntactic knowledge was assessed with two tasks: sentence comprehension and sentence repetition. In the *sentence comprehension* task, students listened to prerecorded sentences and answered questions concerning the syntactically coded information in the sentences. The task was very similar to the sentence comprehension task in Poulsen and Gravgaard (2016), but target and question sentences were presented orally rather than orthographically. Materials were prerecorded in a sound studio, and the task was administered on laptop computers using the OpenSesame version 3.2.5 experiment software (Mathôt, Schreij, & Theeuwes, 2012). In each trial, the student first heard a sentence, which was automatically followed by a question. During the question, two written response options were positioned in the left and the right side of the screen. The students were asked to choose a response by pressing one of two buttons, each corresponding to one of the responses (e.g. left button for left response option).

To manipulate and isolate syntactic difficulty, items were constructed in sets of four around a verb, a set of referents, and one of three syntactic alternations: active vs. passive, premodified noun vs. embedded relative clause, and subject-verb-object word order vs. object-verb-subject word order. This is exemplified in Table 1. For example, 1A and 1B convey the same proposition, but either through an active or a passive construction. 1C and 1D reverse the roles of the participants in 1A and 1B. The reversal items were included to counterbalance any involuntary stereotypic background expectations that could (mis)guide interpretation of the sentences (Traxler, 2014). The passives and embedded relative clauses are often used as challenging constructions in tests of syntactic knowledge (Bishop, 2003; Poulsen & Gravgaard, 2016), but experience from previous studies is that even with these constructions, ceiling effects can be expected with older children. Non-canonical constructions with object-verb-subject (OVS) word order were included in the present study because they are known to cause difficulty from early childhood into adulthood (Kristensen et al., 2014; Thomsen & Poulsen, 2015). The canonical word order of Danish is SVO like in English. However, objects and adverbials are allowed in the preverbal position, in which case the subject moves to the position immediately following the finite verb. SVO/OVS structure is signaled by the order of postverbal NP's relative to non-finite verbs and certain adverbials. Case markings on personal pronouns (as in English) also mark subject/object status, but in the present study, only word order was used to signal syntactic structure.

The materials of the sentence comprehension task included five sets of four items with each syntactic alternation for a total of 60 items. The horizontal position of the correct answer was balanced within item sets. The order of items was fixed in the same quasi-random order for all participants. Items from the same sets were spread out over the list, and the same construction was never repeated twice in a row. The score was the proportion of correct answers. Cronbach's alpha was .80 in the present sample.

Table 1

Approximate Translations of Example Stimuli From the Sentence Comprehension Task

	Active		Passive	Question	Answer
1A	The boy pushes the girl in school	1B	The girl is pushed by the boy in school	Who pushes?	The boy
1C	The girl pushes the boy in school	1D	The boy is pushed by the girl in school	Who pushes?	The girl
	Premodified noun		**Embedded relative clause**	**Question**	**Answer**
2A	The box stands on the red plate every day	2B	The plate that the box stands on is red	Which one is red?	The plate
2C	The plate stands on the red box every day	2D	The box that the plate stands on is red	Which one is red?	The box
	SVO		**OVS (marked by order of finite verb and adverbial**	**Question**	**Answer**
3A	The farmer would still miss the artist	3B	The artist would the farmer still miss	Who misses?	The farmer
3C	The artist would still miss the farmer	3D	The farmer would the artist still miss	Who misses?	The artist

Note. SVO vs. OVS structure is signaled by the order of the non-finite verb and the adverbial relative to the second noun phrase.

In the *sentence repetition task,* the students were asked to repeat 30 sentences verbatim. The sentences systematically included the same syntactic constructions as the sentence comprehension task, but the sentence repetition task was not designed to vary difficulty parametrically. Table 2 displays the included constructions and examples of items. The sentences in the sentence repetition task were longer than in the sentence comprehension task in order for them to draw on syntactic skills rather than just rote verbal short-term memory. The task was administered on a laptop computer with the prerecorded items in a fixed, quasi-randomized order. The same syntactic construction never appeared twice in a row. The score was the proportion of correct answers. Cronbach's alpha was .86 in the present sample.

Table 2

Approximate Translations of Stimuli From the Sentence Repetition Task Sorted by Syntactic Construction

Syntactic construction	Number of items	Example
SVO	4	the little donkey teased the kid in the paddock
Passive	4	the ballet dancer with the sore feet was attacked by the talented singer
OVS	6	the sly witch should the cheerful wizard probably summon
Embedded subject relative	4	in the morning practiced the musician who had hit the soldier
Embedded object relative	8	the secretary that the postman had pushed went directly on holiday
Embedded oblique	4	the red house that the man with the wooden leg lives in must be vacated

Working Memory

The students completed three working memory tasks: Backward digit span, Number sequencing, and Letter-number sequencing from WISC-V, Danish version (Wechsler 2017). In Number and Letter-number sequencing, the students were orally given a string of numbers and numbers and letters, respectively, and had to repeat them in the correct numerical and alphabetical order. In Backward digit span, students were asked to repeat a string of numbers in reverse order. In all three tests, the items gradually increased in length. The number of correct answers was transformed to scaled scores. The manual reports reliability estimates between .72 to .93 for the three tests in the relevant age group.

Vocabulary

Expressive vocabulary was assessed with a task developed for research purposes (Gellert & Vang Christensen, 2012). The students were asked to name 84 color photos of objects. The score was the proportion of correct answers. Cronbach's alpha was .84 in the present sample.

Decoding Fluency

Decoding fluency was assessed with Elbros ordlister ("Elbros word lists") (Elbro, 1990). The students were asked to read two lists of 20 words and two lists of 20 nonwords. Each list contained (non)words of increasing difficulty from two to eight letters. Responses were recorded and scored for accuracy and speed by trained assistants. The score for each list was the number of correct responses divided by the time to complete the list. Average scores for words and nonwords were computed separately. As a measure of reliability, the correlation between the word and nonword fluency was .90 (spearman-brown corrected) in the present sample.

Reading Comprehension

Reading comprehension was assessed with Tekstlæseprøve 8 ("Text reading test 8") (Møller, 2013). The text is a connected exposition on a single subject with 43 maze items (four options each) and 11 two-choice recall items. The assessment was group-administered, and the students were allowed 30 minutes to complete the assignment. This was 5 minutes more than allowed by the test manual to minimize the effect of decoding fluency on the test results. The score for the test was the proportion of correct answers out of all items. 74% of the students completed all items within the time limit. Cronbach's alpha was .84 in the present sample.

Results

One outlier student scored 3.45 SD below the mean in reading comprehension. The reading comprehension score for that student was replaced with a value corresponding to the second lowest scoring student (2.44 SD below the mean). All variables had skew values under 1.

Table 3 presents the descriptive statistics of the individual study variables.

Table 3

Descriptive Statistics

Variable	**Mean**	**SD**	**Min-max**	**Skew**
Reading comprehension (prop. correct)	.73	.12	.41-.94	-.50
Vocabulary (prop. correct)	.83	.08	.61-.95	-.76
Decoding (words pr. min)	97.64	22.74	51.03-152.29	.05
Decoding (nonwords pr. min.)	58.87	17.08	18.91-107.68	.24
Backward digit span (scaled)	10.58	3.07	4-18	.29
Number sequencing (scaled)	10.80	2.50	5-17	.13
Letter-number sequencing (scaled)	10.76	2.85	5-17	.18
Sentence comprehension (prop. correct)	.81	.10	.62-1	-.15
Sentence repetition (prop. correct)	.56	.20	.13-.93	-.12

To simplify further analyses, we computed composite scores for decoding fluency, memory, and syntactic knowledge as averaged z-scores. This was unproblematic for decoding fluency and syntactic knowledge because the correlations between the averaged measures were high (word and nonword fluency, $r = .81$, syntactic knowledge, $r = .62$). In contrast, the correlations between the separate working memory variables were low (r between .24 and .46). These low correlations put into question the reasonableness of the composite score. However, the working memory composite correlated more highly with reading comprehension and the syntactic measures than the separate working memory scores. Thus, this composite measure is the most conservative working memory control measure.

Table 4 presents the zero-order correlations between the study variables. The table includes both the composite and the separate measures of syntactic knowledge. Both measures of syntactic knowledge correlated significantly with reading comprehension. In general, sentence comprehension and sentence repetition correlated with the other measures at about the same level, with a weak tendency for sentence repetition to correlate more highly with other measures.

Table 4

Zero-Order Correlations Between Central Study Variables

Measure	**1**	**2**	**3**	**4**	**5**	**6**
1. Reading comprehension	-					
2. Vocabulary	.50	-				
3. Decoding composite	.45	.07	-			
4. Working memory composite	.24	.18	.23	-		
5. Syntax composite	.46	.31	.24	.45	-	
6. Sentence comprehension	.41	.25	.15	.37	.90	-
7. Sentence repetition	.42	.30	.28	.43	.90	.62

Note. r-values above .21 are significant at .05 level.

The first research question was whether the two syntax measures correlated more highly with each other than with working memory and vocabulary. A substantial correlation would indicate convergent validity, and a higher correlation between syntactic measures than between syntax and working memory would indicate discriminant validity (Campbell & Fiske, 1959). Table 4 shows that the two syntax measures were more highly correlated with each other (r = .62) than with any other measure. This correlation was indeed significantly higher than the correlation between sentence comprehension and composite working memory (r = .37), t = 2.69, p < .01 (Steiger, 1980), but it was not higher than the correlation between sentence repetition and the working memory composite (*r* = .43), *t* = 1.98, *p* = .051. However, we conclude that the pattern is in favor of the analysis that the syntax measures tap into a set of skills that are at least partially separate from working memory. Furthermore, both syntax measures correlated more highly with each other than with vocabulary (both *p*'s < .01). This indicates that the efforts to minimize the vocabulary load on the syntax tasks largely succeeded, and it further supports the interpretation of the syntax measures tapping into their own construct, syntactic knowledge.

The second research question was how much variation in the syntax measures can be explained by working memory. This information can be derived from Table 4. The working memory composite explained 13.7% variance in sentence comprehension, 18.5% variance in sentence repetition, and 20.3% variance in the composite measure of the two.

The third research question was to what extent the syntax measures correlate with reading comprehension because of shared variance with working memory. Tables 5-7 show multiple regression and commonality analyses with reading comprehension. Table 5 shows that in model 1 with sentence comprehension and the working memory composite, sentence comprehension explained a total of 17% variance in reading comprehension. 12% is unique, while 5% is shared with the working memory composite. Model 2 additionally includes decoding and vocabulary as independent variables. In this model, sentence comprehension explained 5.4% unique variance, while 11.5% was common with combinations of decoding, vocabulary, and working memory. Table 6 and 7 show parallel analyses with sentence repetition and the composite syntax measure. The results are largely parallel, except that sentence repetition did not explain significant unique variance beyond decoding, vocabulary, and working memory (*p* = .053).

Table 5

Multiple Regression and Commonality Analyses of Sentence Comprehension With Reading Comprehension as Dependent Variable

Predictor	**β**	**Unique R^2**	**Common R^2**	**Total R^2**
Model 1				
Working memory composite	.103	.009	.050	.059
Sentence comprehension	.373 ***	.120	.050	.170
Model 2				
Decoding	.383***	.138	.060	.198
Vocabulary	.409***	.156	.091	.247
Working memory composite	-.014	.001	.059	.059
Sentence comprehension	**.257****	**.054**	**.115**	**.170**

Note. ** $p < .01$, *** $p < .001$.

Table 6

Multiple Regression and Commonality Analyses of Sentence Repetition With Reading Comprehension as Dependent Variable

Predictor	**β**	**Unique R^2**	**Common R^2**	**Total R^2**
Model 1				
Working memory composite	.076	.005	.054	.059
Sentence repetition	.385***	.121	.054	.175
Model 2				
Decoding	.364***	.121	.078	.198
Vocabulary	.414***	.155	.092	.247
Working memory composite	.004	.001	.059	.059
Sentence repetition	**.190 +**	**.026**	**.149**	**.175**

Note. *** $p < .001$, + $p < .10$.

Table 7

Multiple Regression and Commonality Analyses of the Syntax Composite With Reading Comprehension as Dependent Variable

Predictor	**β**	**Unique R^2**	**Common R^2**	**Total R^2**
Model 1				
Working memory composite	.046	.002	.057	.059
Syntax composite	.441***	.156	.057	.213
Model 2				
Decoding	.363***	.122	.077	.198
Vocabulary	.396***	.142	.105	.247
Working memory composite	-.030	.001	.058	.059
Syntax composite	**.267****	**.052**	**.161**	**.213**

Note. ** $p < .01$, *** $p < .001$.

The fourth research question was whether accuracy on difficult items in the sentence comprehension task would predict unique variance beyond control variables including accuracy on basic items in sentence comprehension. This largely turned out to be the case. Sentence comprehension accuracy was significantly lower on difficult ($M = .69$, $SD =.16$) than on basic items ($M = .93$, $SD = .06$), Wilcoxon signed rank p < .001. Basic ($r = .33$, p < .001) and difficult sentence comprehension ($r = .39$, p < .001) correlated with reading comprehension at approximately the same level. Table 8 presents a hierarchical regression analysis with reading comprehension as the dependent variable. Basic sentence comprehension explained 2% variance in reading comprehension after controlling for working memory, decoding, and vocabulary, but this was not significant ($p = .08$). Difficult sentence comprehension explained a significant 4% unique variance in step 3 after control variables including basic sentence comprehension (*p* = .023). Thus, although both basic and difficult sentence comprehension correlates with reading comprehension at approximately the same level, the correlation between basic sentence comprehension and reading comprehension is largely explained by other factors. These results suggest that when the syntactic load on the sentence task is increased, the sentence comprehension task becomes a stronger unique predictor of reading comprehension.

Table 8

Hierarchical Regression Analyses With Reading Comprehension as Dependent Variable

Predictor	**R^2**	**ΔR^2**	**Final β**
Step 1	.42	.42***	
Working memory Composite			-.01 ns
Decoding			.39***
Vocabulary			.41***
Step 2	.44	.02 +	
Basic sentence comprehension acc.			.04 ns
Step 3	.48	.04 *	
Difficult sentence comprehension acc.			.23 *

Note. * $p < .05$, *** $p < .001$, + $p < .10$

Discussion

The study evaluated the convergent and discriminant validity of two researcher-developed measures of syntactic knowledge, and whether syntactic knowledge is related to reading comprehension in Grade 6 children. The tests were specifically designed to reduce dependence on other cognitive constructs such as problem solving and demanding vocabulary. The analyses showed that the syntax measures, sentence comprehension and sentence repetition, were more highly correlated with each other than with decoding, vocabulary, and working memory. Although the correlation between sentence repetition and sentence comprehension was only marginally stronger than between sentence repetition and working memory (p = .051), the pattern did not differ substantially from the sentence comprehension results. We cautiously interpret these results to support the convergent and discriminant validity of the syntactic knowledge measures and the syntactic knowledge construct.

Furthermore, the present study replicated previous studies that have found unique contributions from sentence-level measures to reading comprehension across several languages, including English, Cantonese, and Danish (Brimo et al., 2017; Deacon & Kieffer, 2018; Language and Reading Research Consortium & Logan, 2017; Poulsen & Gravgaard, 2016; Tong & McBride, 2017). The present results extend the previous results in a number of ways. First, working memory was moderately correlated with the syntactic composite. This supports the notion that sentence comprehension is (partially) dependent on more domain-general working memory capacity, as has been suggested in the sentence processing literature (cf. Schwering & MacDonald, 2020 for a relevant review). But a lot of the variation in the syntax tasks was not explained by working memory, and working memory was not substantially responsible for the correlation between the syntactic measures and reading comprehension: Commonality analyses showed that shared variance between the syntax composite and working memory explained 5.7% variance in reading comprehension, compared to 15.6% uniquely explained by the syntax composite. Thus, for the practical purposes of reading comprehension, there is more to sentence comprehension than just working memory. It should be noted that we used a definition of syntactic knowledge that includes the ability to *process* syntactic information (MacDonald & Christiansen, 2002).

Other conceptualizations may consider processing the domain of the *working* part of working memory (Crain & Shankweiler, 1988; Smith, Macaruso, Shankweiler, & Crain, 1989). The theoretical delimitation of working memory cannot be solved in the present paper. However, from an educational point of view, it useful to know that some children struggle with acquiring and/or using domain-specific syntactic knowledge rather than with more domain-general working memory, as a domain-specific problem may call for more specific interventions.

Second, the present design and results strengthen the evidence that it is syntactic knowledge demands rather than other language comprehension demands that are responsible for the correlation between sentence-level tasks and reading comprehension. The sentence-level tasks were designed to maximize dependence on children's ability to use syntactic knowledge, and to minimize other sources of language comprehension difficulty that have been suggested to explain the correlation between sentence-level tasks and reading comprehension, e.g. from vocabulary or morphology (Language and Reading Research Consortium & Logan, 2017). The low correlation between the syntax tasks and vocabulary suggests that the design efforts were successful to some degree.

Third, the results partially confirmed the result from Poulsen and Gravgaard (2016) that performance on the difficult sentences in the sentence comprehension task explained significant variance beyond performance on basic sentences. Performance on the basic sentences was near ceiling, indicating that the task format in itself is not very challenging. However, in contrast to Poulsen and Gravgaard, accuracy on the basic structures was significantly correlated with reading comprehension. But this correlation was accounted for by the other control variables, suggesting that it was due to other task demands. Performance on the difficult sentences, on the other hand, explained unique variance in reading comprehension even after controlling for performance on basic items. This supports the possibility that the ability to handle syntactic load specifically is related to reading comprehension.

However, these results appear to contradict recent results from a study of English speaking grade 5 students that variance on basic – rather than difficult constructions - uniquely predict reading comprehension (Sorenson Duncan et al., advance online publication). The study used a sentence comprehension task similar to the present, but with generally lower accuracy scores, below chance level for many students on the difficulty constructions. The constructions were largely comparable to the ones in the present study, but task difficulty was higher, as measured by mean accuracy scores, probably because of an additional distractor and because sentences often were nonsensical. Despite the differences in results, both studies indicate that syntactic knowledge is important for the sentence comprehension tasks: Even beyond the first years of schooling, children find some syntactic structures difficult, and this is correlated with reading comprehension after controlling for working memory. The conflicting results suggest that the correlation with reading comprehension depends more on whether the task difficulty is sensitive to the relevant range of skills in the sample, rather than specific constructions. Thus, the problem for some children probably is not that they simply do not know specific difficult constructions that mostly occur in written text, but rather that their syntactic knowledge is not sufficiently robust to be applied with consistent success when the demands are high.

Contrary to Poulsen and Gravgaard (2016), the students in the present study and in Duncan et al. (2020) did not have the opportunity to strategically reprocess the stimuli through rereading. This reduces the possibility that the difference between basic and difficult items reflects individual differences in more general problem solving when faced with difficult tasks, in the sense that some students could be generally more inclined to apply strategic behavior than others.

Together, the present and previous results strengthen the case that individual differences in syntactic knowledge play a role in practice in ordinary classrooms when it comes to reading comprehension. The results support the inclusion of syntactic knowledge as a component of language comprehension in models that explain individual differences in reading comprehension, such as the Simple View of Reading (Gough & Tunmer, 1986; Hoover & Gough, 1990) and newer conceptions in that tradition (Catts, 2018; Perfetti et al., 2005).

Limitations

The present study used researcher-created measures of syntax instead of traditional standardized test such as the TROG or tasks from the CELF. The reasoning was that the traditional tests may introduce non-syntactic factors to avoid ceiling effects, especially at the higher difficulty levels. The present results suggest that the researcher-created tasks successfully avoided heavy influence from vocabulary or memory, although the sentence repetition format may be more heavily influenced by working memory. However, since the study did not include traditional measures, it is not possible to make direct comparisons to see whether the researcher-created measures were indeed purer measures of syntactic knowledge than traditional measures. An important goal for future studies is to make such comparisons.

The present study did not clearly address the issue of the separability of vocabulary and syntax. Influence from vocabulary was minimized in the construction of materials from the syntactic tasks, and the correlation between the syntax measures and vocabulary were weak in this sample of middle-school aged children. It is unlikely that this was due to any simple sense of low reliability or validity of the vocabulary measure, since the reliability was high, and vocabulary was the strongest correlate of reading comprehension. But the lack of multiple indicators of vocabulary prevents modelling of the role of measurement error in the separation of syntax and vocabulary. Lervåg, Hulme, and Melby-Lervåg (2018) in a Norwegian study found that their grammar construct did not predict variance in reading comprehension beyond other language measures when modeling measurement error. Their grammar construct included both morphological and syntactic tasks, and the other language constructs included indicators, such as listening span and inferencing, which presumably depended on syntactic processing of some sort. Further studies are needed to ascertain whether clearer independent contributions to reading comprehension can be found if the different language comprehension sub-constructs use indicators that are more clearly differentiated.

It should be noted that the idea that individual differences in syntactic knowledge is important for reading comprehension does not depend strongly on the separability of individual differences in vocabulary and syntax. There are both theoretical (Ambridge & Lieven, 2015; Goldberg, 1995; Tomasello, 1992) and empirical (Language and Reading Research Consortium, Jiang, Logan, & Jia, 2018) reasons to believe that the development of syntax is tightly linked to the development of vocabulary, and that the processing of different language components are intertwined (cf. Schwering & MacDonald, 2020). A relatively strong correlation between syntactic knowledge and reading comprehension still indicates that children who struggle with reading comprehension also struggle with assigning meaning based on syntactic cues, irrespective of whether these children have other language difficulties or not. However, indications of separability of syntax and vocabulary strengthen the case that syntactic difficulties are a barrier for text comprehension that cannot be explained away by failure to understand certain words. Ultimately, the issue of causality cannot be solved by regression studies. Intervention studies are needed.

Conclusion

The sentence comprehension and sentence repetition measures of the present study appeared to measure a construct separate from basic verbal working memory. Although the question of separability of individual differences in sub-constructs of language comprehension is still unclear, the present study provides evidence that students with poor reading comprehension also have a tendency to misinterpret the literal, syntactically coded meaning of sentences with easy vocabulary, especially if the syntax is challenging. Thus, what superficially appears as poor memory of a text – and maybe spoken messages – could instead stem from ineffectual encoding of propositional meaning based on word-order cues. The size of the correlations indicates that individual differences in syntactic knowledge could be as important as decoding and vocabulary to the variation in reading comprehension in ordinary classrooms. Some studies have shown promise in improving syntactic knowledge of children with developmental language disorder (Balthazar, Ebbels, & Zwitserlood, 2020). But larger scale studies of interventions applicable in ordinary classrooms with practical outcome measures - such as reading comprehension - are needed. Such studies would also provide more direct evidence of causality.

References

Ambridge, B., & Lieven, E. (2015). A constructivist account of child language acquisition. In B. MacWhinney & W. O'Grady (Eds.), *The Handbook of Language Emergence* (pp. 478-510). Hoboken, NJ,: John Wiley & Sons.

Balthazar, C. H., Ebbels, S., & Zwitserlood, R. (2020). Explicit grammatical intervention for developmental language disorder: Three approaches. *Language, Speech & Hearing Services in Schools, 51*, 226-246. doi:10.1044/2019_lshss-19-00046

Bishop, D. (2003). *Test for Reception of Grammar-2*. San Antonia, TX: Harcourt Assessment.

Brimo, D., Apel, K., & Fountain, T. (2017). Examining the contributions of syntactic awareness and syntactic knowledge to reading comprehension. *Journal of Research in Reading, 40*, 57-74. doi:10.1111/1467-9817.12050

Brimo, D., Lund, E., & Sapp, A. (2018). Syntax and reading comprehension: A meta-analysis of different spoken-syntax assessments. *International Journal of Language & Communication Disorders, 53*, 431-445. doi:10.1111/1460-6984.12362

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin, 56*, 81-105. doi:10.1037/h0046016

Catts, H. W. (2018). The simple view of reading: Advancements and false impressions. *39*, 317-323. doi:10.1177/0741932518767563

Crain, S., & Shankweiler, D. (1988). Syntactic complexity and reading acquisition. In A. Davison & G. M. Green (Eds.), *Critical approaches to readability: Theoretical bases of linguistic complexity* (pp. 199-221). Hillsdale, NJ: Erlbaum.

Dabrowska, E., & Street, J. (2006). Individual differences in language attainment: Comprehension of passive sentences by native and non-native English speakers. *Language Sciences, 28*, 604-615. doi:10.1016/j.langsci.2005.11.014

Deacon, S. H., & Kieffer, M. (2018). Understanding how syntactic awareness contributes to reading comprehension: Evidence from mediation and longitudinal models. *Journal of Educational Psychology, 110*, 72-86. doi:10.1037/edu0000198

Elbro, C. (1990). *Differences in Dyslexia*. Copenhagen: Munksgaard.

Ferreira, F. (2003). The misinterpretation of noncanonical sentences. *Cognitive Psychology, 47*, 164-203. doi:10.1016/S0010-0285(03)00005-7

Frizelle, P., O'Neill, C., & Bishop, D. V. M. (2017). Assessing understanding of relative clauses: A comparison of multiple-choice comprehension versus sentence repetition. *Journal of Child Language*, 1-23. doi:10.1017/S0305000916000635

Frizelle, P., Thompson, P., Duta, M., & Bishop, D. V. M. (2019). Assessing children's understanding of complex syntax: A comparison of two methods. *Language Learning, 69*, 255-291. doi:10.1111/lang.12332

Gellert, A., & Vang Christensen, R. (2012). *Produktivt ordforråd [Productive vocabulary].* Department of Nordic Studies and Linguistics, University of Copenhagen. Copenhagen, Denmark.

Goldberg, A. (1995). *Constructions*. Chicago: University of Chicago Press.

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education, 7*, 6-10. doi:10.1177/074193258600700104

Hjetland, H., Lervag, A., Lyster, S.-A., Hagtvet, B., Hulme, C., & Melby-Lervag, M. (2019). Pathways to reading comprehension: A longitudinal study from 4 to 9 years of age. *Journal of Educational Psychology, 111*, 751-763. doi:10.1037/edu0000321

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing: An Interdisciplinary Journal, 2*, 127-160. doi:10.1007/bf00401799

Kidd, E., Brandt, S., Lieven, E., & Tomasello, M. (2007). Object relatives made easy: A cross-linguistic comparison of the constraints influencing young children's processing of relative clauses. *Language and Cognitive Processes, 22*, 860-897. doi:10.1080/01690960601155284

Kintsch, W., & Rawson, K. (2005). Comprehension. In M. J. Snowling & C. Hulme (Eds.), *The Science of Reading: A Handbook* (pp. 209-226). Oxford: Blackwell.

Klem, M., Melby-Lervåg, M., Hagtvet, B., Lyster, S.-A. H., Gustafsson, J.-E., & Hulme, C. (2015). Sentence repetition is a measure of children's language skills rather than working memory limitations. *Developmental Science, 18*, 146-154. doi:10.1111/desc.12202

Kristensen, L. B., Engberg-Pedersen, E., & Poulsen, M. (2014). Context improves comprehension of fronted objects. *Journal of Psycholinguistic Research, 42*, 125-140. doi:10. 1007/ s10936-013-9241-y

Language and Reading Research Consortium, Jiang, H., & Farquharson, K. (2018). Are working memory and behavioral attention equally important for both reading and listening comprehension? A developmental comparison. *Reading & Writing, 31*, 1449-1477. doi:10.1007/s11145-018-9840-y

Language and Reading Research Consortium, Jiang, H., Logan, J., & Jia, R. (2018). Modeling the nature of grammar and vocabulary trajectories from prekindergarten to third grade. *Journal of Speech, Language, and Hearing Research, 61*, 910-923. doi:10.1044/2018_JSLHR-L-17-0090

Language and Reading Research Consortium, & Logan, J. (2017). Pressure points in reading comprehension: A quantile multiple regression analysis. *Journal of Educational Psychology, 109*, 451-464. doi:10.1037/edu0000150

Lervåg, A., Hulme, C., & Melby-Lervåg, M. (2018). Unpicking the developmental relationship between oral language skills and reading comprehension: It's simple, but complex. *Child Development, 89*, 1821-1838. doi:10.1111/cdev.12861

Lombardi, L., & Potter, M. C. (1992). The regeneration of syntax in short term memory. *Journal of Memory and Language, 31*, 713-733. doi:10.1016/0749-596X(92)90036-W

MacDonald, M., & Christiansen, M. H. (2002). Reassessing Working Memory: Comment on Just and Carpenter (1992) and Water and Caplan (1996). *Psychological Review, 109*, 35-54.

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods, 44*, 314-324. doi:doi:10.3758/s13428-011-0168-7

Møller, L. (2013). *Tekstlæseprøve 7 [Text reading test 7]*. Frederiksberg, Denmark: Hogrefe Psykologisk Forlag.

Nippold, M. A. (2017). Reading comprehension deficits in adolescents: Addressing underlying language abilities. *Language, Speech & Hearing Services in Schools, 48*, 125-131. doi:10.1044/2016_LSHSS-16-0048

Owen, A., & Leonard, L. (2006). The production of finite and nonfinite complement clauses by children with specific language impairment and their typically developing peers. *Journal of Speech, Language, and Hearing Research, 49*, 548-571. doi:10.1044/1092-4388(2006/040)

Perfetti, C., Landi, N., & Oakhill, J. (2005). The acquisition of reading comprehension. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 227-247). Oxford: Blackwell.

Polišenská, K., Chiat, S., & Roy, P. (2015). Sentence repetition: What does the task measure? *International Journal of Language & Communication Disorders, 50*, 106-118. doi:doi:10.1111/1460-6984.12126

Poll, G. H., Betz, S. K., & Miller, C. A. (2010). Identification of clinical markers of specific language impairment in adults. *Journal of Speech, Language, and Hearing Research, 53*, 414-429. doi:10.1044/1092-4388(2009/08-0016)

Poulsen, M., & Gravgaard, A. K. D. (2016). Who did what to whom? The relationship between syntactic aspects of sentence comprehension and text comprehension. *Scientific Studies of Reading, 20*, 325-338. doi:10.1080/10888438.2016.1180695

Riches, N. G. (2012). Sentence repetition in children with specific language impairment: an investigation of underlying mechanisms: Sentence repetition in children with SLI. *International Journal of Language & Communication Disorders, 47*, 499-510. doi:10.1111/j.1460-6984.2012.00158.x

Riches, N. G., Loucas, T., Baird, G., Charman, T., & Simonoff, E. (2010). Sentence repetition in adolescents with specific language impairments and autism: An investigation of complex syntax. *International Journal of Language & Communication Disorders, 45*, 47-60. doi:10.3109/13682820802647676

Schwering, S. C., & MacDonald, M. C. (2020). Verbal working memory as emergent from language comprehension and production. *Frontiers in human neuroscience, 14*, 68-68. doi:10.3389/fnhum.2020.00068

Semel, E., Wiig, E. H., & Secord, W. A. (2006). *Clinical Evaluation of Language Fundamentals: Fourth edition*. London: Psychological Corporation.

Silva, M., & Cain, K. (2015). The Relations Between Lower And Higher Level Comprehension Skills and Their Role in Prediction of Early Reading Comprehension. *Journal of Educational Psychology, 107*, 321-331. doi:10.1037/a0037769

Slobin, D. I. (1973). Cognitive prerequisites of the development of grammar. In C. A. Ferguson & D. I. Slobin (Eds.), *Studies of child language development*. New York: Holt, Rinehart & Winston.

Smith, S. T., Macaruso, P., Shankweiler, D., & Crain, S. (1989). Syntactic comprehension in young poor readers. *Applied Psycholinguistics, 10*, 429-454. doi:10.1017/S0142716400009012

Sorenson Duncan, T., Mimeau, C., Crowel, N., & Deacon, S. H. (advance online publication). Not all sentences are created equal: evaluating the relation between children’s understanding of basic and difficult sentences and their reading comprehension. *Journal of Educational Psychology*. doi:10.1037/edu0000545

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin, 37*, 245-251.

Thomsen, D. B., & Poulsen, M. (2015). Cue conflicts in context: interplay between morphosyntax and discourse context in Danish preschoolers’ semantic role assignment. *Journal of Child Language, 42*, 1237-1266. doi:10.1017/S0305000914000786

Tomasello, M. (1992). *First verbs: a case study of early grammatical development*. Cambridge: Cambridge University Press.

Tong, X., & McBride, C. (2017). A reciprocal relationship between syntactic awareness and reading comprehension. *Learning and Individual Differences, 57*, 33-44. doi:10.1016/j.lindif.2017.05.005

Traxler, M. J. (2014). Trends in syntactic parsing: anticipation, Bayesian estimation, and good-enough parsing. *Trends in Cognitive Sciences, 18*, 605-611. doi:10.1016/j.tics.2014.08.001