

The influence of syntactic knowledge on reading comprehension varies as a function of oral vocabulary in Spanish-speaking children

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Background: Reading comprehension is a complex process influenced by many factors. However, the abilities that are known to influence reading comprehension may not contribute equally for children with different levels of oral language.

Aims: Here we examined the relationship of two factors known to influence reading comprehension (morphology and syntax) in a group of children who varied in their levels of oral vocabulary.

Method: Two hundred seventy-three typically developing Spanish-speaking fourth graders were assessed on non-verbal intelligence, word and pseudoword reading, oral vocabulary, morphological awareness and syntax, along with reading comprehension ability. Standardised oral language scores within this group ranged from the first to the 99th percentile. Mediated multiple regression with moderation was used to assess (1) whether the influence of oral vocabulary on reading comprehension was mediated by decoding, morphology or syntax and (2) whether the effects of syntax on reading comprehension varied as a function of oral vocabulary levels.

Results: There was a direct positive relationship between vocabulary and reading comprehension, and this was mediated by word reading and syntax, but not by pseudoword reading or morphology. Furthermore, the relation between syntax and reading comprehension was moderated by oral vocabulary such that the strength of this relationship diminished as oral vocabulary levels increased.

Conclusions: These findings suggest that longitudinal research is necessary to explore the possibility that a syntax intervention might be beneficial for readers with low oral vocabulary.

Keywords: reading comprehension, vocabulary, syntax, morphological awareness, word reading

Highlights

What is already known about this topic

- Previous studies have observed a strong association between vocabulary and reading comprehension.
- Syntax and morphology are connected to reading comprehension.
- The abilities known to influence reading comprehension might not contribute equally for all readers.

What this paper adds

- As the relationships between reading component skills and reading comprehension vary according to reader proficiency, we wondered if this was also the case for oral language proficiency.
- We examined how the influence of reading, morphological awareness and syntax, variables traditionally associated with reading comprehension, varied depending on the level of oral vocabulary knowledge.
- We found that the influence of syntax on reading comprehension is strongest when oral vocabulary levels are low.

Implications for theory, policy or practice

- There needs to be recognition and understanding that variation between types of readers is very important and must be taken into account when designing instruction and intervention programmes in order to meet the needs of each type of reading profile.
- Our findings have implications for instruction addressing the relative contributions of language skills to reading comprehension for low vocabulary readers.
- This result suggests that longitudinal research is necessary to explore the possibility that a syntax intervention might be beneficial for readers with low oral vocabulary.

The simple view of reading, proposed by Hoover and Gough (1990), characterises skilled reading as a product of decoding and listening comprehension. The role of decoding is more important in the novice reader, but as reading ability improves, oral comprehension grows in influence (Chen & Vellutino 1997). In this model, the difficulties of poor

comprehenders, who can decode fluently and accurately, stem from weaknesses in oral language. These weaknesses can affect any aspect of oral language, such as vocabulary, morphology or syntax.

With respect to vocabulary, many studies have observed a strong association between vocabulary and reading comprehension (e.g., Cain & Oakhill 2014). This relationship becomes apparent in first grade but continues well beyond this point (Ricketts et al. 2020; Verhoeven & van Leeuwe 2008). Consequently, low vocabulary is often considered a typical characteristic of poor comprehenders in any grade (Joshi 2005). However, as Spencer et al. (2017) have observed, vocabulary may also influence reading comprehension indirectly via other mediating factors. For example, Cromley and Azevedo (2007) reported that the relationship between vocabulary and reading comprehension was mediated by inference making ability while Segers and Verhoeven (2016) have reported that this relationship is mediated by logical reasoning. More recently, Oslund et al. (2018) reported a significant indirect effect of reading vocabulary on reading comprehension via both silent reading efficiency and inference making ability in a sample of sixth to eighth grade English-speaking children. Thus, it appears that the relationship between vocabulary and reading comprehension is complex, being composed of both direct and indirect effects. Moreover, it has recently been suggested that explanation for the close relationship between oral vocabulary and reading comprehension is that they are ‘best conceptualized as reflecting a single higher order language construct’ (p. 389, Ricketts et al. 2020).

Despite the wealth of studies which have examined the relationship between vocabulary and reading comprehension, relatively few have been undertaken in languages other than English. As Caravolas et al. (2019) have noted, orthographic consistency affects the development of reading comprehension, and thus, the specific factors that influence reading comprehension. For this reason, it is not possible to simply assume that the abilities, which have been shown to influence reading comprehension in English, will be the same factors that influence reading comprehension in languages with a transparent orthography.

In Spanish, a transparent orthography, several studies have reported that vocabulary directly influences reading comprehension. For example, a study by Figueroa-Sepúlveda and Gallego-Ortega (2018) using 206 students drawn from second and fourth year students reported that the degree of lexical development had a significant impact on the participants’ level of reading comprehension. Similarly, Suárez et al. (2010) reported a relationship between low levels of vocabulary and a poor level of competence in reading comprehension in a large sample of 3883 primary school students aged between 7 and 12 years. More recently, Calet et al. (2020) reported that both vocabulary and decoding ability predicted reading comprehension in 139 fifth and sixth grade Spanish-speaking children.

In contrast to direct effects, studies looking for possible indirect (mediated) effects of vocabulary on reading comprehension in Spanish-speaking children are rare. In a recent study primarily designed to assess the influence of morphological awareness on reading comprehension in fourth grade Spanish-speaking children, D’Alessio et al. (2019) reported that vocabulary had a significant direct effect on word decoding as well as on reading comprehension, but that decoding did not significantly influence reading comprehension in their model. This result suggests that there was no mediating effect of decoding on the relationship between vocabulary and reading comprehension.

Indirect evidence that vocabulary’s effect on reading comprehension is mediated by other factors in another transparent language does exist. Tobia and Marzocchi (2014) found that vocabulary played a significant role in predicting reading fluency among third to fifth grade Italian speaking children whereas Florit et al. (2008) found that reading

fluency (speed) and reading comprehension were correlated in a sample of 74 Italian speaking children aged between 8 and 11 years. Taken together, these results suggest that in Italian, apart from any direct effect vocabulary has on reading comprehension, this relationship may be mediated by reading ability. Nevertheless, given the scarcity of studies undertaken in transparent languages, further investigation is needed to fully understand the relationship between vocabulary and reading comprehension in Spanish.

Although morphology and syntax have received significantly less attention than vocabulary, they too have been linked to reading comprehension. Several studies have found associations between morphology and reading comprehension (Kirby et al. 2012; Levesque et al. 2019). Deacon et al. (2014) have suggested that morphology acts in two ways. First, morphology makes a direct contribution to comprehension as it is a critical component of linguistic comprehension in the simple view of reading model. However, it also has an indirect influence due to its role in word recognition – morphology facilitates the analysis of small meaningful units of words, such as prefixes and suffixes, and helps to associate unfamiliar words with words that are already stored in the mental lexicon. In this way, morphology can enhance vocabulary acquisition (Carlisle 2000). Of relevance, Carlisle was interested in reading comprehension at both the word and text level. Thus, she used *reading* vocabulary as a measure of word-level reading comprehension rather than as a predictor of text-level reading comprehension. For this reason, studies which are interested in assessing the direct and indirect effects of morphology on text-level reading comprehension often evaluate *reading* vocabulary as a possible mediating factor (e.g., Goodwin et al. 2017). In contrast, when receptive (oral) vocabulary is included, it is often used as a control variable (predictor of) other factors – for example, word reading (D’Alessio et al. 2019).

Evidence regarding a link between morphological awareness is mixed. Kirby et al. (2012) found a relationship between morphological awareness and the development of reading comprehension in a sample of 103 children who were followed from kindergarten to third grade. However, Levesque et al. (2019) analysed the roles of morphological awareness and morphological analysis in reading comprehension in typically developing students from grades 3 and 4 finding that morphological analysis, but not morphological awareness, predicted gains in reading comprehension. However, Levesque et al. (2021) refined this idea in their Morphological Pathways Framework. More precisely, this framework implies a direct pathway between morphological awareness and reading comprehension and an indirect pathway of morphological awareness through morphological decoding and morphological analysis.

The depth of the writing system of the language may also influence the relationship (Levesque et al. 2021). In languages with transparent orthographies, such as Spanish, accurate word decoding can be achieved through the mere application grapheme–phoneme conversion rules. For this reason, D’Alessio et al. (2019) suggested that morphology may have a diminished role in transparent languages as there is no need for readers in these languages to consciously reflect upon the structure of the word in order to know how to decode it. Although these authors found a direct relationship between morphology and reading comprehension, they argued that this relationship was due to the fact that morphology provides access to the semantic and syntactic information of new words. In support of this idea, in a study involving 234 third grade Spanish-speaking children, Simpson et al. reported that the relationship between morphology and reading comprehension in their sample disappeared once syntactic knowledge was taken into account (something which was not controlled for in the D’Alessio et al. study). While a

more recent longitudinal study (Lyster et al. 2021) did report a relationship between morphology and reading comprehension in a transparent language (Norwegian); again, syntax was not assessed in this sample.

With respect to syntax, many studies have found that it is related to reading comprehension (Brimo et al. 2017; Cain 2007; Mokhtari & Niederhauser 2013; Muter et al. 2004). A consensus view on how syntax influences reading comprehension is that it permits the identification of the elements of a sentence, which, in turn, helps to determine the topic and general meaning of that sentence. Syntax also contributes in generating the situation model of a text because it allows the reader to relate ideas within and between sentences (Gottardo et al. 2018). The connection between syntax and reading comprehension appears to be robust. Muter et al. (2004) carried out a 2-year longitudinal study of 90 British children during their first 2 years of learning to read. These authors reported that later reading comprehension was predicted by earlier vocabulary and grammatical skills. The relation between syntax and reading comprehension was strong ($r = .61$) and remained so after controlling for phonological awareness, word-level reading and receptive vocabulary. Cain (2007) analysed the role of receptive vocabulary and syntax in a sample of 196 English-speaking children aged 7–8 and 9–10 in which word-level reading, reading comprehension and memory were also evaluated, concluding that the relationship between syntactic knowledge and reading comprehension was indirect and was influenced by a number of factors, one of which was vocabulary. Mokhtari and Niederhauser (2013) also explored the contributions of vocabulary knowledge and syntax to reading comprehension performance. In their group of fifth grade students, both vocabulary and syntax were shown to be explained additional variance in reading comprehension beyond their shared contribution. One possible interpretation of this result is that syntax may mediate the relationship between vocabulary and reading comprehension.

More recently, Brimo et al. (2017) specifically explored the role of syntactic knowledge and syntactic awareness on reading comprehension in a sample of 179 adolescents. Other factors known to influence reading comprehension, such as word-level reading, short-term memory and vocabulary knowledge skills, were also assessed. In line with the results reported by Cain (2007) as well as Mokhtari and Niederhauser (2013), syntax accounted for significant variance in reading comprehension. Vocabulary was the only other significant contributor to reading comprehension.

As can be seen to this point, the role of vocabulary, morphology and syntax on reading comprehension has been broadly assessed. Nevertheless, surprisingly few studies have explored whether these relationships change depending on the type of reader. One exception is the study recently reported by Oslund et al. (2018) who examined reading comprehension in a sample of sixth to eighth grade English-speaking children. As previously noted, as well as a direct effect of vocabulary on reading comprehension, these authors also reported an indirect effect via both silent reading efficiency and inference making ability. However, when the analysis was repeated after dividing the sample into struggling and adequate comprehenders, two findings emerged. First, the direct effect of vocabulary on reading comprehension was almost three times as strong for good comprehenders, compared with struggling comprehenders. This suggests that that adolescents who struggle with reading and typical adolescent readers may differ with respect to the abilities that underpin reading comprehension. Second, although there was no significant difference between the two groups in terms of the direct effect of vocabulary on silent reading, the indirect path from vocabulary to reading comprehension via silent reading was not significant for the struggling comprehenders. Apart from supporting the

idea that struggling and adequate comprehenders may differ with respect to the abilities that underpin comprehension, it also suggests the possible existence of a moderating effect of vocabulary on the relationship between silent reading and reading comprehension.

Lee and Chen (2019) have also reported varying results depending on the reader profile. These authors investigated the effects of reading fluency and vocabulary knowledge in the prediction of reading comprehension among bilingual English–French speaking students in grades 2 and 3. An interaction between reading fluency and vocabulary predicted reading comprehension in grade 3 in both English and French such that vocabulary contributed to reading comprehension for students with moderate to high level of fluency, but it did not contribute to reading comprehension for students with low fluency. The authors offered several possible explanations for this result, including that in grade 3, vocabulary functions as a moderating variable in the relationship between reading fluency and reading comprehension.

In summary, reading proficiency, vocabulary, morphology and syntax are factors that have often been shown to influence reading comprehension in English. However, despite the fact that orthographic consistency has been shown to influence the development of reading comprehension, relatively few studies have examined the development of reading comprehension in orthographies other than English (Caravolas et al. 2019). Consequently, these relationships have been less studied in Spanish, and some questions remain open. First, in shallow languages, such as Spanish and Italian, there is some evidence to suggest that reading ability may moderate the relationship between vocabulary and reading comprehension (Figueroa-Sepúlveda & Gallego-Ortega 2018), although this remains an underexplored area. Second, the link between morphology and reading comprehension in Spanish remains unclear. In similarly aged samples D'Alessio et al. (2019) reported a significant relationship between these two factors whereas Simpson et al. (2020) failed to find such a relationship. Third, although the link between syntax and reading comprehension seems well established, it has been suggested that this relationship may be influenced by vocabulary (Cain 2007), but again, this has not been previously explored in Spanish. More generally, the often reported influence on reading comprehension of variables such as vocabulary, morphology and syntax have rarely been explored with respect to different reading profiles. Recent studies such as those of Oslund et al. (2018) and Lee and Chen (2019) suggest that the strength of these relationships may vary, or interact, depending in the reading profile of the individual. The recognition and understanding of this variation between types of readers is very important in order to adapt instruction and intervention programmes to different readers' profiles.

Aims of the present study

In the present study, the roles of reading proficiency, vocabulary, morphology and syntax in reading comprehension were examined simultaneously among a representative sample of fourth grade school children who varied in their vocabulary levels in order to explore two main areas. First, we were interested in examining the effects of vocabulary, syntactic knowledge, morphological awareness and reading proficiency on reading comprehension in Spanish, a shallow orthography. Although some studies have reported that vocabulary mediates the relationship between morphology and reading comprehension (e.g., Levesque et al. 2017) and between syntax and reading comprehension (e.g., Guo et al. 2011), Spencer et al. (2017) observed that vocabulary may influence reading comprehension

indirectly via other mediating factors. Hence, other studies have evaluated whether the relationship between vocabulary and reading comprehension is mediated by other factors (e.g., D'Alessio et al. 2019). In the present study, we were interested in exploring the relationship between receptive (oral) vocabulary and reading comprehension. Given that oral vocabulary develops before other skills, such as word reading, we were particularly interested to determine if the relationship between vocabulary and reading comprehension was mediated by the other factors known to influence reading comprehension. We hypothesised that there would be a significant direct relationship between vocabulary and reading comprehension and that based on previous literature, this relationship was likely to be mediated by syntactic knowledge and reading ability. In contrast, given the contradictory findings concerning the effect of morphological awareness on reading comprehension in Spanish, we did not a priori form a hypothesis regarding the possible mediating effect of morphology.

Second, we were interested to determine if the influence of syntax and morphology on reading comprehension was moderated by the level of receptive vocabulary. We hypothesised that the relationship between morphology and syntax with reading comprehension could differ depending on the level of vocabulary. If morphology supports the association of novel words to previously learned words via the analysis of morphological similarities within the lexicon, the efficacy of this process would be lessened in children with reduced vocabularies simply because there would be less words present in the lexicon with which to form associations. Consequently, morphology's influence on reading comprehension may be limited in children possessing low vocabulary levels. With respect to syntax, the analysis of the elements of a sentence can provide cues to extract its general meaning compensating the lack of vocabulary, so it was expected that syntax may exert a more important role in reading comprehension of those readers with low vocabulary. To our knowledge, no previous studies have focused on the possible moderating effect vocabulary may exert on the relationship between oral components of language and reading comprehension.

Method

Participants

The initial sample comprised 273 grade 4 students (131 girls and 142 boys) with a mean age of 9 years and 4 months ($SD = 4$ months, range: 7 years and 11 months–10 years and 11 months). None of the participants had been identified by the schools as presenting developmental language disorder nor had received any additional support. The children were recruited from 17 schools, which reduced the likelihood of biases due to school idiosyncrasies and/or socioeconomic status factors. All schools were located in and around the southern Spanish city of Seville. This study was approved by the Andalusian Biomedical Research Committee (regional health administration). All participants had parental and school consent to take part in the study.

Tests and materials

Intelligence. Non-verbal intelligence was assessed using the Spanish version of the Raven Progressive Matrices (Raven et al. 1995). The standard set of matrices was used in this

study. The test consists of 60 abstract diagrams, which have a small section missing. Underneath the diagram are six possible alternatives to complete the diagram. On each trial, the participant is required to indicate the correct response. There is no time limit, and one point is awarded for each correct response. The manual does not provide test–retest or reliability scores for the Spanish population.

Reading aloud. Word and pseudoword reading were evaluated using the subtests of the *Batería de Evaluación de los Procesos Lectores, Revisada* (PROLEC-R; Cuertos et al. 2007). The word reading subtest consists of 20 high-frequency and 20 low-frequency words between five and eight letters long, containing either two or three syllables. One point is awarded for each word read aloud correctly. Additionally, the time in seconds to read the whole list is recorded. A reading fluency measure is calculated by dividing the number of correctly read items by the total reading time and multiplying by 100. The value for Cronbach's alpha provided in the manual is $\alpha = .74$. The 40 items for the pseudoword reading task were created by changing one or two letters from each of the items in the word reading task. Application and scoring of the pseudoword reading task are identical to the word reading task. The value for Cronbach's alpha provided in the manual is $\alpha = .68$.

Receptive vocabulary. The Spanish version of the standardised Peabody Picture Vocabulary Test (PPVT-III; (Dunn et al. 2006) was used. In this test, the child selects one of four pictures to match a spoken word in meaning. There are 192 items in total, and one point is awarded for each correct response. The Spanish version has a value for Cronbach's alpha of $\alpha = 0.91$.

Morphology awareness. The morphology subtest of the *Batería de Lenguaje Objetiva y Criterial – Screening Revisada* (BLOC-SR; Puyuelo et al. 2007) was used. The test evaluates the participants' comprehension and expression of inflectional morphology for regular and irregular verbs, pronouns (personal, possessive and reflexive), comparatives, superlatives and derived nouns. On each trial, the participant sees a picture and the administrator describes the picture. The administrator then changes the phrase slightly and asks the participant for help in finishing the phrase. For example, the participant sees a picture of a child eating an ice cream and hears 'A este niño le gusta mucho comer helados [This boy really likes eating ice cream]'. This is followed by '¿Me ayudas terminar esta frase? Mañana él ... [Can you help me finish this sentence? Tomorrow he ...]', with the correct response being 'will eat an ice cream'. Forty-seven items are administered in total although 15 are demonstration items and are not awarded points. Accordingly, the maximum possible raw score is 32. The manual states that the reliability is high – Cronbach's alpha is $\alpha = 0.86$.

Syntactic knowledge. The *Test de Comprensión de Estructuras Gramaticales* (CEG; Mendoza et al. 2005) was used. This test was inspired by the Test for the Reception of Grammar (TROG; Bishop 1983) and is similar in format to the PPVT. On each trial, the participant that hears spoken phrase is required to indicate which of the four pictures best represents the spoken phrase. There are 80 items, and one point is awarded for each correct response. The manual states that Cronbach's alpha is $\alpha = 0.91$.

Text comprehension. The text comprehension subtest of the *Test de lectura y escritura en Español* (LEE; Defior et al. 2006) was used. The participant has to read three texts and

answer several questions about their contents. The texts for fourth grade are one narrative and two expository texts. For each text, the participant has to answer three literal questions about explicit information in the text and three inferential questions. The questions can be answered reading again the text, but in this case, this behaviour is noted. The subtest also includes a task of selecting a title and choosing an abstract for each text. The total punctuation ranges from 0 to 48 (0 to 16 for each text). The manual states that Cronbach's alpha for fourth grade is $\alpha = 0.72$.

Procedure

Evaluations took place within schools during children's normal class time, and children were evaluated individually in three separate sessions. In the first session, non-verbal intelligence (Raven) was evaluated. In the second session, children were evaluated on word reading (PROLEC-R), followed by text comprehension (Test LEE). Receptive vocabulary (PPVT), receptive syntax (CEG) and morphology (BLOC) were evaluated in the final session. Testing order was the same for all children, and is as described above, except for session 3, in which the testing order was randomised.

Analysis plan

The conceptual model examined by our analyses is presented in Figure 1. Given that receptive vocabulary starts to develop before reading, we think that receptive vocabulary influences other variables related to reading (path a). In this study, the variables evaluated are morphology, syntax, word reading and pseudoword reading. These in turn will influence reading comprehension (path b). Thus, the relation between receptive vocabulary and reading comprehension will be mediated by these variables. Nevertheless, we expect that receptive vocabulary will directly influence reading comprehension above and beyond the mediating effects of these other variables (path c). Finally, we think that the strength of the relation between reading comprehension and variables such as morphology and syntax may be moderated by receptive vocabulary (path d). That is, the degree to which variables such as morphology and syntax influence reading comprehension may be influenced by the oral language profile of each child. To assess the hypothesised paths by which receptive vocabulary might influence reading comprehension, we undertook correlational,

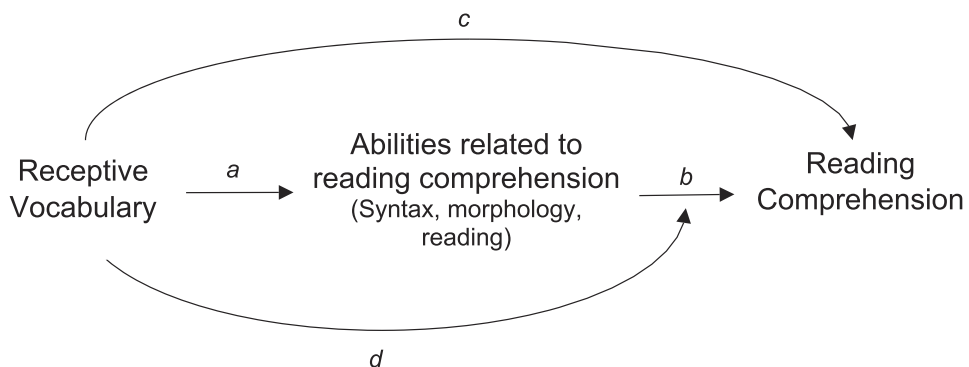


Figure 1. Conceptual representation of the analyses undertaken.

mediational and moderational analyses, leading us to develop moderated mediation tests of our model.

Results

Correlational analyses

Descriptive statistics for all variables for the 273 children and correlations between them are shown in Table 1. All variables were significantly correlated with reading comprehension, and all correlations were of approximately medium strength (r s ranging from .30 to .44), with the exception of the correlation involving pseudoword reading, which was small-to-medium in strength ($r = .22$). The correlation between vocabulary and syntactic knowledge ($r = .44$) was approximately twice as strong as the correlations between vocabulary and word reading, pseudoword reading and morphological awareness (.18, .18 and .24, respectively). Similarly, the correlation between syntactic knowledge and reading comprehension ($r = .44$) was stronger than the correlations found between reading comprehension and all of word reading, pseudoword reading and morphological awareness (.30, .22, and .25, respectively).

Relationship between vocabulary and reading comprehension

To achieve our first objective, that of evaluating the direct effects of reading, syntax and morphology along with the direct and indirect effects of receptive vocabulary on reading comprehension, the model shown in Figure 2 was evaluated. Conceptually, this model is equivalent to a parallel multiple mediator regression model (Hayes & Rockwood 2017) in which receptive vocabulary is the predictor variable, text comprehension is the outcome variable, non-verbal IQ is a covariate, and all other variables serve to mediate the relationship between receptive vocabulary and text comprehension. The data were analysed in SPSS version 20 using macro PROCESS (version 3.4.1; Hayes n.d.) specifying the option 'model = 4'. Prior to performing the analyses, the data were standardised, and the model was evaluated with bootstrap confidence intervals using 10,000 samples, and mean centring of all variables.

Standardised coefficients for the model are shown in Table 2. Receptive vocabulary indirectly influenced reading comprehension through its effect on word reading ability. Children with higher vocabulary had better word reading proficiency ($\beta = .157$), and children with better word reading efficiency had better text comprehension ($\beta = .222$). The bootstrapped confidence interval for this indirect effect ($\beta = .034$) was entirely above zero (.001 to .083). Vocabulary also indirectly influenced reading comprehension through its effect on syntactic knowledge. Children with higher vocabulary had better syntactic knowledge ($\beta = .374$), and children with better syntactic knowledge had better text comprehension ($\beta = .232$). The bootstrapped confidence interval for this indirect effect ($\beta = .087$) was entirely above zero (.036 to .152).

In contrast, although children with high vocabulary were more proficient at pseudoword reading ($\beta = .207$) and had better morphological awareness ($\beta = .132$), there was no evidence that either pseudoword reading or morphological awareness directly influenced reading comprehension. Thus, there was no evidence to suggest that the effect of vocabulary on reading comprehension was mediated by either pseudoword reading or

Table 1. Descriptive statistics and correlations for study variables.

Variable	Descriptive statistics			Correlations						
	Max	Mean	(SD)	Range	1	2	3	4	5	6
	Possible	Raw	Std	Raw	NVI	WRF	PWRF	MA	SK	RV
1. Non-verbal intelligence (NVI)	60	37.4	(6.15)	12-52	<5-95	-	-	-	-	-
2. Word reading fluency (WRF)	n/a	107.8	(31.71)	27-222	SD-H ^a	.08	-	-	-	-
3. Pseudoword reading fluency (PWRF)	n/a	60.2	(16.04)	21-136	SD - H ^a	.05	.73***	-	-	-
4. Morphological awareness (MA)	32	22.8	(4.35)	8-32	1-99	.35***	.16**	.12*	-	-
5. Syntactic knowledge (SK)	80	70.1	(5.06)	52-79	1-99	.36***	.28***	.27***	.35***	-
6. Receptive vocabulary (RV)	192	116.2	(15.04)	60-169	0.1-99.9	.34***	.18**	.18**	.24***	.44***
7. Text comprehension	48	39.0	(5.84)	13-48	10-90	.31***	.30***	.22***	.25***	.44***

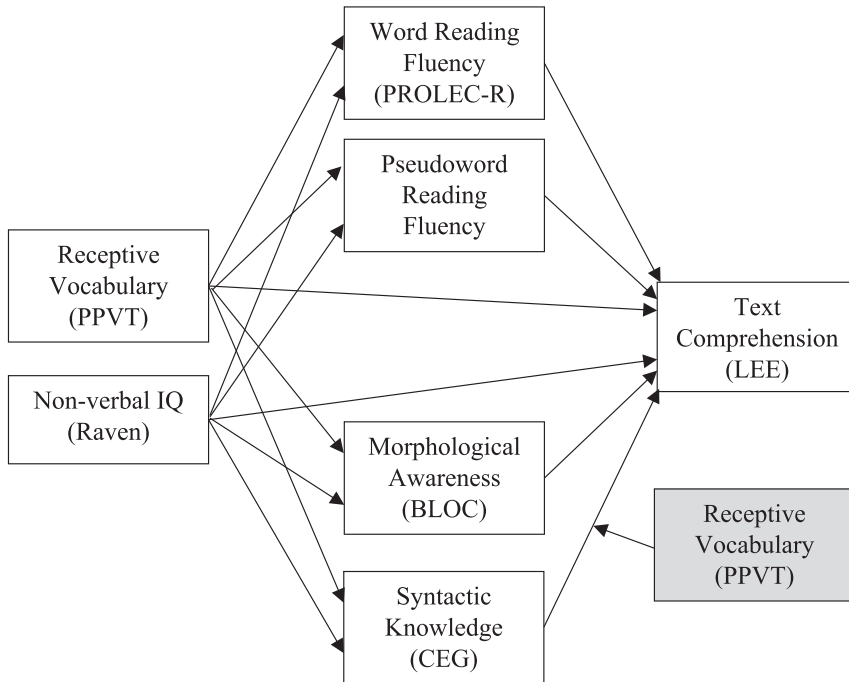
Note. Max possible = the maximum possible score achievable in each task. *SD* = standard deviation. Raw = raw score. Std = standardised percentile scores in the range of 1-100, unless otherwise noted. n/a, not applicable.

For the PROLEC-R word reading and pseudoword reading sub-tasks the manual provides only descriptive standardised scores. The full range of descriptive scores are severe difficulty (SD), mild difficulty (MD), low (L), medium (M), and high (H). The three categories from low to high are considered to encompass the typically developing range.

* $p < .05$.

** $p < .01$.

*** $p < .001$.



Note. Model 1 consisted of all of the unshaded boxes along with the connecting arrows. The shaded box represents the addition made to form Model 2 to test for the mediation effect of vocabulary.

Figure 2. A parallel multiple mediator regression model to evaluate the effects of reading fluency, morphological awareness, syntactic knowledge and receptive vocabulary on reading comprehension, including a possible mediating effect of receptive vocabulary.

Note. Model 1 consisted of all of the unshaded boxes along with the connecting arrows. The shaded box represents the addition made to form model 2 to test for the mediation effect of vocabulary.

morphological awareness. Bootstrapped confidence intervals for these two indirect effects support the conclusion about a lack of an indirect effect of vocabulary on reading comprehension via pseudoword reading or morphological awareness.

Finally, in addition to the significant direct effects of word reading and syntactic knowledge on reading comprehension already mentioned, vocabulary also directly influenced reading comprehension ($\beta = .233$) independent of the previously described mediated effects. Thus, the total effect of vocabulary on reading comprehension was $\beta = .354$, with approximately one third of the effect being made up of indirect effects via syntax and word reading proficiency.

Moderating effects of vocabulary

Our second objective was to assess the possible moderating effect of receptive vocabulary on the relationships between syntax and morphology with reading comprehension. However, given the non-significant result between morphology and reading comprehension in

Table 2. Standardised coefficients for model 1 – used to evaluate the direct effects of reading fluency, morphological awareness and syntactic knowledge along with the direct and indirect effects of receptive vocabulary on reading comprehension.

Paths	β	p	95% CI
Paths controlling for non-verbal IQ			
Non-verbal IQ → Word reading	.022	.736	-.105, .149
Non-verbal IQ → Pseudoword reading	-.034	.599	-.160, .093
Non-verbal IQ → Syntactic knowledge	.231	<.001	.118, .344
Non-verbal IQ → Morphological awareness	.302	<.001	.181, .423
Non-verbal IQ → Reading comprehension	.103	.087	-.015, .220
Direct paths			
Vocabulary → Word reading	.157	.017	.028, .287
Word reading → Reading comprehension	.222	.005	.068, .376
Vocabulary → Pseudoword reading	.207	.002	.078, .335
Pseudoword reading → Reading comprehension	-.058	.457	-.213, .096
Vocabulary → Syntactic knowledge	.374	<.001	.259, .489
Syntactic knowledge → Reading comprehension	.232	<.001	.107, .357
Vocabulary → Morphological awareness	.132	.036	.009, .254
Morphological awareness → Reading comprehension	.051	.385	-.064, .165
Vocabulary → Reading comprehension	.233	<.001	.112, .354
Indirect paths			
Vocabulary → Word reading → Comprehension	.034		.001, .083
Vocabulary → Pseudoword reading → Comprehension	-.012		-.046, .018
Vocabulary → Syntactic knowledge → Comprehension	.087		.036, .152
Vocabulary → Morphological awareness → Comprehension	.007		-.010, .026

Note. The macro PROCESS does not provide p values for indirect paths, but significance can be inferred from the confidence intervals – confidence intervals containing zero indicate non-significant paths.

the previous analysis, this relationship was not explored any further. Hence, to assess the possible moderating effect of vocabulary, the model shown in Figure 2 was modified to include moderation from vocabulary along the syntax → comprehension path. The shaded box in Figure 2 indicates the change made to model 1 to evaluate this possible mediating effect. Within the macro PROCESS, this would be very similar to option ‘model = 14’, although the WMATRIX option was required to exclude moderation of the non-significant path from morphological awareness to reading comprehension.

Results of this analysis are shown in Table 3. Given that moderation was added to just one path, which is directly connected to reading comprehension, paths that do not directly influence reading comprehension have been omitted from the table as they retain the same β and p values as model 1.

Table 3. Standardised coefficients of direct paths to reading comprehension along with simple slopes analyses for model 2 to assess the possible moderating effect of receptive vocabulary.

Paths		β	p	95% CI
Control and insignificant paths from model 1				
Non-verbal IQ	→ Comprehension	.111	.067	-.008, .230
Pseudoword reading	→ Comprehension	-.053	.497	-.208, .101
Morphological awareness	→ Comprehension	.041	.483	-.074, .157
Paths of interest				
Word reading	→ Comprehension	.216	.006	.061, .371
Syntactic knowledge	→ Comprehension	.219	.001	.092, .347
Vocabulary	→ Comprehension	.228	<.001	.106, .349
Simple slopes analyses of the moderation				
Syntactic knowledge X vocabulary (-1SD vocabulary)		.261	<.001	.124, .399
Syntactic knowledge X vocabulary (mean vocabulary)		.219	<.001	.092, .347
Syntactic knowledge X vocabulary (+1SD vocabulary)		.177	.035	.013, .341

The direct paths influencing reading comprehension have not changed greatly between models 1 and 2. However, more relevant to the issue of moderation are the simple slopes analyses. As per our expectations, syntax exerted a stronger influence on reading comprehension in children with lower levels of vocabulary (from $\beta = .259$ for children with vocabulary 1 *SD* below the mean to $\beta = .178$ for children with vocabulary 1 *SD* above the mean). To further probe for possible moderation effects of vocabulary, follow-up analyses to identify possible Johnson–Neyman significance regions were undertaken (Hayes 2017). This form of analysis can reveal distinct regions in the data where the relationship under investigation transitions between statistically significant and non-significant values.

A Johnson–Neyman point was identified when vocabulary was equal to +1.1. Taken together with the simple slopes analysis, the conclusion is that there is a significant relationship between syntactic knowledge and reading comprehension for children with vocabulary scores lower than 1.1 *SDs* above the mean (approximately 87% of the sample). Furthermore, the strength of this relationship is inversely proportional to vocabulary levels such that the benefit to reading comprehension of improved syntactic knowledge is greatest for children with low vocabulary. In contrast, for children with vocabulary scores above 1.1 *SDs* of the mean (approximately 13% of the sample), changes in levels of syntactic knowledge did not exert significant influence on reading comprehension.

Discussion

In this study, we analysed 4th grade students' levels of receptive vocabulary, reading proficiency, morphology and syntax in relation to their reading comprehension while controlling for non-verbal IQ to explore two main areas. First, we were interested to see if the relationship between vocabulary and reading comprehension was mediated by reading proficiency, syntactic knowledge or morphological awareness. Our second aim

was to examine whether the relationships of morphology and syntax with reading comprehension differed depending on the level of vocabulary. To our knowledge, no previous studies have focused on analysing the moderating effect of vocabulary on the relationship between reading comprehension and factors such as syntactic knowledge and reading proficiency.

As in previous studies (Joshi 2005; Oslund et al. 2018; Verhoeven & van Leeuwe 2008), and specifically in Spanish-speaking children (Figueroa-Sepúlveda & Gallego-Ortega 2018; Suárez et al. 2010), our data showed that vocabulary played a statistically significant role as a predictor of reading comprehension in typical readers. These data are consistent with what is proposed by the simple view of reading model. However, we were able to show that the effect of vocabulary is both direct and indirect. Approximately one third of vocabulary's influence on reading comprehension is mediated by reading proficiency and syntactic knowledge.

In terms of reading proficiency, word reading but not pseudoword reading was a significant predictor of reading comprehension. Although some studies have previously shown that both factors are related to reading comprehension (e.g., Calet et al. 2015), in other studies where additional factors are taken into account, such as morphological awareness and vocabulary, the effects of pseudoword reading generally disappear (e.g., D'Alessio et al. 2019; Simpson et al. 2020). Age is also an important factor when assessing the abilities that influence reading comprehension. For example, in Ricketts et al.'s (2020) longitudinal study, word reading at 12 years was not a predictor of growth in reading comprehension in English over the subsequent 2 years. Given that Spanish is a shallow language in which all words can be read aloud correctly using a small set of grapheme-to-phoneme conversion rules, by grade 4 there is far less variability in pseudoword reading ability, and hence, its relevance in terms of a predictor of reading comprehension diminishes. This is borne out in Calet et al.'s study in which the strength of the relationship between pseudoword reading and reading comprehension diminished from $\beta = .50$ in grade 2 to just $\beta = .15$ in grade 4. Taking into account the age of our participants (grade 4 students) and the fact that we included factors like morphological awareness and vocabulary in the model, it is not surprising that pseudoword reading was not related to reading comprehension.

Turning now to morphology, this factor did not play a significant role in reading comprehension despite the fact that these two factors were weak-to-moderately correlated. Although previous studies have found direct and indirect associations between morphology and reading comprehension (Kirby et al. 2012; Levesque et al. 2019), these studies have usually been undertaken in English (Levesque et al. 2021). Nevertheless, a link between morphology and reading comprehension in Spanish-speaking children has also been reported in some (e.g., D'Alessio et al. 2019), but not all studies (e.g., Simpson et al. 2020). D'Alessio et al. argued that the relationship between morphology and reading comprehension represents the fact that morphology provides access to the semantic and syntactic information of new words. However, these authors did not control for syntactic knowledge. This is important because a recent study carried out by Simpson et al. (2020) with Spanish-speaking children reported that the relationship between morphology and reading comprehension disappeared once levels of syntactic knowledge were controlled. The present study also controlled for syntactic knowledge, and this potentially explains the discrepancy with the results reported by D'Alessio et al.

With respect to syntax, the present study found a significant influence of syntactic knowledge on reading comprehension (after controlling for factors such as non-verbal

IQ, vocabulary, morphological awareness and reading ability). Considering that syntax is part of the oral language domain, our results could be interpreted as support of models such as the simple view of reading, which consider that oral language influences reading comprehension. This result is not surprising given that it is line with many previous studies that have emphasised the role of syntax on reading development (Brimo et al. 2017; Cain 2007; Mokhtari & Niederhauser 2013; Muter et al. 2004). Thus, while this result for syntax is unsurprising, the novelty came when we explored our second aim – to examine whether the relationship between syntax and reading comprehension was moderated by vocabulary. We hypothesised that syntax could exert a more important role in reading comprehension of those readers with low vocabulary levels because in these readers the analysis of the elements of a sentence could provide the cues to extract its general meaning compensating their scarce of vocabulary. The results confirmed our hypothesis as they have shown that the relationship between syntactic knowledge and reading comprehension is stronger for children with lower vocabulary scores. Furthermore, the strength of this relationship is inversely proportional to vocabulary levels, indicating that increased syntactic knowledge would provide most benefit to reading comprehension for those children with the lowest vocabulary levels (children who have to compensate their word knowledge with other strategies, such as syntactic analysis).

Given that the reading population is heterogeneous with respect to oral language skills, our results imply that not all readers require the same intervention to improve their reading comprehension. To the best of our knowledge, this is the first study that sheds light on this issue and the results have implications for instruction. Our findings address the relative contributions of language skills to reading comprehension of low vocabulary readers. Given that the strongest relationship found between syntax and text comprehension is in children with the low receptive vocabulary, this result suggests that longitudinal research is necessary to explore the possibility that a syntax intervention might be beneficial for readers with low oral vocabulary.

Another contribution of this study concerns the separated analyses of different components of language skills (vocabulary, morphology and syntax). As Brimo et al. (2017) point out, researchers frequently study reading comprehension analysing ‘language skills as a combined factor’ (p. 68), and this makes it impossible to identify specific components of language that should be targeted in the intervention. The combination of a range of different readers according to their proficiency in vocabulary, and different components of language, helps us to determine the specific grade of influence of each language domain on reading comprehension of children with different vocabulary profiles.

As well as these contributions, we must acknowledge several limitations to this study. First, when assessing mediated relationships, for example, whether variable *X* exerts an effect on variable *Y*, and whether this is mediated by variable *M*, a mathematically equivalent evaluation is to assess if variable *M* exerts an effect on variable *Y*, and whether this is mediated by variable *X*. That is, the relationships within the models are correlations, and thus, no conclusion can be made about causality. This point is well made by Lee and Chen (2019) who offer the following two seemingly contradictory explanations to account for their finding that an interaction between reading fluency and vocabulary predicted reading comprehension. It is possible that ‘fluency functions as a moderating variable in the relationship between vocabulary and reading comprehension’ (p. 1674) and second, it is possible that ‘vocabulary acts as a moderating variable in the relationship between reading fluency and reading comprehension’ (p. 1674). In general, attempts to resolve competing explanations such as these require that the model be grounded in a previous

theory. A problem arises at this point because as noted in the introduction, there is no agreement in the field as to exactly how the variables of interest in this study are related. That is, some studies use vocabulary to mediate other relationships involving reading comprehension (e.g., Levesque et al. 2017) whereas others evaluate the relationship between vocabulary and reading comprehension mediated by other variables (e.g., D'Alessio et al. 2019). Factors that influence how vocabulary is included in each model include how vocabulary is measured (oral vs written; expressive vs receptive) and the specific research goals of each study. As explained in the introduction, we were interested in exploring factors that may mediate the relationship between vocabulary and reading comprehension, and this was partly motivated because we assessed *receptive* vocabulary. Related to this point is the fact that our data were collected concurrently. Future studies could try to disentangle these issues by undertaking longitudinal studies, which provide a firmer footing to infer causality. Additionally, in relation to the generalizability of our results, the sample consisted of just fourth grade students. Thus, caution should be used in extending these findings to children of other ages or grades.

In conclusion, in this study, we have found that syntax and word reading proficiency-mediated vocabulary's effect on reading comprehension and that the relation among syntactic knowledge and reading comprehension differs depending on the level of vocabulary exhibited, being stronger in those children with lower vocabulary.

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Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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