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The impact of vocabulary, grammar and decoding on reading comprehension among children with SLI: a longitudinal study

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ABSTRACT

Predictors of reading comprehension among children with SLI have been rarely studied in Spanish. Even more sparse are longitudinal studies inspecting the evolution of their reading abilities. The aim of the present study is to inspect how decoding, production of grammatical/ungrammatical sentences, production of simple/complex sentences, and vocabulary (measured with two instruments) predict reading comprehension among Spanish-speaking monolingual school-age children with SLI in two grades: 2nd grade and 4th grade. Forty-eight children were recruited for this study, evenly grouped in two conditions: SLI and Typical. Groups were balanced by gender with no differences in months of age. All children were assessed twice: when in 2nd grade and when in 4th grade. Several multiple regression analyses were conducted. Findings revealed differences in terms of which particular predictors significantly impacted reading comprehension in each group. Vocabulary and syntax complexity are the most consistent predictors of reading performance. Decoding predicted reading comprehension performance only in the observed early stage (2nd grade), becoming non-significant over time. Grammaticality was found to have no impact on reading comprehension in both groups. Reported results suggest that vocabulary and complex syntax solidly predict reading comprehension, while decoding and grammaticality play a minor or even negligible role. Thus, interventions designed to improve reading comprehension among children with SLI might benefit from targeting these two particular dimensions of language.

1. Introduction

Proficient reading involves several linguistic skills. Phonological awareness, for instance, is a critical skill that allows children to learn decoding (Muter et al., 2004). Morphology, syntax, vocabulary, and discourse also play an essential role in reading comprehension (Roth et al., 2002). Crucially, linguistic skill impairment among preschoolers is known to be a risk factor that can hinder their future reading performance (Catts, 1993). Since children with SLI usually perform low on linguistic dimensions strongly related with reading (such as phonology, vocabulary and grammar), they are also likely to underperform when learning to read (Bishop & Adams,

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1990; Botting et al., 2006; Catts et al., 2002). In fact, literature consistently reports diminished reading performance among children with SLI who speak a variety of languages (Aguilar-Mediavilla, Buil-Legaz, Pérez-Castelló, Rigo-Carratalà & Adrover-Roig, 2014; Botting et al., 2006; Brizzolara, Gasperini, Pfanner, Cristofani, Casalini & Chilosi, 2011; Nithart, Demont, Majerus, Leybaert, Poncelet & Metz-Lutz, 2009).

Bishop & Snowling (2004) advanced the Partial Distinction Hypothesis to explain how linguistic deficit impacts reading comprehension among children with SLI. This hypothesis states that children with SLI who perform poorly with respect to phonological awareness will likely perform poorly on word recognition. Also, their problems in dimensions such as vocabulary, grammar, and discourse make them prone to score low in reading comprehension (Adlof, Tiffany & Hogan, 2018). Consequently, within this framework, children with SLI are expected to perform poorly both in decoding and in reading comprehension. However, some findings are inconsistent with the Partial Distinction Hypothesis inasmuch as children with SLI have been reported to be more challenged by reading comprehension than by decoding (Bishop & Adams, 1990; St. Clair et al., 2010). Bishop, McDonald, Bird & Hayiou-Thomas (2009) reported children with SLI to perform poorly on reading comprehension, but within normal limits on decoding. Kelso, Fletcher & Lee (2007) studied reading patterns in a sample of children with SLI and reported two distinct profiles: a) Children performing low in decoding and reading comprehension and b) Children performing normally in decoding and low in reading comprehension. This latter profile reveals specific reading-comprehension problems. Children with mixed reading disability perform poorly both in phonological measures, receptive vocabulary, and grammar comprehension, while children with specific reading comprehension impairments perform adequately in phonological measures but low in receptive vocabulary and grammar comprehension (Kelso et al., 2007).

The literature is still somewhat limited with respect to longitudinal studies that have addressed the relationship between linguistic deficits and the development of reading (but see Catts et al., 2008 for a study in English speaking children). Of particular interest to the current study is the question of how the impact of linguistic deficits on reading develops over time. Thus, the goal of our study is precisely to examine this. A handful of the existing longitudinal studies have shed light on issues such as how reading develops and which abilities best predict decoding and reading comprehension over time. It has been shown that during children's development, reading problems are directly tied to the persistence of linguistic problems. Bishop and Adams (1990) assessed children with SLI at 4, 5, and 8 years of age and found that children performing low on oral language measures both at age 4 and 5 also performed low in reading when they were 8. However, children who performed low on oral language measures at age 4, but who were within the normal range at age 5, attained normal reading levels by age 8. Similarly, Catts et al. (2002) conducted a longitudinal study observing kindergarten children with language impairments. By 2nd grade, some children still had linguistic problems, while some others had attained a linguistic performance within normal range. They found that children with persistent linguistic problems performed significantly lower on reading than children who had improved on linguistic measures, both in 2nd grade and in 4th grade.

Longitudinal studies have also shown that despite consistently lower performance on decoding and reading comprehension by children with SLI, the growth trajectory of these dimensions is similar to children with typical language development. Catts et al. (2008) studied children with SLI and children with Typical Language Development (TLD) up to 10th grade. They reported that both word recognition and reading comprehension among children with SLI were consistently lower in all grades. However, skill trajectories were similar in both groups, with accelerated improvement between fourth and eighth grade and deceleration between eighth and tenth grade. St. Clair et al. (2010) reported similar findings. They showed that, both in decoding and reading comprehension, students with SLI consistently performed below typical norms until 16 years of age. As for the development of these skills, they were shown to improve sharply during childhood to subsequently decelerate during adolescence. Reading performance often becomes stable around 16. This study further confirms that students with SLI follow a reading trajectory similar to that of children with TLD.

As for the linguistic predictors of decoding and reading comprehension, literature suggests that these dimensions rest on different abilities, with their specific impact changing over time. A longitudinal study by Catts (1993) assessed the syntactic and semantic performance of children with SLI during kindergarten. Children's reading comprehension was subsequently assessed during their first years of elementary school. Whether expressive or receptive, kindergarteners' syntactic and semantic skills were found to significantly predict future reading comprehension performance. The study also found that phonological awareness and naming speed during kindergarten are the best predictors of decoding performance during early elementary school. Similar results were found in a longitudinal study conducted by Botting et al. (2006). The authors reported that narrative production and receptive grammar among children with SLI aged 7 were the best predictors of their reading comprehension at aged 11. St. Clair et al. (2010) reported that both expressive and receptive language abilities significantly predict future reading comprehension, with expressive language reportedly being the strongest predictor.

In summary, the literature suggests that children with SLI struggle with both decoding and reading comprehension. Developmental patterns of children with SLI and children with TLD are similar in terms of reading skills development, with children with SLI usually and consistently performing lower than children with TLD. Decoding and reading comprehension are supported by different abilities which impact changes over time. While decoding rests on phonological dimensions, reading comprehension relies primarily on syntactic and semantic dimensions. However, these findings are relative to non-Spanish-speaking children. To our knowledge, no longitudinal studies have been conducted with monolingual Spanish-speaking children with SLI. Thus, one aim of our study is to examine the longitudinal course of reading in monolingual Spanish-speaking children with SLI.

1.1. Reading disabilities among Spanish-speaking children with SLI

Evidence about reading processes and development has mainly been gathered among English-speaking children with SLI

(Brizzolara et al., 2011). However, English is an orthographically opaque (as opposed to transparent) language. The opaque/transparent language distinction found in the literature poses that transparent languages allow a rather consistent mapping between sounds and graphemes, unlike opaque languages with inconsistent mapping. Thus, the question remains as to whether the reading patterns observed for English-speaking children remain the same in some other transparent languages, like Spanish. The question is relevant inasmuch as children speaking transparent languages might learn to decode at a faster pace than children speaking opaque languages (Catts, 2018). Since Spanish is a highly transparent language, this may lead to different reading patterns than the ones reported for English speakers.

Research on reading-related problems among Spanish-speaking children with SLI is not as abundant as the research on English-speaking children with SLI (see Acosta et al., 2016). Studies involving Spanish-speaking children with SLI have focused on reading profiles, the development of reading comprehension and decoding processes, and topics such as determining which linguistic dimensions better predict decoding and reading comprehension. It is worth mentioning that studies have been conducted both with monolingual and bilingual children with SLI.

Four reading profiles have been established in the Spanish language literature, based on performance in decoding and reading comprehension. Three profiles of reading impairment have been established in children with SLI: a) performing low in reading comprehension; b) performing low in both reading comprehension and decoding; and c) performing low in decoding. It should be noted that it is rather uncommon that children with SLI reported in these studies only have a decoding deficit (Buil-Legaz et al., 2015; Coloma, Caroca, Kurte, Melipil, Ortiz & Quezada, 2018).

Evidence about the development of decoding and reading comprehension seems to confirm that reading comprehension is a core problem for Spanish-speaking children with SLI. Buil-Legaz, Aguilar-Mediavilla & Rodríguez-Ferreiro (2016) found that eight-year old bilingual children with SLI (Catalan-Spanish) performed significantly lower than children with TLD, both in decoding and reading comprehension. By the age of 12, however, differences remained significant only for reading comprehension. Another study (Sanz-Torrent et al., 2010) examining eleven-year old Catalan-Spanish bilingual students reported that children with SLI struggled with both decoding and reading comprehension, but that their reading comprehension performance was particularly low. Cross-sectional studies with monolingual Spanish-speaking children with SLI report similar results. Children in 1st grade perform low both in decoding and reading comprehension (Coloma et al., 2015a; Coloma et al., 2015b; De Barbieri et al., 2016). However, by 4th grade their decoding problems have receded, but their comprehension remains hindered (Lafont, 2018). Moreover, Acosta et al. (2016) maintain that the presence of reading impairment in Spanish-speaking children with SLI occurs regardless of the particular type of deficit (expressive-only or both expressive and receptive).

In sum, findings reveal that while reading comprehension problems tend to persist over time, decoding problems tend to be transient. As students with SLI reach the later years of their primary education, decoding problems are likely to either disappear or become much less severe. Spanish's transparent orthography might help them approach decoding tasks efficiently.

Finally, linguistic predictors of decoding and reading comprehension have been studied among bilingual children (Catalan-Spanish). Aguilar-Mediavilla et al. (2014) reported that, for children with SLI at age 6, phonological awareness was the best predictor of future reading performance (at 8 years of age), and that vocabulary, measured at 6 years of age, significantly predicted future reading comprehension (at 8 years of age). The same children were assessed a few years later, at age 12, and semantic fluency was found to be the only dimension significantly predicting reading comprehension (Buil-Legaz et al. 2015).

Since studies focused on reading among Spanish-speaking children are scarce and longitudinal studies are even scarcer, more evidence is needed to confirm the conclusions implicit in the available literature. It is particularly important to ascertain whether reading comprehension problems are indeed more persistent than decoding problems as children grow older and progress through school.

Taken together, the aims of this study are: 1) to describe performance in decoding and reading comprehension in monolingual Spanish-speaking students with SLI, both when in 2nd and 4th grade; 2) to measure the impact of vocabulary, grammar, and decoding performance on reading comprehension in children with SLI during 2nd and 4th grade and; 3) to determine whether vocabulary, grammar, and decoding performance of children with SLI in 2nd grade can predict their reading comprehension in 4th grade.

2. Methods

2.1. Participants

2.1.1. Sample

The sample consisted of 48 children: 24 children with SLI (10 female and 14 male) and a control group of 24 children with TLD (10 female and 14 male). Children with TLD performed typically on academic achievement given their grade and were within normal range on language measures. All participants were assessed twice: when attending 2nd grade and when attending 4th grade. Participants' socio-economic status (SES) was determined based on the standards provided by the Chilean Ministry of Education (Agencia de Calidad de la Educación, 2012). These standards translate into three groups: group A (parents with 8 years of schooling on average and a US$214 monthly household income), group B (parents with 10 years of schooling on average and a US$316 monthly household income), and group C (parents with 12 years of schooling on average or more and a US$482 monthly household income). Most students attended private government-subsidized schools. A few children attended public schools. The average socio-economic status of students in subsidized private schools is "group C" and the average socio-economic status of students in public schools is "group A". Table 1 provides demographic data for both groups.

Children's parents/caregivers signed an informed consent form authorizing participation in the research study. The study and

Table 1
Demographic Data by Grade

	Second grade		Fourth grade	
	SLI	TLD	SLI	TLD
Gender				
Female	10	10	10	10
Male	14	14	14	14
Age	7. 7	7.5	9.6	9.6
School Type				
Public schools	3	5	3	5
Subsidized private schools	21	19	21	19

consent form were approved by the Ethics Committee of the University of Chile School of Medicine.

2.1.2. Selection criteria

Children with SLI were selected from a group of students attending educational institutions with "school integration programs" (in Spanish, Programas de Integración Escolar, PIE). These programs were conceived in Chile to allow children with special needs to attend the same schools that those without special needs attend, since regular schools very often prevent children with any kind of impairment from enrolling. Participants from these schools had been previously diagnosed with SLI when attending kindergarten, when they were approximately five years old. The diagnoses were determined by speech-language pathologists in all cases and were based on standard guidelines issued by Chilean Ministry of Education (Ministerio de Educación, 2010). These guidelines state that for SLI to be diagnosed, children must exhibit grammatical problems. Pedagogical and psycho-pedagogical evaluations need to be conducted in order to dismiss any other disorders that might affect linguistic learning. The mandatory diagnostic battery for SLI includes two instruments, one of them being Allen Toronto's Exploratory Test of Spanish Grammar (Pavez, 2010, used to assess grammar). In this study, children with SLI were selected based exclusively on their grammar performance, as captured by this instrument.

Allen Toronto's Exploratory Test of Spanish Grammar (ETSG, Pavez, 2010) is an instrument consisting of two subtests: an expressive subtest and a receptive subtest, both totaling 23 items each. Sub-tests consider the following linguistic forms: sentences (affirmative, negative, and passive), pronouns (personal, indefinite, demonstrative, relative, and interrogative), verbs (verb tense, third-person verb, linking verbs), and finally possessive and interrogative adjectives. The grammatical dimensions assessed by this test are consistent with the problems typically present in Spanish-speaking children with SLI, inasmuch as they usually struggle with function-words and verbs (Anderson & Souto, 2005; Bedore & Leonard, 2005; Morgan et al., 2013), as well as with sentence-grammaticality (Coloma et al., 2016).

When engaged in the expressive task, children must repeat sentences that become increasingly longer and more syntactically sophisticated. When engaged in the receptive task, children have to select, from a four-image set, the one image that best depicts a previously heard sentence. The score is subsequently contrasted against the test's norms to place a given child within a particular performance level (normal, at risk, or deficit).

This test has been shown to differentiate children with SLI from children with TLD based on grammatical performance. Pavez (2010) reports that the test's final version was used to compare 30 children with SLI against 30 children with TLD. Children with SLI were found to perform significantly lower than children with TLD ($t(58) = -3.42$, $p < .001$, receptive sub-test; $t(58) = -7.57$, $p < .001$, expressive subtest). Additionally, this test has been used in a range of studies observing Chilean children with SLI, successfully identifying SLI in highly controlled genetics-related studies (De Barbieri et al., 2018; Villanueva, Palomino, & Palomino, 2008; Villanueva et al., 2011), as well as in studies from other fields (Alfaro-Faccio et al., 2016; Allende et al., 2015; Martínez, Bruna, Guzmán, Herrera, Valle, & Vásquez, 2002; Schonhaut et al., 2008).

Reliability was inspected by correlating test/retest scores. Pearson's correlation coefficients are $r(59) = 0.77$ for the expressive subtest, and $r(59) = 0.83$ for the receptive subtest (Pavez, 2010), both coefficients being acceptable (Hernández, Fernández & Baptista, 2010).

In summary, MINEDUC guidelines specify that a child will be diagnosed with SLI whenever their scores on either the receptive or the expressive subtest of the ETSG are at deficit level (MINEDUC, "Decreto Supremo N° 170, 2010). It is worth mentioning that even if assessed, phonology was not used to discriminate children with SLI. Selection was based on grammar, non-linguistic cognitive skills, and hearing. Table 2 details criteria used to diagnose children with SLI.

All children with SLI scored within deficit level in the grammar dimension, that is, < 26 (expressive) and < 35 (receptive) in Allen Toronto's Exploratory Test of Spanish Grammar.

Children with TLD were classmates of children with SLI attending the same schools and taking the same courses. They were selected by asking children's teachers to provide a list with all the children they considered as performing typically in terms of academic achievement and having no language or learning problems.

Once all suitable children with SLI and with TLD were identified, they were all screened to ensure that their non-verbal cognition and their hearing were within normal levels. Non-verbal cognition was assessed using Raven's Colored Progressive Matrices scale. This test was chosen because its non-verbal modality makes it appropriate for all participants, regardless of their education level or

Table 2
Instruments and cut-off scores used to identify children with SLI.

	Normal	At risk	Deficit
ETSG (expressive)	> 36	26-36	< 26
ETSG (receptive)	> 41	38-41	< 35
Raven	> 15		
Audiometry test	< 20 dB		

Note. ETSG (Exploratory Test of Spanish Grammar, expressive and receptive); Raven (Raven's Colored Progressive Matrices scale). Figures in the table provide the cut-off raw scores and ranges for children to be considered as normal, at risk or with deficit, considering each instrument's scale.

linguistic abilities. Test scores ≥ 25th percentile are deemed to be within normal limits (Raven's Colored Progressive Matrices Scale, 2005). In spite of all selected children being normal in non-verbal cognition, statistical differences emerged when comparing groups ($t(46) = 3.29$, $p = 0.002$). This difference is addressed below in the Results section, based on the idea that the main purpose of this study was not to compare two groups of children already known to be different, but to inspect reading in each group individually. Hearing was tested using a sweep-frequency audiometer (Interacoustics, model AD629) at a frequency of 500, 1000, 2000, and 4000 Hz. Normal hearing was defined as detection of an intensity of 20 dB or below, according to the international criteria proposed by American Speech-Language-Hearing Association (ASHA, 2005).

2.2. Materials

2.2.1. Tests of oral language skills

2.2.1.1. Vocabulary. Vocabulary was assessed using the "Picture Vocabulary" subtest from the Spanish-language version of Woodcock-Muñoz Language Survey-Revised (Woodcock et al., 2005). The instrument consists of 58 items of increasing difficulty, as target words become progressively less familiar. Each item is illustrated with a picture that represents a particular target word. Although the test addresses both comprehension and vocabulary production, it should be noted that 52 of the items measure expression. For the 6 remaining comprehension items, participants are asked to identify the image on a card matching a particular target word; for the expression items, the participant is asked to utter the word represented by the picture. Each correct response receives one point. Therefore, the maximum score is 58 points. The test has a reliability of 0.89, as informed by the test's authors, obtained by Kuder and Richardson formula.

2.2.1.2. Grammar. Grammar was assessed by analyzing speech samples obtained from all children by means of the Narrative Development Assessment (NDA, Pavez et al., 2008). The NDA elicits narrative samples by asking children to retell three short stories specifically constructed for children. The characters are different human-like animals engaging in several activities. No visual support is provided. In this study, the NDA was used solely to elicit language samples that could later be analyzed grammatically. Once obtained, narratives were transcribed by one of the authors of this study following the guidelines prescribed by the instrument NDA. Once the transcription process was completed, all of the sentences in the speech samples were firstly categorized as either simple or complex. Subsequently, the same sentences were categorized as grammatical/ungrammatical. A total number of simple/complex and grammatical/ungrammatical sentences was then obtained for each child.

For the purposes of this study, sentences were defined as minimum units of predication consisting of a subject and a predicate (Bosque, 2010). Following this definition, simple sentences consist of one predicate nucleus and no other subordinate verbs (e.g. 'she ate everything'), while complex sentences include one or more subordinate clauses (Bosque, 2010). This analytical approach has been implemented in other studies focused on SLI in Spanish (Jackson-Maldonado & Maldonado, 2017; Pavez et al., 2015). Sentences were labeled as ungrammatical whenever any of its grammatical elements did not follow the canonical morphosyntactic organization of Spanish. Among these grammatical alterations, omissions or substitutions of mandatory grammatical elements were consistently found. The most frequent grammatical errors in the language samples from this study involved articles, clitic pronouns, prepositions, or verbs, which is consistent with what the literature on Spanish-speaking SLI also suggests (Auza & Morgan, 2013a, 2013b; Bedore & Leonard 2001, 2005). Analyses were conducted in several stages. In the first stage, around 20% of the speech samples were jointly discussed and analyzed by the three reviewers (all authors of this study) that took part in this process, so as to agree on general and particular criteria. After this, the rest of the analyses were conducted by two of this study's authors. Agreement on identification and counting was 98% for simple and complex sentences and 96% for grammatical and ungrammatical sentences. A third author subsequently reviewed the whole corpus again, focusing on a few specific problematic cases. Mean number and range of produced sentences for children with SLI was 30.33 (16-45) in 2nd grade and 36.29 (18-55) in 4th grade. Mean number and range of produced sentences for children with TLD was 34.33 (18-50) in 2nd grade and 39.26 (27-59) in 4th grade. Totals varied between children, which is addressed in the Data Analysis section.

2.2.2. Tests of reading skills

2.2.2.1. Decoding. Decoding was measured using the "Letter-Word Identification" subtest from the Spanish-language version of Woodcock-Muñoz Language Survey-Revised (Woodcock et al., 2005). This test consists of 75 items. The first items require participants to identify letters, while the remaining items require them to read single-words fluently. The test first presents children

with rather familiar words to subsequently present them with increasingly uncommon lexical items that demand sophisticated decoding skills. Correct responses are scored with one point each, the maximum score being 75. Consequently, higher scores in this test reflect higher decoding skills. As reported by its authors, this test's reliability metric is 0.96 by Kuder and Richardson's formula.

2.2.2.2. Reading comprehension. Reading comprehension was assessed using two tests: the Passage Comprehension subtest from the Spanish-language version of Woodcock-Muñoz Language Survey-Revised (Woodcock et al., 2005) and the Passage Comprehension subtest from the Test of Reading and Writing in Spanish (Defior et al., 2006). Since the actual name of both instruments is the same in Spanish, for convenience they were labeled as RC1 (Woodcock et al. 2005) and RC2 (Defior et al., 2006) and they will be referred to in this way throughout this study.

The RC1 subtest measures comprehension of words, sentences, and passages. The first items assess the ability to match single-words and pictures, and then phrases and pictures. Next, participants are asked to complete sentences of varying syntactic complexity. Finally, texts with progressively more difficult syntax and vocabulary are presented and participants are asked to complete some passages with a contextually adequate word. Correct responses are scored one point, with a maximum score of 32 points. As indicated by the author, the test has a reliability of 0.95, as measured using the Kuder and Richardson formula.

The RC2 subtest measures the ability to relate and integrate sentences that make up a passage. Two narrative passages and one expositive passage are presented. For each passage, participants are presented with 3 literal questions, 3 inferential questions, a "title selection" item, and a "summary selection" item. Scoring is as follows: 1 point for correct answers to literal questions; 2 points for correct answers to inferential questions; 1 point for selection of a secondary idea; and 1 point for selection of the main idea. The maximum score is 48 points. The test's authors report Cronbach's alpha coefficients of 0.69 for second-grade students and of 0.71 for fourth-grade students. This test was chosen because it is widely used in Spanish-oriented studies in Latin America and Spain (Diuk & Ferroni, 2013; Ferroni et al., 2016; Querejeta, Piacente, Guerrero, Ortiz & Alva, 2013; Strasser et al., 2017).

A composite reading comprehension score was also constructed by first converting each child's raw score on each test to a z-score based on each group's mean (Table 5 below provides the means and the SDs for both tests). Subsequently, z-scores were averaged to produce a non-weighted composite score. This procedure was conducted on children's scores and group means in 2nd and in 4th grade.

2.3. Test administration

Tests were administered in the facilities provided by the schools the children attend. A suitable room was chosen for individual administration of all tests, conducted by speech therapists specially trained on each instrument. The same assessment procedure was implemented for both groups in 2nd grade (2014) and 4th grade (2016). All assessments were conducted by strictly observing each test's instructions. The sequence for the tests' administration was determined on the assumption that children would perform better on reading measures during the second semester than during the first semester. Vocabulary and Grammar were assessed during the first semester (April-May). Decoding and reading comprehension were assessed during the second semester (October-November).

2.4. Data Analysis

Data were analyzed and plotted with R statistical software (R Core Team, 2018; Wickam, 2009; Canty & Ripley 2015). To control for differences between children, the total number of grammatical/ungrammatical and simple/complex sentences were converted into a percentage based on each child's total number of produced sentences. For convenience, remaining measures were also transformed to percentages considering each instrument's maximum score. For all variables, higher percentages reflect higher performance. Data were firstly inspected by means of mixed-factor ANOVAs conducted on the variables of interest, to explore children's general performance. Multiple regression analyses were subsequently conducted to inspect how linguistics and decoding abilities predict reading comprehension. To make sure that selected linguistic variables did impact reading measures, they were all entered as single predictors in simple regression models to determine their individual effect on reading measures. Results showed that sentence grammaticality did not significantly predict either composite score, RC1 score or RC2 score (R^2 values ranging from 0.001 to 0.05), and was therefore not included as a predictor in the remaining analyses to increase statistical power. Thus, the selected predictors were decoding, vocabulary, and sentence complexity. To determine whether observed significant group-differences on non-verbal cognition (Raven's Colored Progressive Matrices Scale, 2005) had a relevant effect on the reading comprehension measures, all models for 2nd grade in each group were fitted including score on Raven's test as covariate. Results showed that the Raven covariate had no significant effect on reading comprehension in either group. Since an important purpose of this study was to inspect the possible differential impact of linguistic predictors among children with SLI and children with TLD and since the analyses were conducted on each group independently, the decision was made not to include non-verbal cognition in the reported analyses. Four extremely influential cases were identified and removed from final sample based on Cook's distance and Hat-Values. Linearity and homoscedasticity were tested for all reported models. We report all violations of linearity and homoscedasticity below. To reduce the impact of these violations, as well as the impact of possible sample-related bias, statistical significance for predictors is not discussed based on p-values, but on regressors' 95% confidence intervals.

Table 3
Descriptives for observed measures

		TLD			SLI		
	Grade	Mean	SD	Range	Mean	SD	Range
Complexity[1]	Second	39.00	13.14	17.86-73.91	31.27	13.87	8.70-53.57
	Fourth	47.82	9.00	31.03-62.07	40.30	10.68	20.00-59.38
Grammaticality[2]	Second	84.81	8.81	60.87-100.00	77.30	9.76	57.14-94.74
	Fourth	84.57	9.82	59.26-97.83	77.65	12.08	51.52-95.00
Vocabulary[3]	Second	61.54	5.59	46.55-70.69	56.54	6.99	46.55-67.24
	Fourth	67.62	6.49	55.17-79.31	62.57	6.92	50.00-74.14
Decoding[4]	Second	68.75	12.88	38.67-96.00	50.56	15.28	18.67-84.00
	Fourth	78.03	18.01	50.67-97.33	68.44	14.28	46.67-92.00
RC1[5]	Second	53.80	6.25	40.62-65.62	43.36	13.14	9.38-56.25
	Fourth	63.18	7.17	46.88-81.25	54.04	6.99	40.62-65.62
RC2[6]	Second	75.36	8.60	64.58-93.75	53.82	19.91	0.00-79.17
	Fourth	84.69	9.39	66.67-97.92	74.83	14.27	29.17-91.67

Note. Mean, standard deviation, and range for all variables in both groups, 2nd grade and 4th grade, expressed in percentages. 1: Percentage of orally produced complex sentences in a retelling task. 2: Percentage of orally produced grammatical sentences in a retelling task. 3: Picture Vocabulary subtest from the Spanish-language version of Woodcock-Muñoz Language Survey-Revised. 4: Letter-Word Identification subtest from the Spanish-language version of Woodcock-Muñoz Language Survey-Revised. 5: Passage Comprehension subtest from the Spanish-language version of Woodcock-Muñoz Language Survey-Revised. 6: Passage Comprehension subtest from the Test of Reading and Writing in Spanish.

3. Results

3.1. General performance in 2nd grade and 4th grade

Table 3 provides descriptives for general results. ANOVA results are provided in Table 4. Fig. 1 provides means plots for all observed variables.

Results show significant main effects for group in all variables ($p = 0.01$ or lower). As for grade, the main effect is significant for all variables ($p < 0.01$) except sentence grammaticality ($p = 0.97$). The interaction was only significant for RC2 ($p = 0.003$). The origin of this interaction is a sizable significant between-group difference in 2nd grade ($t(46) = -4.84$, $p < 0.001$, $d = 1.59$) that becomes ostensibly smaller in 4th grade ($t(46) = -2.81$, $p = 0.007$, $d = 1.05$). Cohen's d shows a considerable decrease in size effect, as much as 0.54 (that is, slightly more than half a pooled standard deviation, Lakens, 2013). Overall, results consistently suggest significantly lower scores for children with SLI, both in 2nd and 4th grade. When considering how performance develops over time, children in 4th grade perform, in all measures but grammaticality, significantly higher than children in 2nd grade, irrespective of their SLI/TLD condition. It is worth mentioning that even if the interaction for decoding is not statistically significant, the difference between children with SLI and children with TLD in 4th grade is the smallest observed between-group difference ($t(46) = -2.01$, $p = 0.05$, $d = 0.82$ in 4th grade). This suggests that the improvement of children with SLI on decoding is higher than their improvement on other abilities when considering children with TLD as reference.

3.2. Decoding, vocabulary, and sentence complexity as predictors of reading comprehension in 2nd and 4th grade

Firstly, regression models were constructed to inspect how selected variables predicted reading comprehension scores (Composite score, RC1 score and RC2 score) in 2nd grade. A non-parametric BCa bootstrap (15,000 replications) was also conducted for all models, so as to control sample-related biases (Davidson & Hinkley, 1997). It should be noted throughout this section that any given predictor will be considered as significant only when its 95% Confidence Interval (CI) does not include zero. Multiple regression

Table 4
Mixed-factor ANOVA results for all inspected variables

	Group			Grade			Group by Grade		
	F	p	GES	F	p	GES	F	p	GES
Sentence complexity	7.20	0.01	0.09	20.56	< 0.01	0.12	0.00	0.95	—
Sentence grammaticality	8.83	< 0.01	0.11	0.00	0.97	—	0.02	0.86	—
Vocabulary	8.41	< 0.01	0.13	58.21	< 0.01	0.18	0.01	0.98	—
Decoding	14.76	< 0.01	0.18	28.09	< 0.01	0.17	2.78	0.10	0.02
RC1	18.26	< 0.01	0.24	65.00	< 0.01	0.25	0.27	0.60	—
RC2	19.29	< 0.01	0.25	63.96	< 0.01	0.24	9.31	< 0.01	0.04

Note. The two reading comprehension instruments used are labeled as RC1 and RC2. When relevant, Generalized Eta Squared (GES) is provided as effect-size measure, 0.02 being small, 0.13 being medium, and 0.26 being large (Bakeman, 2005).

Table 5
Multiple regression results (2nd grade)

	Measure	Composite			RC1			RC2		
		b	p	CI	b	p	CI	b	p	CI
SLI	Decoding	0.04	< 0.01	(0.03, 0.07)	0.20	< 0.01	(0.13, 0.31)	0.47	< 0.01	(0.24, 0.64)
	Vocabulary	0.10	< 0.01	(0.06, 0.16)	0.5	< 0.01	(0.25, 0.76)	0.91	< 0.01	(0.38, 1.54)
	Complexity	0.02	< 0.01	(0.00, 0.03)	0.1	0.03	(0.00, 0.14)	0.21	< 0.01	(0.05, 0.35)
	R^2	0.80			0.75			0.71		
TLD	Decoding	0.03	0.08	(-0.02, 0.06)	0.1	0.08	(-0.05, 0.14)	0.09	0.21	(-0.12, 0.23)
	Vocabulary	0.07	0.15	(0.01, 0.17)	0.1	0.28	(-0.06, 0.32)	0.31	0.16	(-0.05, 0.78)
	Complexity	0.04	< 0.01	(0.01, 0.07)	0.1	0.10	(-0.04, 0.13)	0.22	< 0.01	(0.10, 0.35)
	R^2	0.45			0.25			0.49		

Note. The first column lists the observed predictors and adjusted R^2. Results are presented for three models predicting the two reading comprehension instruments used (labeled as RC1 and RC2) and a composite score. Coefficients are significant when their bootstrapped 95% Confidence Intervals do not include zero.

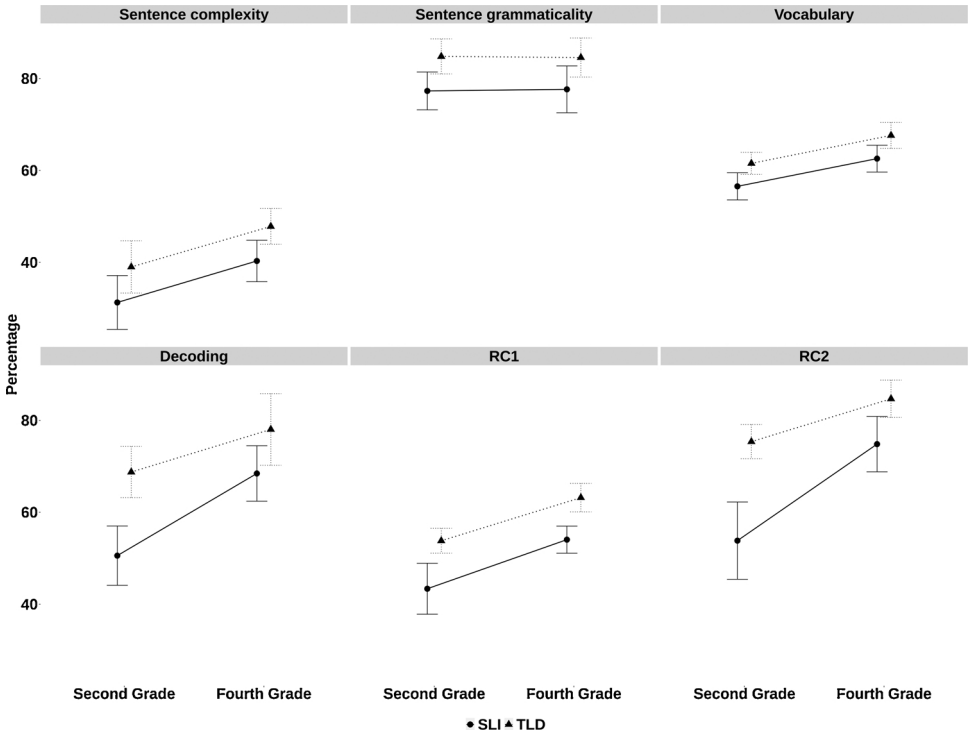

Fig. 1. Mean plots for all observed variables. Error bars represent 95% confidence intervals.

results for 2nd grade, along with bootstrapped coefficients and adjusted R^2 values are presented in Table 5.

Bootstrapped coefficients provided in Table 5 suggest that, in 2nd grade, decoding, vocabulary, and sentence complexity significantly predict all reading comprehension measures in children with SLI (CIs for sentence complexity being 0.0043-0.0301 for Composite score and 0.0044-0.1384 for RC1, therefore complying with the here adopted criterion for significance, as set forth by Davidson & Hinkley, 1997). As for children with TLD, both sentence complexity and vocabulary significantly predict reading comprehension composite scores (it is worth to mention that even if vocabulary's p-value is above standard 0.05 alpha level, its bootstrapped coefficient is non-zero). Adjusted R^2 values are sizable in both groups, translating into f^2 values well above 0.35, therefore reflecting, following Cohen (1992), large effect sizes. Regular multiple regression assumptions (i.e. homoscedasticity and linearity) were checked for all models and violations were observed. Among children with SLI, violations were mostly related to outcome variables that did not fully follow linear patterns, homoscedasticity still holding. Among children with TLD, the only observed assumption violation was related to homoscedasticity (RC1 instrument). Overall, this suggests that responses from children with TLD are more stable and more consistent than those of children with SLI, at least at this developmental stage. Even if the implemented bootstrap procedure does correct sample-related bias, reported results for this grade should be considered with caution.

The same analysis was conducted on the same children while in 4th grade. Results are presented in Table 6.

Table 6
Multiple regression results (4th grade)

		Composite			RC1			RC2		
		b	p	CI	b	p	CI	b	p	CI
SLI	Decoding	0.01	0.38	(-0.02, 0.05)	−0.01	0.76	(-0.11, 0.09)	0.23	0.04	(0.03, 0.50)
	Vocabulary	0.12	< 0.01	(0.04, 0.22)	0.23	0.06	(-0.02, 0.47)	0.94	< 0.01	(0.44, 1.68)
	Complexity	0.01	0.65	(-0.03, 0.04)	0.03	0.5	(-0.08, 0.11)	0.00	0.99	(-0.22, 0.17)
	R^2	0.3			0.08			0.44		
TLD	Decoding	0.00	0.84	(-0.02, 0.03)	0.01	0.69	(-0.05, 0.12)	−0.01	0.90	(-0.13, 0.10)
	Vocabulary	0.07	0.13	(0.01, 0.17)	0.00	0.99	(-0.21, 0.26)	0.62	< 0.01	(0.29, 0.10)
	Complexity	0.01	0.39	(-0.03, 0.06)	0.01	0.89	(-0.14, 0.11)	0.12	0.15	(-0.05, 0.34)
	R^2	0.02			−0.15			0.28		

Note. The First column lists the observed predictors and adjusted R^2. Results are presented for three models predicting the two reading comprehension instruments used (labeled as RC1 and RC2) and a composite score. Coefficients are significant when their bootstrapped 95% Confidence Intervals do not include zero.

Results provided in Table 6 show that vocabulary significantly predicts the composite score in both groups (vocabulary's p-value is above standard 0.05 alpha level among children with TLD but its bootstrapped coefficient is, strictly speaking, non-zero: 0.0003-0.1723). However, while the adjusted R^2 for composite score among children with SLI is 0.3, variance explained by the same for children with TLD is nearly zero (0.02). This suggests that vocabulary accounts for a relevant amount of reading comprehension (f^2 above 0.35) among children with SLI but does not importantly contribute to reading comprehension among typical children, statistical significance notwithstanding. All of these models complied with linear regression assumptions, unlike previously reports for 2nd grade results. This might suggest that inconsistent group behavior in 2nd grade somehow adjusted and stabilized in 4th grade.

3.3. 2nd grade abilities as predictors of 4th grade reading comprehension performance

Finally, data were modeled to inspect whether performance in 2nd grade predicted reading comprehension scores in 4th grade. Results are presented in Table 7.

Adjusted R^2 values presented in Table 7 suggest that models relevantly explain variance in each group (f^2 values above 0.35), with higher values among children with SLI. However, while both vocabulary and sentence complexity significantly predict reading among children with SLI, only sentence complexity predicts performance on the composite measure among children with TLD. Multiple regression assumptions were inspected and met by all models.

4. Discussion

Results show that children with SLI perform lower than children with TLD, both in 2nd and 4th grade, on all measures. Both groups were also observed to significantly improve performance over time on all measures except sentence grammaticality. Also, since sentence grammaticality did not significantly predict performance on reading comprehension, it was excluded from reported analyses.

It should be noted that sentences were labeled as ungrammatical whenever any of their grammatical elements did not follow the canonical morphosyntactic organization prescribed by Spanish grammar. The most frequent grammatical errors in the language

Table 7
Multiple regression results (2nd grade scores as predictors of 4th grade reading comprehension)

		Composite			RC1			RC2		
		b	p	CI	b	p	CI	b	p	CI
SLI	Decoding	0	0.06	(-0.00, 0.04)	0	0.16	(-0.05, 0.10)	0.1	0.19	(-0.03, 0.26)
	Vocabulary	0.1	0.01	(0.03, 0.14)	0.1	0.18	(-0.06, 0.33)	0.7	0.02	(0.30, 1.25)
	Complexity	0	< 0.01	(0.02, 0.06)	0.1	< 0.01	(0.03, 0.13)	0.3	< 0.01	(0.11, 0.46)
	R^2	0.58			0.43			0.56		
TLD	Decoding	0	0.35	(-0.01, 0.06)	0	0.87	(-0.08, 0.15)	0.1	0.15	(-0.02, 0.28)
	Vocabulary	0	0.84	(-0.09, 0.11)	0	0.88	(-0.23, 0.40)	0	0.87	(-0.50, 0.47)
	Complexity	0	0.01	(0.01, 0.07)	0.1	0.19	(-0.04, 0.18)	0.2	0.01	(0.10, 0.37)
	R^2	0.27			−0.00			0.36		

Note. The first column lists the observed predictors and adjusted R^2. Results are presented for three models predicting the two reading comprehension instruments used (labeled as RC1 and RC2) and composite score. Coefficients are significant when their bootstrapped 95% Confidence Intervals do not include zero.

samples observed in this study involved articles, clitic pronouns, prepositions, or verbs. Consequently, sentence grammaticality was mostly established based on within-sentence morphological dimensions. Sentence complexity, on the other hand, was evaluated by distinguishing simple sentences (with no subordinate clauses) from complex sentences including one or more subordinate clauses. Thus, sentence complexity captured a syntactic dimension. This might explain the non-significant role played by grammar when predicting reading comprehension: syntax might simply be a better predictor than morphology. This is consistent with studies carried out in English reporting that syntactic complexity predicts reading comprehension (Distefano & Valencia, 1980; Scott, 2009). Presented results do not provide grounds to dismiss the impact of grammar on reading comprehension. To the contrary, results suggest that only one particular observed grammatical dimension (syntax) predicts reading comprehension. Considering this distinction may be of interest for future research.

As for the impact of the remaining linguistic variables on reading comprehension, results showed differences between children with SLI and children with TLD. These differences can be found both in the significance of predictors and in the substantial disparity of variance explained by respective models.

Findings regarding reading comprehension are consistent with the literature, since they show that children with SLI perform poorer than their peers with TLD and that this difference persists over time. The longitudinal study by Catts et al. (2008) showed that children with SLI perform significantly lower than children with TLD both in decoding and reading comprehension and that these differences only recede by 10th grade. St. Clair et al. (2010) reported differences in decoding and reading comprehension persisting until age 16. However, Buil-Legaz et al. (2016) reported that, by age 12, differences were only observable in reading comprehension, and that the decoding performance of children with SLI was similar to that of children with TLD. This pattern is most consistent with presented results, since among children with SLI, decoding appears to improve more quickly than the other observed measures. It is worth mentioning that both the present study and the study by Buil-Legaz et al. (2015) were conducted with children who speak orthographically transparent languages (Spanish and Catalan). It is very likely that orthographic transparency might facilitate decoding for children with SLI, although they still need more time than children with TLD to master this skill. The literature supports the idea that orthographically transparent languages allow children to decode faster and in a more automated fashion than orthographically opaque languages (Catts, 2018).

Regarding predictors of reading comprehension in children with SLI, results for 2nd grade show that decoding, vocabulary, and sentence complexity all significantly impact reading comprehension. These skills amount to 80% of their reading comprehension variance. Following the Simple View of Reading (Hoover & Goough, 1990), decoding plays a key role in reading comprehension when children are learning how to decode written words. Within this framework, the significant role of decoding among children with SLI can be explained by their lack of automated processes. While in 2nd grade, children with SLI's mean on decoding was 50.56%. In the same grade, typical children's mean was 68.75%, with decoding not significantly predicting their reading comprehension. The relevant role of decoding among children with SLI at this stage suggests that their reading comprehension is strongly determined by unautomated low-level processing. Interestingly, by 4th grade children with SLI's group mean is 68.44% and decoding does not significantly predict reading, which is most similar to the results observed among children with TLD in 2nd grade.

Across a number of studies, vocabulary is consistently documented as a predictor of reading comprehension (Aguilar-Mediavilla et al., 2014; Miranda-Casas et al., 2010; Muter et al., 2004) because children need to know the meaning of the words a text contains in order to fully understand it (Ouellette, 2006). Finally, complex-sentence production also significantly predicted reading comprehension, which might suggest that sophisticated sentence-level processes correlate with textual comprehension (Oakhill et al., 2003). As for children with TLD, only vocabulary and sentence complexity significantly predicted reading comprehension, explaining 45% of variance. Unlike children with SLI, decoding does not appear to play a prominent role, probably reflecting more automatic processing.

The significant impact of vocabulary observed for both groups is noteworthy, especially considering the fact that children with SLI perform lower on this measure than children with TLD. There is feedback between vocabulary and reading comprehension, since reading provides opportunities to learn new words and word-knowledge allows children to comprehend texts. Thus, the significant impact of vocabulary and lower performance makes children with SLI especially prone to simultaneously underperform on reading comprehension and vocabulary (Ricketts et al., 2007).

In 4th grade, reading comprehension performance in children with SLI is only significantly predicted by vocabulary. Also, explained variance decreased to 30% – as compared to previous 80%. This suggests that, by 4th grade, reading comprehension among children with SLI is influenced by dimensions other than the ones modeled in this study. Most likely, inference-generation, comprehension monitoring, super-structural text knowledge, and working memory start playing a relevant role (Palincsar and Brown, 1984; Oakhill & Cain, 2012), since decoding skills become more automatic and leave room for higher-order processing. The significant impact of vocabulary is consistent with the findings of Buil-Legaz et al. (2015). They reported semantic fluency as the only predictor that significantly impacts the reading comprehension of children with SLI at age 12. As for children with TLD, none of the modeled predictors significantly impact reading comprehension. This suggests that, by this grade, the variables that impact reading comprehension are not the linguistic variables explored here.

When inspecting 2nd grade measures as predictors of 4th grade reading comprehension performance among children with SLI, vocabulary and sentence complexity were found to significantly predict reading comprehension, with the explained variance amounting to 58%. Since 2nd grade reading comprehension was significantly predicted by all modeled variables, these results seem to reinforce the idea that the important role of decoding recedes with time. Still, vocabulary and sentence complexity predict more than half of the explained variance, suggesting that future reading comprehension of children with SLI will be strongly related to these linguistic variables. Among children with TLD, the only significant predictor was sentence complexity, and the explained variance amounts to 25%. Again, this seems to point to a higher degree of complexity in the processes underlying reading skills in TLD

children, with a fair amount of variance most probably explained by variables other than the ones modeled in this study. Finally, it should be noted that multiple regression assumptions were only fully met when modeling 4th grade measures. This most likely reflects high within-group diversity among children with SLI and children with TLD when they are in 2nd grade. Apparently, as they grow older, not only does their general performance increase, but they also appear to be more consistent with children from their respective groups, at least from the point of view of multiple regression assumptions.

It is worth mentioning that a consistent differential effect was found for the RC1 and RC2 measures. More precisely, there were cases when results showed a significant prediction for the composite score and RC2, but no significance for RC1. This means that in such cases, composite score significance is driven only by performance on RC2. As mentioned in the Method section, the RC1 subtest assesses the comprehension of sentences and passages. However, reading comprehension is measured by means of cloze technique. In other words, children were asked to complete inputs with one word, even if they were indeed given varying portions of contextual information. The RC2 reading test, on the other hand, demands that children deploy both literal comprehension skills and inferential skills. Given the instrument's design, the higher the score the more accurate is the deployment of inferential skills (for instance, precisely selecting the main idea of a text/passage, adequately selecting a title for a text, see above). Thus, predictors found to significantly impact performance on both RC2 and composite score (but not on RC1) might be unveiling a relation with global comprehension processes. RC2 test's items capture the ability to integrate information which is not explicitly stated in the text. RC1's cloze-based items, on the other hand, capture more local relations based on much more explicit contextual information.

5. Limitations

The observed sample of SLI children is relatively small if standard sample size criteria are adopted. Bootstrapped coefficients compensate for this by providing robust results controlling potential sample-related bias, but more research is needed with larger samples to complement the findings from the current study. Another limitation is the Cronbach's alpha coefficient for one of the reading comprehension measures used in this study. Depending on the adopted criterion it might be considered as low (but acceptable) or insufficient. Even if the value is not indisputably strong, the test was chosen because it is widely used in Spanish-oriented studies in Latin America and Spain. Finally, we lacked the information needed to establish initial detailed linguistic profiles for children with SLI. Thus, we cannot claim that our findings can be readily generalized, since future longitudinal studies might provide a different picture if children with different baseline linguistic skills were to be observed. We believe, however that our findings contribute to our understanding of reading among monolingual Spanish-speaking children with SLI.

6. Conclusions

Results show that sentence complexity and vocabulary play a role in children's reading comprehension performance in 2nd grade and in 4th grade. Decoding, on the other hand, only plays some role in 2nd grade and solely among children with SLI. As one important predictor of reading comprehension among children with SLI, vocabulary should be central when designing and implementing interventions. Breadth and depth of vocabulary might be targeted systematically with children with SLI to improve their reading abilities.

Vocabulary breadth has been reported as impacting decoding (Aarnoutse et al., 2001). Depth, on the other hand, involves mastering the deeper meaning of words, which is more related with reading comprehension. Stimulating both aspects will positively impact the reading process of children with SLI. This study also showed that syntactic complexity also predicts reading comprehension, while ungrammaticality does not seem to influence reading comprehension, in spite of reportedly being one of the defining features of children with SLI (Mendoza, 2015).

Reported findings are especially relevant when considering the consequences of the language-based problems that children with SLI have. Literature has shown that their impairment makes them particularly prone to academic underperformance as students. Since reading comprehension is involved in many aspects of schooling and is of the essence for many subjects and domains, it is quite plausible to assume that improvements in reading may very well positively impact academic achievement in general.

Author Statement

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Appendix A. Supplementary data

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