Let's eat grandma: Awareness of punctuation and capitalization rules' violations predicts the development of reading comprehension

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ARTICLE INFO

ABSTRACT

An increasing body of evidence indicates that reading and writing are interconnected, but more studies are needed to investigate the mechanisms through which these two skills are associated. In this paper we report a study where we explored the relationship between second grade students' awareness of punctuation and capitalization rules' violations (a component of writing process) and their reading comprehension. The results showed that students' awareness of punctuation and capitalization rules' violations was moderately corelated with reading comprehension ($r = .64$) and predicted reading comprehension tested in Spring after accounting for reading comprehension tested in Fall, word decoding fluency, listening comprehension, general cognitive ability, and demographic variables. Our findings outline an under-researched association between reading and writing and point out to a potential new avenue to improve reading comprehension.

1. Introduction

Learning to read is one of the most critical skills developed in elementary school that has long-lasting consequences on students' academic achievement. The ultimate goal of learning to read a text is to comprehend its meaning, but this is a slow-developing and strenuous process because reading comprehension is a multi-dimensional construct, influenced by many factors (Catts, 2018). One of the factors associated with the development of reading comprehension is writing, and a growing body of literature indicates that writing supports reading (and vice-versa). Consequently, to address difficulties in reading comprehension, it is important to explore its relationship with writing and recent recommendations made to advance the science of reading suggest that such association needs to be more fully interconnected in reading research (Graham, 2020). In this paper we'll address this issue, by presenting the results of a developmental study that investigated the relationship between students' awareness of capitalization and punctuation rules' violations (a component of the writing process) and reading comprehension. To the best of our knowledge, this is the first developmental study to investigate such an association, and one of the increasing number of studies that help explain how reading and writing can be connected.

1.1. Reading and writing: A mutually supportive connection

While the relationship between reading and writing has been documented for a long time (e.g. Fitzgerald & Shanahan, 2000), recent meta-analyses have shed a light on the power of this relationship and the mechanisms through which these two skills are interconnected. In one such meta-analysis, Graham, Aitken et al. (2021) compared the writing skills of children with reading difficulties with the ones of their typically developed peers. They found a large discrepancy between the two groups ($d = $ about 1.00): children with reading difficulties performing poorer than their typically developed peers in the areas of spelling, written vocabulary, syntax, writing quality, sentence skills, organization of content, writing outputs and handwriting. The authors suggested that literacy instruction should focus on both reading and writing in order to address the needs of children with reading difficulties. Importantly for the purpose of this paper, none of the studies that met the inclusion criteria for this meta-analysis found an association between poor reading comprehension and a deficit in the area of writing mechanics, such as punctuation or capitalization.

The claim that reading and writing are interconnected is also supported by two meta-analyses which investigated the extent of which writing and writing instruction improves reading comprehension. One of the studies (Graham & Herbert, 2011) found that reading comprehension improved when the students wrote about what they read ($d = $

0.37–0.50), when they increased the amount of writing ($d = 0.35$), or when they received explicit writing instruction in the areas of text and sentence structure and writing process ($d = 0.22$–0.27). The other meta-analysis (Graham & Santangelo, 2014) found that spelling instruction improved reading comprehension ($d = 0.66$). The evidence supports the idea that writing instruction can improve reading comprehension, but it also indicates that additional research is needed to "determine if other writing practices improve reading and how writing interventions can be designed so that they maximally enhance students' reading skills." (Graham & Herbert, 2011, p. 736). Notably, none of the studies that met the inclusion criteria of these meta-analyses indicated that improving students' awareness of writing mechanics such as punctuation and capitalization would increase reading comprehension.

The relationship between reading and writing seems to be bidirectional. In a meta-analysis, Graham et al. (2018) investigated the effects of reading instruction on the writing quality in more than 90 studies. They found that students' interaction with text as well as reading instruction improved their specific writing skills (particularly spelling) and the overall quality of writing (composition). Importantly, none of the studies indicated whether improvement in reading was associated with improvement in students' awareness of writing mechanics, such as punctuation and capitalization.

1.2. Text revision for punctuation and capitalization: A component of the writing process

Writing is a multi-step process and one of the essential steps in this process is text revision (Graham, 2019; MacArthur, 2019). During text revision, writers distance themselves from the writing and critically analyze the text, including the appropriate usage of punctuation and capitalization rules. Learning these rules is an important aspect of the writing development, and explicit instruction of punctuation and capitalization rules can be found pervasively in elementary schools across the world (Cutler & Graham, 2008; Dockrell, Marshall, & Wise, 2016; Gilbert & Graham, 2010; Graham et al., 2021; Parr & Jesson, 2016). Students are introduced gradually to these rules, and the concepts are practiced and repeated frequently in the first years of elementary school. For instance, children from Romania (the country where this study was implemented) start to learn to write in Grade 0, when they are about 6 years old. During the first years of instruction the students are expected to identify the sentences within a text, to be aware of the punctuation at the end of the sentences (period, exclamation and question marks), of the commas between elements of three or more items, to capitalize the proper nous and the words at the beginning of the sentence, and to be aware of the marks indicating a dialogue (a colon at the end of the sentence preceding the direct speech, and a dash at the beginning of the sentence indicating direct speech). The students learn these rules both implicitly (through repeated exposure to text), and explicitly (through direct instruction provided by the teacher). Typically, the students are exposed to all of these rules by the end of the 1st grade, as indicated by the instructional workbooks approved by the Romanian Ministry of Education which can be accessed at www.manuale.edu.ro.

Just like in many elementary schools across the world, a common practice in Romanian elementary schools to teach these skills is text revision, where teachers provide students with passages that include punctuation and capitalization rules' violations and expect their students to identify such violations (i.e., to edit the text for punctuation and capitalization errors), a procedure that we have used in our study to test these skills.

1.3. The association between text revision for punctuation and capitalization and reading comprehension: A theoretical model

Several theoretical frameworks explain the association between reading and writing and one of these frameworks is the *shared knowledge theory* (Graham, 2020). This theory stipulates that both readers and writers share common knowledge, such as pragmatic knowledge of the text features, syntax and mechanics when they read and write (Fitzgerald & Shanahan, 2000; Graham, 2020). For instance, on the one hand, to convey the message correctly, the writer needs to have knowledge about what a sentence is, how to write a correct sentence (e. g., by including a subject and a predicate), or what the writing conventions are to properly mark the sentence in the text (capitalize the letter of the first word and use punctuation at the end of the sentence). In addition, revising a text for punctuation and capitalization requires reading skills, such as being able to decode the text fluently, or to understand the meaning of the words.

On the other hand, to fully understand the written message, the reader (just like the writer) needs to understand what a sentence is, how it is marked in the text, and where and why he or she needs to pause and to stop while reading it. Thus, the communication between the writer and the reader can only be possible if both actors are equipped with the same knowledge. When one of the actors lacks some of the necessary knowledge about the writing conventions to communicate (e.g., the writer fails to add a question mark at the end of an interrogative sentence), it can affect the communication process with the reader (which in this case, will fail to understand that the writer meant to ask a question, and not to make a statement).

1.4. Empirical evidence supporting indirect associations between the awareness of punctuation and capitalization rules' violations and reading comprehension

Reading and writing are interconnected at many levels, and despite a lack of evidence of a direct association between reading comprehension and the awareness of punctuation and capitalization rules' violations, empirical evidence suggests that the two factors are at least indirectly associated.

One of such associations is explained by the role of punctuation in reading prosody, a subcomponent of reading fluency which has been associated with reading comprehension (Kim, Quinn, & Petscher, 2021; Wade-Woolley, Wood, Chan, & Weideman, 2022; Wolters, Kim, & Szura, 2022). Empirical evidence found that punctuation is critical in students' acquisition of appropriate breathing pauses when they read orally (Godde, Bailly, & Bosse, 2022), while inappropriate pausing was found to be negatively correlated with reading comprehension ($r = -.61$), predicting it even after controlling for reading fluency and vocabulary (Arcand et al., 2014). Readers use punctuation to decide on prosodic features such as reading cadence (*Uhm … well … I think I will go … wait a minute! I just remembered something!*) or intonation (*"Really?" whispered Lisa. "Really!" replied her friend*). In the first example, the reader needs to know the function of ellipsis to better understand the hesitation/insecurity of the speaker. In the second example, it is crucial for the reader to know the function of the question marks and exclamation marks to understand that Lisa is asking a question, and her friend is replying excitedly. Thus, the awareness of punctuation rules can be associated with reading comprehension indirectly via reading prosody, a subcomponent of reading fluency.

Students' awareness of punctuation and capitalization rules' violations can also contribute to reading comprehension by facilitating readers' awareness of the sentence structure, which is a strong predictor of reading comprehension (Lervåg, et al., 2018; MacKey, Lynch, Duncan, & Deacon, 2021). For instance, capitalizing the first word in the sentence and ending the sentence with a punctuation mark sets clear boundaries for readers to understand where the message starts and where it ends. Writers also use commas to clarify the sentence structure and to communicate more effectively with the reader, as depicted by the popular example *Let's eat, grandma* (where in the absence of the comma, the message becomes a gruesome incitement to cannibalism). Additionally, commas play other important roles in the sentence structure, such as helping the readers identify two separate clauses that are joined

by a conjunction (I like reading, and I love listening to music.), or to set off a nonessential or nonrestrictive clause (My neighbor, who was always friendly, moved to another state.) The potential association between punctuation and reading comprehension is also supported by empirical neuroscientific evidence. In one study, readers' eye movements were influenced by syntactic boundaries set by punctuation (Andrews & Veldre, 2021) and another study found longer fixations at clause and sentence boundaries made by commas and periods (Hirotani, Frazier, & Rayner, 2006). The authors interpreted these findings as evidence that punctuation facilitates rereading a text, which in turn has the potential to improve reading comprehension. Notably, these studies focused on the most basic punctuation rules (i.e. periods and commas), but we could not find empirical evidence to indicate the possibility that understanding the function of dialogue marks could predict the development of reading comprehension – an issue that we'll address in this paper.

The punctuation marks indicating direct speech or a dialogue (sometimes in conjunction with other punctuation marks) can also facilitate reading comprehension, by helping the readers understand the text and sentence structure, and by helping the readers correctly identify the speaker and the narrator. To illustrate this idea, let's look at the following sentences that include identical words, produced in the same sequence: *"Where is it, Danny?" asked his friend impatiently. vs. "Where is it?" Danny asked his friend impatiently.* In the first example, the speaker is Danny's friend (because the closing quotation mark was placed after the word Danny), while in the second example, the speaker is Danny (because the quotation marks ended after the word *it*). Here, the quotation marks (in conjunction with the question marks) play a fundamental role in conveying the meaning of the text.

Another writing skill potentially associated with reading comprehension is the awareness (and the correct usage) of capitalization. We use capital letters to indicate the beginning of a sentence (thus, showing awareness of the sentence structure), or to indicate a proper noun (thus, identifying names in the text, which have a different function and meaning compared to all the other words). Experimental evidence has shown that when these conventions are violated by inverting the capitalization rules, by capitalizing the initial letters of all words, or by capitalizing the initial letters of randomly chosen words, the reading rate decreased by 4% through 19% (Bock, 1986). A more recent eye tracking study supports these findings. Rayner and Schotter (2014) have manipulated the capitalization features of the words, by presenting the participants words that could be both capitalized (e.g. Ballet of Paris) or not (e.g. ballet). They found that fixation times on capitalized words were shorter than the fixation times on the same words that started with lower-case letters, suggesting that capitalization can reduce the reading time because it carries enhanced semantic information. Although the increase in reading rate is not a direct indicator of reading comprehension, it is one of its two main predictors (Hoover & Tunmer, 2022). Hence, these findings suggest that the awareness of capitalization rules can contribute indirectly to reading comprehension via reading fluency: the readers who understand the capitalization conventions being able to read more fluently. In addition to the reading rate benefits, proper noun capitalization was also found to help readers make inferences about a sentence's syntactic structure (Cutter, Martin, & Sturt, 2020). The study suggests that when students are aware of the capital letters in the text, they do a better job at inferring syntactic category (in particular) or predicting the meaning of the text (in general). Nevertheless, we did not find a study to test the extent of which such awareness of capitalization rules' violations could contribute directly to the development of reading comprehension, an issue that we'll address in this paper.

1.5. Predictors of reading comprehension: Theory and empirical evidence

To better understand the potential contribution of students' awareness of punctuation and capitalization rules' violations to the development of reading comprehension in elementary school (which is the focus

of our study), we first need to understand the main factors that predict reading comprehension and to account for them as potential confounding variables.

The two main predictors of the development of reading comprehension are of word decoding fluency (i.e. effectively sounding out a list of written words) and listening comprehension (i.e. understanding the meaning of a message conveyed orally), as theorized by the *simple view of reading* (Gough & Tunmer, 1986; Hoover & Gough, 1990). This theoretical model has been successfully tested in more than 150 empirical studies (Hoover & Tunmer, 2022), the two predictors explaining most of the variance in reading comprehension (Kim, 2017; Lervåg, Hulme, & Melby-Lervåg, 2017; Lonigan, Burgess, & Schatschneider, 2018). Thus, identifying new predictors of reading comprehension beyond word decoding fluency and listening comprehension is paramount to advance reading research.

Another important predictor of reading comprehension in developmental studies is its autoregressor (i.e. reading comprehension tested at an earlier point in time) (e.g. Lervåg, Dolean, Tincas, & Melby-Lervag, 2019; Dolean, Lervåg, Visu-Petra, & Melby-Lervag, 2021). The autoregressor is usually strongly correlated with the dependent variable, and any variable that can predict reading comprehension beyond its autoregressor is considered to have a strong predictive validity.

Reading comprehension can also be predicted by the general cognitive ability (e.g. Lervåg et al., 2019). General cognitive ability is particularly important when readers are expected to make inferences and show the ability to comprehend beyond the literal meaning of the text, a defining feature of the reading comprehension test that we used in our study. Thus, accounting for general cognitive ability is important when testing the potential effects of other predictors, such as the one we tested in our study.

2. The present study

While instruction of punctuation and capitalization rules is mostly used to teach (or remediate) writing skills, the aforementioned empirical evidence supports its potential contribution to the development of reading comprehension. This research (approved by the research ethics committee of the university where the first author of this study is affiliated, reference number 19624) does not go as far as to test whether improving awareness of punctuation and capitalization rules' violations can improve reading comprehension, but it makes the first step in this direction, by trying to identify a potential direct association between these variables.

A unique feature of our study is that we have measured the students' awareness of the punctuation and capitalization rules' violations with a challenging set of tests developed and field tested by the first author prior to this study (see Fig. 1). Unlike other assessments of the awareness of punctuation and capitalization rules' violations which typically measure limited skills (e.g., periods and commas) in disconnected sentences, the added value of our assessments is that they investigate in depth knowledge of punctuation rules (such as the appropriate placement dialogue marks) in an authentic text containing multiple connected sentences.

Another important feature of our study is that we don't just analyze the concurrent association between students' awareness of punctuation and capitalization rules' violations and reading comprehension, but we analyze their effects on the development of reading comprehension during one academic year.

We hypothesize that given the multiple roles that punctuation and capitalization rules have in facilitating reading comprehension, it is plausible that awareness of these rules' violations can predict the development of reading comprehension. To the best of our knowledge, this is the first research to test empirically the direct association between these two variables.

Thus, our study aimed to answer the following research question:
To what extent does awareness of punctuation and capitalization

Fig. 1. Example of an Assessment Depicting a Student's Unawareness of Some of the Punctuation and Capitalization Rules' Violations (left) and its Translation in English (right). The Check Marks Indicate the Correctly Identified Rules' Violations.

rules' violation predict the development of reading comprehension?

3. Method

3.2. Participants

We performed a power analysis by considering the data's clustered nature. Since decoding and language skills typically explain more than 90% of the variance in reading comprehension (e.g. Kim, 2017; Lervag et al., 2018; Lonigan et al., 2018), we assumed an effect size of minimum 0.8 and an intra-class correlation of 0.20 (Hedges & Hedberg, 2007). We used the Optimal Design software (Raudenbush et al., 2011) to perform the power analysis. Based on a desired statistical power of 0.8, with α = 0.05, and 16 clusters (i.e., the number of schools we had institutional agreement with), the analysis showed that we would need at least 160 participants to attain the appropriated statistical power (n = 10 participants per cluster).

One hundred and eighty-eight monolingual students (95 boys) randomly selected from 34 classrooms nested in 16 different schools from the Transylvania region (north-west) of Romania participated in this study. The gender distribution was representative for the Romanian school age population, where about half of the students are boys, and half are girls. All students were registered in second grade and attended public schools in both rural ($n = 7$) and urban ($n = 9$) communities. Public schools are a typical school setting in Romania, as private schools can be only found in a few large cities. The urbanization ratio was also representative for Romania, where the urban/rural ratio is about 50:50. The mean age of the participating students was 96 months (age range: 89–114 months). The sample included Romanian ($n = 181$, or 96.3%) and Roma minority students ($n = 7$, or 3.7%). According to the ethnic structure of the Romanian population from 2011 population census (www.insse.ro), 88.6% of the people living in Romania are Romanian and 3.2% are Roma. We did not include linguistic minority students in our sample because accounting for bilingualism was beyond the scope of our current study and most linguistic minority groups that can be found in Romania (e.g. German, Turkish, or Ukrainian) were underrepresented or could not be found in the Transylvanian region where the study was conducted.

3.3. Measures

3.3.1. Reading comprehension

We tested reading comprehension with the Form A of the Romanian adapted version of Neale Analysis of Reading Ability – Second Edition (NARA II; Neale, 1997). The test was previously piloted and then used in another longitudinal study (Lervåg et al., 2019). The test included 6 stories that gradually increased in difficulty. Each story was followed by open-ended questions (4 questions after story 1, respectively 8 questions after stories 2 through 6). Each correctly answered question was scored with 1 point, the students having the potential of earning a total of 44 points. The internal consistency of the test was high when the students were tested in Fall (α = 0.95) and in Spring (α = 0.95).

3.3.2. Listening comprehension

We tested listening comprehension with the Form B of the Romanian adapted version of Neale Analysis of Reading Ability – Second Edition (NARA II; Neale, 1997). The measure was previously field tested on a different sample or Romanian children. Just like Form A, the test included 6 stories that gradually increased in difficulty, and each story was followed by open-ended questions (4 questions after story 1, and 8 questions after stories 2 through 6). The internal consistency of this test was high (α = 0.93).

3.3.3. Word decoding fluency

We used a Romanian word decoding fluency test similar to the Test of Word Reading Efficiency – Second Edition (TOWRE-2 - Torgesen, Wagner, & Rashotte, 2012), and previously field tested and successfully used in another study (Dolean, Melby-Lervag, Tincas, Damsa, & Lervag, 2019). The test had two lists of 80 words (Form 1) and 80 nonsense words (Form 2) with increased length and complexity. The students were asked to read as correctly and as fast as they could in 40s. Each word/nonsense word read correctly was marked with one point. There was a strong positive correlation between the two forms ($r = 0.94$). The final word decoding fluency score that we used in our analysis was the average between the two scores.

3.3.4. Editing for punctuation and capitalization

Students' awareness of capitalization and punctuation rules' violations was tested with two parallel forms of an editing task (See Fig. 1 for an example of one of the two forms). The tests were previously field tested and successfully used in another study (Dolean & Lervåg, 2021) that measured the development of writing skills (but not their relationship with reading comprehension). The design of the tests was similar to item 19 of the Written Expression subtest of OWLS-II (Carrow-Woolfolk, 2011). Each test included 34 errors (14 capital letters, 7 periods, 5 dialogue marks, 2 question marks, 2 exclamation points, 3

comas and 1 colon). Each correctly identified error received one point, so the maximum number of points the students could have receive for each test was 34. The internal consistency of this test was good ($\alpha = 0.88$ Form A and $\alpha = 0.91$ for Form B), and there was a strong positive correlation between the two forms ($r = 0.86$). We calculated the final score by averaging the scores of the two parallel forms.

3.3.5. General cognitive ability

We tested the general cognitive ability with Raven's Colored Progressive Matrices (Raven, Raven, & Court, 1991), a test used to measure the non-verbal abilities and abstract reasoning. The scale has 36 items with increasing complexity, each item including a visual geometric design that had a missing piece. The students were required to choose the correct missing piece out of several choices displayed at the bottom of the page. The scores ranged on a scale from 0 to 36. The internal consistency of our data was good ($\alpha = 0.86$).

3.4. Procedures

Reading comprehension and the general cognitive ability were individually assessed by trained research assistants in a quiet room within the school where the students attended. The testing of the two constructs took place at the beginning of the school year (September). Each session lasted between 20 and 40 min, and the students took breaks between the testing sessions. The students were tested within a testing window that lasted about 3 weeks (although most students were tested within two weeks). The scoring sheets were coded and reported by research assistants. We tested again the students' reading comprehension at the end of the school year (May 2019), using the same test (NARA-II), and under the same administration conditions.

Editing for punctuation and capitalization was group-administered by trained research assistants, following a scripted protocol. The test was administered at the beginning of the school year (September). The students who missed school the day of the test administration, were tested separately during a designated make-up testing day, scheduled within a week of the original test administration. The answer sheets were collected and scored by trained research assistants.

4. Results

The descriptive statistics including mean, standard deviation, skewness, kurtosis, and correlation coefficients for all variables measured in the Romanian sample are included in Table 1. The percentage of missing data across the variables tested varied between 2.1 and 4.8%, with a total of 41 missing values (21.8%). We employed the Little's MCAR analysis to test for the pattern of the missing values. Results showed that our values missed at random [$\chi^2(30) = 29.669$, $p = .483$]. To obtain the same number of observations across the models included in the multilevel analysis (see below), we treated missing

values replacing them with the mean of their corresponding variable. The results were similar to the ones that we had when we analyzed the data that contained missing values.

Given the nested structure of the data, we employed a multilevel linear mixed model analysis to test the predictors of students' reading comprehension scores collected in Spring. *Students* ($n = 188$) were clustered within *classrooms* ($n = 32$), and classrooms were nested within *schools* ($n = 16$). We ran a sequence of eight regressions to determine the model of best fit.

First, we tested a null model in which we included only the random intercepts for classrooms and schools. This model showed a significant variance for schools ($\sigma^2_{00} = 0.38$, $p < .001$) but a lack of variance for classrooms ($\sigma^2_{00} = 0.00$). The variance in the outcome variable explained by the clustering effect of schools was 36.2%. Since the random effect of classrooms was zero in the first place, we have eliminated it from the subsequent analyses.

The second model that we tested included fixed effects for the demographic variables (i.e., age and gender) and the random intercept for schools. Adding the demographic factors lowered the schools' variance ($\sigma^2_{00} = 0.36$). As such, the second model had a marginal R^2 of 0.008, but the same conditional R^2 of 0.362.

In the third model we added the students' general cognitive ability as a fixed effect, which lead to an increase in the marginal R^2 to 0.239 and to an increase of the total variance to 0.520. In this model the random effect of schools continued to decrease ($\sigma^2_{00} = 0.28$).

The fourth model included the reading comprehension scores collected in Fall, with a marginal R^2 of 0.720 and a conditional R^2 of 0.783. The random effect of schools was reduced even more, explaining only 6% of the variance in the outcome variable.

Next, we added in the fifth model the scores for listening comprehension and word decoding fluency. Marginal R^2 increased to 0.740 and the conditional R^2 to 0.802. The schools' random effect continued to explain 6% of the variance.

In the sixth model we included editing for punctuation and capitalization as a predictor, which significantly improved the marginal R^2 to 0.751 and the conditional R^2 to 0.810. The school's random effect remained constant (see Table 2).

Finally, we allowed the slopes for Fall reading comprehension scores (the seventh model) and editing scores (the eighth model) to vary as a function of schools. However, none of these models provided better fit: $\chi^2(2) = 5.984$, $p = .050$ (the seventh model) and $\chi^2(2) = 4.208$, $p = .121$ (the eighth model).

The results of our analysis indicated that the students' reading comprehension scores in Spring were positively predicted by their performance on listening comprehension [$\beta = 0.23$, $t(186) = 4.51$, $p < .001$], reading comprehension assessed in the Fall [$\beta = 0.56$, $t(183) = 8.67$, $p < .001$] and by their editing skills [$\beta = 0.14$, $t(187) = 2.54$, $p = .012$]. However, the demographic covariates (i.e., age and gender), the word decoding fluency, and the general cognitive ability scores were not

Table 1
Correlations and descriptive statistics of the measured variables.

Variable	1	2	3	4	5	6	7
1. Age (months)	–						
2. Editing	−.104	–					
3. Cognitive ability	.153*	.503**	–				
4. Listening Comprehension	−.066	.492**	.544**	–			
5. Reading Comprehension Fall	−.109	.638**	.581**	.725**	–		
6. Reading Comprehension Spring	−.079	.636**	.519**	.729**	.846**	–	
7. Word Decoding Fluency	−.063	.703**	.531**	.429**	.596**	.545**	–
M	95.66	11.80	25.36	18.52	16	21.20	27.71
SD	3.65	8.12	5.66	8.88	10.14	10.68	12.79
Minimum	89	0	11	0	0	0	0
Maximum	114	33	35	40	43	44	60
Skewness	1.38	.51	−.44	.03	.46	.00	.33
Kurtosis	4.37	−.57	−.63	−.79	−.51	−.82	−.36

*p < .05; **p < .01.

Table 2

Coefficients of the multilevel model predicting students' reading comprehension in spring.

	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7		Model 8	
	b	S.E.	b	S.E.	b	S.E.	b	S.E.	b	S.E.	b	S.E.	b	S.E.	b	S.E.
Fixed Effects																
(Intercept)	−0.04	0.17	1.89	1.67	0.38	1.44	−0.63	0.96	−0.52	0.91	−0.50	0.89	−0.47	0.87	−0.67	0.88
Age			−0.02	0.02	−0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Gender			0.10	0.12	0.09	0.11	0.14	0.07	0.12	0.07	0.09	0.07	0.08	0.07	0.07	0.07
Cognitive ability					0.48**	0.06	0.07	0.05	0.01	0.05	−0.01	0.05	−0.02	0.04	0.00	0.04
Reading Comprehension Fall							0.80**	0.05	0.59**	0.06	0.56**	0.06	0.55**	0.08	0.55**	0.06
Listening Comprehension									0.24**	0.05	0.23**	0.05	0.26**	0.05	0.23**	0.05
Word Decoding Fluency									0.09	0.04	0.03	0.05	0.04	0.05	0.03	0.05
Editing											0.14*	0.05	0.12*	0.05	0.13*	0.06
Random Effects																
Class-level Variance	0.00															
School-level Variance	0.38		0.36		0.28		0.06		0.06		0.06		0.04		0.04	
Reading Comprehension Fall													0.03			
Editing															0.02	
Marginal R²/Conditional R²	0.000/0.362		0.008/0.362		0.239/0.520		0.720/0.783		0.740/0.802		0.751/0.810		0.748/0.826		0.753/0.818	

*$p < .05$; **$p < .001$.

significant predictors of the outcome variable (see Table 2).

Considering the moderate correlations between editing and listening comprehension ($r = 0.49$), and word decoding fluency respectively ($r = 0.70$) we conducted two post-hoc analyses to test for the potential mediation effects of editing on the relationships between listening comprehension (on the one hand), word decoding fluency (on the other hand) and reading comprehension measured in Spring. Using the Bootstrap Confidence Intervals with the Percentile Method (Hayes & Scharkow, 2013) we performed these analyses while controlling for the dependent variable's autoregressor (i.e., reading comprehension tested in Fall). The first analysis indicated that the indirect effect was not significant for listening comprehension ($b = 0.011$, CI 95% [−0.025; 0.05], $p = .570$), because the path *a* (the relationship between listening comprehension and editing) was not significant ($b = 0.057$, CI 95% [−0.090; 0.205], $p = .442$). The second analysis showed a significant indirect effect of editing on the relationship between word decoding fluency and reading comprehension in Spring ($b = 0.072$, CI 95% [0.022; 0.130], $p < .001$), while the direct effect of word decoding fluency on our dependent variable was no longer significant ($b = 0.053$, CI 95% [−0.03; 0.150], $p = .208$). This analysis indicated that students' editing skills completely mediated the effect of word decoding fluency on reading comprehension measured in Spring.

To check for the statistical power achieved, we performed a post-hoc power analysis based on the results in the multilevel analyses (effect size of 0.81 and intra-class correlation of 0.24). Using the Optimal Design software (Raudenbush et al., 2011), the analysis showed an achieved power of 0.78, which is in line with the optimal level of power recommended (Cohen, 2013, p. 242).

5. Discussion

The aim of this paper was to test the extent of which students' awareness of punctuation and capitalization rules' violations can predict the development of reading comprehension. Our initial data indicated a moderate positive correlation between students' awareness of punctuation and capitalization rules' violations and reading comprehension in Fall ($r = 0.64$) and Spring ($r = 0.64$), suggesting an important association between these variables. The subsequent multilevel linear mixed model analysis indicated that students' awareness of punctuation and capitalization rules' violations tested with a task like the one presented in Fig. 1 had a direct, unique effect on the development of reading comprehension beyond fluent decoding and listening comprehension (as outlined by the *simple view of reading*) and beyond the autoregressor. These effects were important considering the strong correlation between

the reading comprehension scores collected in Fall and Spring ($r = 0.85$), as well as the strong correlation between the listening comprehension scores tested in Fall and the reading comprehension scores tested in Spring ($r = 0.73$). In the reading literature we rarely find variables that have a unique effect on reading comprehension after controlling for decoding fluency, listening comprehension and its autoregressor, and our findings suggest that students' awareness of punctuation and capitalization rules' violations is not only important for the development of the writing skills, but it seems to be an underrated and under-researched strategy to potentially improve reading comprehension.

Our last model showed a significant effect of language skills, but a weak effect of decoding fluency on reading comprehension. These results are not surprising, as the literature has shown that decoding fluency has a curvilinear effect on the development of reading comprehension, i.e., the decoding fluency plays a less important role in reading comprehension once the students learn to decode fluently enough (Lervåg et al., 2018; Dolean et al., 2021). Thus, our data suggest that the students in our sample had adequate decoding fluency skills. At the same time, the strong effects of listening comprehension are not surprising, as the literature shows that the oral language comprehension plays an increasingly important role in the development of reading comprehension, the two factors becoming one construct by the time the students reach middle school (Lervag et al., 2018; Ricketts, Lervåg, Dawson, Taylor, & Hulme, 2020).

Interestingly, our final model showed that the general non-verbal intelligence did not have a significant effect on reading comprehension after accounting for all the other independent variables. These results are not trivial, especially considering that previous longitudinal research conducted in Romania indicated that the non-verbal cognitive ability (measured with Raven matrices, just like in this study) had a direct effect on the development of reading comprehension (measured with NARA II, just like in this study) of students from 1st through 3rd grade (Lervåg et al., 2019). These findings strengthen the significance of our study and underline the importance of students' awareness of punctuation and capitalization rules' violations on predicting the development of reading comprehension.

It is noteworthy the moderate correlation between our editing task and decoding fluency ($r = 0.70$) and the fact that editing mediated the effects of decoding (but not of listening comprehension) on reading comprehension tested in Spring after controlling for reading comprehension tested in Fall. While our data does not allow us to test the directionality of the association between the editing task and word decoding fluency, it is plausible that the later variable played a critical

role in solving the editing task, which required students to read the text repeatedly until they could comprehend it. So in our study, it was the students' word decoding skills (and not their listening comprehension skills) that contributed to their ability to identify the writing conventions' errors of a text.

5.1. Theoretical implication

Our study showed that the students' awareness of writing conventions can uniquely predict the development of reading comprehension beyond the effects of word reading fluency and listening comprehension. However, such awareness plays a paramount role in reading prosody (Arcand et al., 2014; Godde et al., 2022), given that a good reader needs to know well such writing conventions in order to properly use phrasing, intonation, expression, or to have an adequate cadence while reading (Godde, Bosse, & Bailly, 2020). Thus, it is plausible that students' awareness of punctuation and capitalization rules' violations might be a proxy for (or at least one of the indicators of) reading prosody and it's likely that our findings uncovered a mechanism through which prosody (or at least one indicator of prosody) is associated with reading comprehension (Godde et al., 2020; Kim et al., 2021; Wade-Woolley et al., 2022; Wolters et al., 2022). They also seem to be consistent with the idea that prosody becomes a stronger predictor of reading comprehension than word decoding fluency once the readers can read fast and accurately enough (Godde et al., 2020).

Therefore, our findings seem to suggest that the *simple view of reading* can be augmented by recognizing prosody as a potential mediator of the effects of the word decoding fluency on reading comprehension (see Fig. 2).

5.2. Implications for practitioners

A noteworthy practical implication of our study is that our assessment of students' awareness of punctuation and capitalization rules' violations might have captured some of the underlying components of the multidimensional construct that is reading comprehension (Catts, 2018). This is particularly important given that researchers have pointed to numerous validity and reliability threats of the assessment of reading comprehension. For instance, when Keegan and Meenan (2014) assessed 995 students with four different standardized reding comprehension tests, the bivariate correlations between these tests ranged between 0.45 and 0.68. Their findings indicated that different reading comprehension tests measure different skills, the authors suggesting that "practitioners and researchers should take a more nuanced view of comprehension deficits and use multiple tests to establish the nature of a child's reading comprehension deficit." (p. 133). Given that our correlation coefficient between editing and reading comprehension was .64 (i.e., as high or higher than the ones from Keegan and Meenan study), it is possible that our editing test measures certain underlying skills that are necessary for

a good reading comprehension, such as reading prosody (Wade-Woolley et al., 2022). While we certainly don't try to say that our editing test should replace a comprehensive standardized reading comprehension test, we suggest that the assessment introduced here could provide valuable information about some sources of reading comprehension difficulties. Thus, our assessment can be effectively used as a screener at the beginning of the school year, as a formative assessment throughout the year, or it could be added to a reading comprehension standardized assessment battery.

Additionally, the brevity (2–4 min) of the group-administered editing assessment presented in this paper has the potential to save important instructional time for teachers while providing them with crucial information about their students' reading and writing skills. The time saving benefit is particularly relevant for teachers, especially when they are expected to frequently progress monitor the literacy development of their students. Thus, such an instrument can save important instructional time by progress monitoring several literacy skills (word reading, reading comprehension, and writing conventions).

5.3. Limitations and future research

Our study has several limitations and suggests at least five directions for future research.

First, our claim that students' awareness of punctuation and capitalization rules' violations can be a proxy for prosody is speculative. Thus, our theoretical model needs to be tested empirically. To do that, future studies should assess students' awareness of punctuation and capitalization together with other prosody indicators (e.g. phrasing, intonation, cadence) and test whether they all load into one single latent variable (prosody). Then, the effects of this variables on reading comprehension should be tested on students of different skills/age groups, while accounting for word decoding fluency and oral language comprehension.

Second, in spite of the original contribution of this study, this is just one piece of evidence testing the hypothesis on a sample of children from Romania. More studies are necessary to replicate our findings, conducted in different settings, using different tests, and selecting samples of students speaking different languages.

Third, while in our study we only tested the effects of writing conventions' violations on the development of reading comprehension, it might be possible that the effects can be bidirectional. Future developmental research could test this hypothesis.

Fourth, we measured students' awareness of writing conventions' violations with a behavioral task (editing) and not with a direct measure of their visual processing of the written text (eye movement). Future studies could strengthen our findings by including eye-movement measures to assess students' awareness of the writing conventions' violations.

Finally, now that we have established a direct association between the students' awareness of punctuation and capitalization rules' violations and reading comprehension, future studies are necessary to test the extent of which intervention programs designed to improve the development of students' awareness of capitalization and punctuation rules' violations can lead to an improvement of reading comprehension.

6. Conclusion

Reading and writing are interconnected at many different levels and in this study, we have identified how a component of the writing process (i.e. text revision for writing conventions' violations) can predict reading development. Our findings support an augmented theoretical model of the *simple view of reading* which suggests that prosody (and its underlying mechanisms) can mediate the effects of word decoding fluency on reading comprehension. Thus, both researchers and practitioners should pay closer attention to the non-negligible role of the students' awareness of the writing conventions on the development of
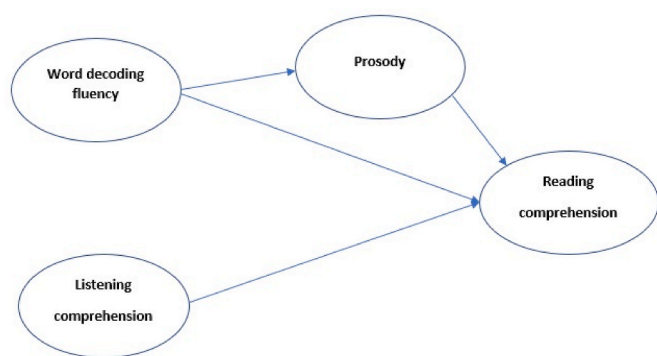

Fig. 2. Augmented model of the "simple view of reading" including the unique effects of prosody on reading comprehension.

reading comprehension.

Data availability

Upon request.

Ethics statements

This research was approved by the research ethics committee of the university where the first author of this study is affiliated (reference number 19624). All participants had a signed parental approval for participation in our study.

Author contributions

Dacian Dolean: Conceptualization, Methodology, Data collection, Writing – original draft, review & editing, Narcisa Prodan: Data analysis, Writing – data analysis.

Author statement

All work is original.

Declaration of competing interest

The research was approved by the ethics committee of Babes-Bolyai University.

Acknowledgement

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