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Original articles

Progress of error typology and self-correction in schoolchildren's text reading

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ABSTRACT

Purpose: to verify the progress of error typology and percentage of self-correction in text reading and their association with reading fluency in second/third graders (group 1) and fifth/sixth graders (group 2) and the influence of education level on the typology of errors and percentage of self-correction.

Methods: an observational, analytical, and longitudinal study. Altogether, 41 students were assessed during the COVID-19 pandemic regarding text reading fluency, percentage of self-corrections and errors, and error typology. The Wilcoxon and paired t-tests were used to compare means, and Pearson's and Spearman's tests for correlations. The p-value was set at $p < 0.05$.

Results: group 1 had a decrease in the percentage of errors and an increase, followed by a decrease, in self-corrections. Group 2 had an increase in the percentage of self-corrections, with no variation in errors. The association analysis revealed that the higher the reading speed, the lower the percentage of self-corrections. In the second assessment, group 1 had more self-corrections than group 2 and, in the third one, group 2 had more errors than group 1.

Conclusion: the increase in reading fluency and the decrease in errors occur progressively – unlike self-correction, which varies throughout the school year. However, there is an inverse relationship between speed and self-correction.

Keywords: COVID-19; Reading; Learning; Educational Measurement; Speech, Language and Hearing Sciences

INTRODUCTION

School failure resulting from learning difficulties brings with it enormous costs to society. Hence, studies on the typology of errors, self-correction, and reading fluency can help to understand the mechanisms involved in reading and how it is learned[1-3].

Research has seldom analyzed the typology of student errors[4]. However, studies[5,6] point out that the topic importantly warns for the knowledge of underlying processes, the error as an attempt to read correctly, which must be overcome or modified as students progress in school. Moreover, the number and types of student errors can also be indications of difficulties in writing[4].

Studies in the Brazilian literature have investigated the typology of errors, assessed with lists of isolated words[1,7-9]. However, it is important to use reading in context, especially to analyze the typology of errors, self-correction, and reading fluency. This modality also enables the assessment of reading comprehension and expressiveness.

The literature[10] describes self-correction as a strategy in which the reader monitors and corrects their reading errors. Nguyen, Del Tufo, and Cutting[3] establish a relationship between self-correction skills and executive functions, associating self-correction with the perception and correction of reading errors. They indicate the good use of cognitive skills in the reevaluation of signaling systems for accurate text processing, a factor that helps in the constancy of reading fluency.

The literature available on the topic has not yet reached a consensus on the relationship between self-correction and reading development. However, research such as that of D'Agostino, Kelly, and Rodgers[11] suggests a positive relationship between them. The authors observed in their results that the ability to self-correct can boost reading proficiency in the early years, providing important feedback for the early word identification systems being developed by the beginning reader.

The relevance of reading fluency measures, self-correction, and typology of errors in academic performance makes it crucial to study and monitor them in order to understand the factors that interfere with learning to read. In this regard, the context generated by the COVID-19 pandemic has impacted student performance and revealed the urgency of specific interventions to mitigate such effects.

Health measures to contain the spread of coronavirus infections in Brazil led schools to adopt emergency remote teaching. The sudden and prolonged closure of schools negatively impacted education, especially among students learning to read[12-14]. United Nations[15] and World Bank[16] reports mention such impacts, indicating that school closures in Latin America and the Caribbean may have affected the reading comprehension of approximately 77% of middle school students, a percentage that reached 55% before the pandemic, with greater educational losses, especially for the low-income population[16].

As for Brazil, Alves et al.[17] point out that second graders suffered a greater impact on their reading fluency, with results below those expected for that grade in school. The technical report, "Networked literacy: An investigation into remote literacy teaching during the COVID-19 pandemic"[18] highlights the insufficiency and difficulties in remote teaching, which does not consider the specificities of learning to read and write – aspects that are possibly associated with the results found by Alves et al.[17].

Thus, longitudinal analysis of students during and after school closures allows us to monitor the impacts of remote learning and the progress of Brazilian students' reading skills on an individual basis. It can also be used to seek remedial interventions to prevent students' academic progress from being compromised and these difficulties from continuing into adulthood.

Therefore, this study aimed to verify the progress of error typology and the percentage of self-correction in reading texts and their association with reading fluency in second/third and fifth/sixth graders of a private school during and after emergency remote teaching. It also aimed to verify the influence of the education level on the typology of errors and the percentage of self-correction in reading texts.

METHODS

This study was approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais, Brazil, under CAAE no. 35588820.0.0000.5149 and evaluation report no. 4.453.235. This observational, analytical, longitudinal study had a sample selected for convenience. Participants and their parents/guardians filled out informed assent and consent forms.

The research included students transitioning from second to third grade (group 1 – the phase immediately after acquiring reading fluency) and from fifth to sixth grade (group 2 – the phase when they progress from intermediate to disciplinary literacy). Both classes were from a private school, approached from 2020 to 2021.

The longitudinal study included 26 second/third graders and 15 fifth/sixth graders, totaling 41 students, of which 18 were females and 23 were males. Research participation criteria were enrollment in the second grade and continuation in the third grade in the following year and enrollment in the fifth grade in 2020 and continuation in the sixth grade in the following year. The study excluded students whose parent/guardian helped them during reading, with important phonological substitutions, and who did not participate in any stage of the collection, regardless of the reason.

The readings were recorded remotely in three stages due to social distancing measures taken against COVID-19. The first recording took place in September 2020, the second in March 2021, and the third in September 2021, for a total of 153 reading recordings. The students were in remote learning in the first two recordings and back in in-person learning in the third one.

Suitable texts were selected for each grade, according to the protocol "Assessment of Reading Comprehension of Expository Texts"[19], to assess reading fluency and classify error types.

The reading was recorded via video call in the Zoom application, on a computer or another device with a suitable screen size for reading the text. It was recommended that a quiet place be chosen outside of class hours to carry out the reading.

Students were previously instructed on how to do the reading, and all questions they had were clarified. After the instructions, students read the text projected on the screen aloud while the call was recorded. The audio was extracted to analyze reading parameters.

The parameters analyzed in the reading recordings were the percentage of self-corrections, the percentage and classification of errors, and speed (number of words read per minute – WPM) and accuracy (number of words correct per minute – WCPM).

The types of errors were classified according to the study by Ávila et al.[1], reading lists of isolated words. Since the reading was in context, six categories were added (T11-T16) to cover all error types, following the criteria described in Chart 1.

Chart 1. Error typology classification according to Ávila et al. (2009), with categories added by the authors

Error Typology Classification	Criteria
T1 – Substitution for a visually similar word	When the presented word was read as if it were another orthographically similar word
T2 – Regularizations	When irregular words, with values of the letter "x", were read as regular (with the sound value of the digraph -ch) – (example: exagero read as echagero)
T3 – Mistaking the rule of grapheme-phoneme correspondence	When consonants, which maintain a univocal relationship with a phoneme, or vowels were substituted in word reading, causing incorrect reading (example: ganso read as canso)
T4 – Deletions and additions	When vowels or consonants were deleted or added
T5 – Misspelling	When the error occurred due to failure to use the correspondence rules dependent on the graphemic context (example: mesada read as messada, gemada read as guemada)
T6 – Sequence inversions	When some letters in the target stimulus were read in reverse sequence (example: esgoto read as egosto)
T7 – Error regarding the use of stress	When there was a correct assignment of the sound value of the graphemes, but an error in identifying the stressed syllable (example: xale read as chalé)
T8 – Misusing accent marks	When there was a correct assignment of the sound value of the graphemes, but errors in the appropriate use of stress determined by the accent mark (example: lâmpada read as lampáda)
T9 – Complex errors	When more than one error occurred in the same word
T10 – Refusals	When the child refused to read the word
T11 – Word addition*	When the child adds an article or articulator to the word (example: como Pedro read as como o Pedro)
T12 – Word deletion*	When a word, an articulator, or an article is deleted
T13 – Wod repetition*	When a word is repeated
T14 – Plural and singular*	(Example: são read as é; or coisas read as coisa – i.e., "are" read as "is"; or "things" read as "thing"); this classification overlaps with category T4. Therefore, if the omission or addition of a letter implies a variation of plural or singular, it should be classified as T14
T15 – Semantic substitution*	Words from the same context, but that are not similar (example: árvores read as floresta – i.e., "trees" read as "forest")
T16 – Word inversion*	Inversion of word order in the text

* categories added by the authors

The WPM analysis used the number of words read in the text, divided by the time (minutes) spent reading. The percentages of self-corrections and errors were calculated from the sum of the manual markings from listening to the recordings, divided by the number of words in the text. The WCPM was obtained by the following formula: [number of words in the text - (number of total errors + T11 errors + T13 errors)], divided by the time in minutes spent reading.

Statistical analysis

Collected data were entered into Excel and analyzed using IBM SPSS, version 23. A descriptive analysis of the data was performed using measures of central tendency and variability for continuous variables (WPM, WCPM, percentage of self-correction, percentage of errors, and typology of errors). The distribution of the continuous variables was assessed using the Kolmogorov-Smirnov test with Lilliefors correction, which indicated a normal distribution for reading speed and accuracy and percentage of self-correction and an asymmetric distribution for the percentage of errors and typology of errors. These data underwent cross-sectional and longitudinal analyses.

The longitudinal analysis used the t-test for paired samples for variables with normal distribution and the Wilcoxon test for variables with asymmetric distribution.

The correlation analysis between self-correction, speed, and percentage of errors used Spearman's correlation test for comparisons with the asymmetric variable (percentage of errors) and Pearson's correlation for comparisons with the symmetric variables (reading speed and percentage of self-correction). Correlation for the data was considered based on p-values < 0.05. The degree of correlation was classified with the following scale: 0 – 0.2 = Very poor correlation; 0.21 – 0.4 = Poor correlation; 0.41 – 0.6 = Fair correlation; 0.61 – 0.8 = Good correlation; 0.8 – 1.0 = Excellent correlation[20].

The cross-sectional analysis used the t-test for variables with normal distribution and the Mann-Whitney test for variables with asymmetric distribution.

RESULTS

Reading performance: self-correction, percentage of errors, WPM, and WCPM

Table 1 shows the performance of students in group 1 (second/third graders) regarding the percentage of self-correction, percentage of errors, WPM, and WCPM, in September 2020, March 2021, and September 2021.

Table 1. Performance of students in group 1 (second/third graders) in words per minute, correct words per minute, percentage of self-correction, and percentage of errors in September 2020, March 2021, and September 2021

Variables	Measures	Sept 2020 (T1)	Mar 2021 (T2)	Sept 2021 (T3)	p-value T1 x T2	p-value T2 x T3	p-value T1 x T3
% of self-corrections	Mean	1.05	2.04	1.28	0.006*	0.005*	0.399
	Standard deviation	0.93	1.46	0.83			
% of errors	Mean	5.06	3.26	1.43	0.026*	0.001*	0.001*
	Standard deviation	5.17	2.74	1.06			
Reading speed (WPM)	Mean	84.53	75.78	96.39	0.012*	0.001*	0.001*
	Standard deviation	20.66	23.02	20.66			
Accuracy (WCPM)	Mean	80.68	73.42	95.05	0.027*	0.001*	0.001*
	Standard deviation	21.79	22.68	20.63			

Captions: WPM = words per minute; WCPM = words correct per minute; % = percentage; T1 = time 1; T2 = time 2; T3 = time 3; Sept = September; Mar = March; * p-value < 0.05; t-test for paired samples with a normal distribution and Wilcoxon test for samples with an asymmetrical distribution (% of error)

The results in Table 1 indicate that the percentage of self-correction had a statistically significant increase from September 2020 to March 2021 (p = 0.006) and a decrease from March 2021 to September 2021 (p = 0.005). September 2020 and September 2021 had similar values, with no statistically significant difference. The percentage of errors had a statistically significant decrease between the three periods.

Reading speed and accuracy decreased between September 2020 and March 2021 and improved between March 2021 and September 2021. The performance also increased from September 2020 to September 2021.

Table 2 shows the performance of students in group 2 (fifth/sixth graders) regarding the percentage of self-corrections and errors, WPM, and WCPM in September 2020, March 2021, and September 2021.

Table 2. Performance of students in group 2 (fifth/sixth graders) in words per minute, words correct per minute, percentage of self-correction, and percentage of errors in September 2020, March 2021, and September 2021

Variables	Measures	Sept 2020 (T1)	Mar 2021 (T2)	Sept 2021 (T3)	p-value T1 x T2	p-value T2 x T3	p-value T1 x T3
% of self-corrections	Mean	0.68	0.62	1.52	0.700	0.005*	0.001*
	Standard deviation	0.59	0.62	0.68			
% of errors	Mean	2.91	3.54	2.93	0.233	0.334	1.000
	Standard deviation	2.32	1.91	2.10			
Reading speed (WPM)	Mean	103.61	106.48	116.61	0.364	0.001*	0.001*
	Standard deviation	12.73	17.12	17.68			
Accuracy (WCPM)	Mean	100.63	102.68	113.25	0.481	0.001*	0.001*
	Standard deviation	12.83	16.43	17.84			

Captions: WPM = words per minute; WCPM = words correct per minute; % = percentage; T1 = time 1; T2 = time 2; T3 = time 3; Sept = September; Mar = March; * p-value < 0.05; t-test for paired samples with a normal distribution and Wilcoxon test for samples with an asymmetrical distribution (% of error)

The results indicate that group 2 had a statistically significant increase in WPM, WCPM, and percentage of self-corrections between March 2021 and September 2021 and between September 2020 and September 2021. The percentage of errors did not have a statistically significant difference between the three moments.

Analysis of the typology of errors in text reading

Tables 3 and 4 present the results of the statistical analysis of the percentage of each error type of students in groups 1 (second/third graders) and 2 (fifth/sixth graders), respectively, in the three collection moments: September 2020, March 2021, and September 2021.

Table 3. Descriptive analysis of the error types of students in group 1 (second/third graders) in September 2020, March 2021, and September 2021

Error types	Measures	Sept 2020 (T1)	Mar 2021 (T2)	Sept 2021 (T3)	p-value T1 x T2	p-value T2 x T3	p-value T1 x T3
%T1	Mean	1.09	1.13	0.66	0.848	0.025*	0.178
	Standard deviation	1.18	1.30	0.80			
	N (%)	15 (57.69%)	17 (65.38%)	15 (57.69%)			
%T2	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T3	Mean	0.19	0.27	0.02	0.570	0.026*	0.141
	Standard deviation	0.64	0.64	0.11			
	N (%)	3 (11.53%)	6 (23.07%)	1 (3.84%)			
%T4	Mean	0.35	0.38	0.00	0.645	0.004*	0.024*
	Standard deviation	0.70	0.54	0.00			
	N (%)	6 (23.07%)	10 (38.46%)	0 (0%)			
%T5	Mean	0.00	0.02	0.19	0.317	0.052	0.003*
	Standard deviation	0.00	0.14	0.27			
	N (%)	0 (0%)	1 (3.84%)	10 (38.46%)			
%T6	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T7	Mean	0.00	0.27	0.15	0.004*	0.213	0.038*
	Standard deviation	0.00	0.41	0.34			
	N (%)	0 (0%)	9 (34.61%)	5 (19.23%)			
%T8	Mean	0.11	0.19	0.11	0.671	0.259	0.916
	Standard deviation	0.33	0.43	0.28			
	N (%)	3 (11.53%)	5 (19.23%)	4 (15.38%)			
%T9	Mean	0.00	0.16	0.04	0.034*	0.058	0.157
	Standard deviation	0.00	0.37	0.15			
	N (%)	0 (0%)	5 (19.23%)	2 (7.69%)			
%T10	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T11	Mean	0.07	0.08	0.08	1.000	0.914	0.914
	Standard deviation	0.27	0.31	0.20			
	N (%)	2 (7.69%)	2 (7.69%)	4 (15.38%)			
%T12	Mean	2.23	0.38	0.19	0.005*	0.108	0.005*
	Standard deviation	3.80	0.93	0.39			
	N (%)	12 (46.15%)	6 (23.07%)	7 (26.92%)			
%T13	Mean	0.11	0.08	0.00	1.000	0.180	0.317
	Standard deviation	0.60	0.31	0.00			
	N (%)	1 (3.84%)	2 (7.69%)	0 (0%)			
%T14	Mean	0.94	0.41	0.02	0.035*	0.007*	0.002*
	Standard deviation	1.22	0.64	0.11			
	N (%)	12 (46.15%)	9 (34.61%)	1 (3.84%)			
%T15	Mean	0.11	0.00	0.00	0.180	1.000	0.180
	Standard deviation	0.44	0.00	0.00			
	N (%)	2 (7.69%)	0 (0%)	0 (0%)			
%T16	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			

Captions: % = percentage; T1 = time 1; T2 = time 2; T3 = time 3; Sept = September; Mar = March; * p-value < 0.05; N = number of students who made the error; Wilcoxon test

The results in Table 3 indicate that the most common error types in group 1 (second/third graders) in September 2020 were T1 – substitution for visually similar word (57.69% of students), T12 – omission of words (46.15% of students), and T14 - plural and singular (46.15% of students). In March 2021, the types that stood out were T1 – substitution for a visually similar word (65.38% of students), T4 – deletions and additions (38.46% of students), T7 – stress errors (34.61% of students), and T14 – plural and singular (34.61% of students). As for September 2021, the most repeated types of errors were T1 – substitution for visually similar words (57.69% of students) and T5 – misspelling (38.46% of students).

The percentage of T12 and T14 errors had a statistically significant decrease, and that of T7 and T9 errors had a statistically significant increase, from September 2020 to March 2021. Also, the percentage of T1, T3, T4, and T14 had a statistically significant decrease, and that of T5 errors had a statistically significant increase, from March 2021 to September 2021. The percentage of T4, T12, and T14 errors had a statistically significant decrease, and that of T5 and T7 errors had a statistically significant increase from September 2020 to September 2021. The other percentages of error types had no statistically significant difference.

The results in Table 4 indicate that the most common error types in group 2 (fifth/sixth graders) in September 2020 were T1 – substitution for a visually similar word (66.66% of students) and T12 – deletion of words (66.66% of students). In March 2021, the most common types were T1 – substitution for a visually similar word (66.66% of students), T12 – deletion of words (66.66% of students), and T5 – misspelling (60% of students). Lastly, the most common errors in September 2021 were T1 – substitution for a visually similar word (80% of students) and T12 – deletion of words (60% of students).

Table 4. Descriptive analysis of the error types of students in group 2 (fifth/sixth graders) in September 2020, March 2021, and September 2021

Error types	Measures	Sept 2020 (T1)	Mar 2021 (T2)	Sept 2021 (T3)	p-value T1 x T2	p-value T2 x T3	p-value T1 x T3
%T1	Mean	0.62	0.56	1.15	0.972	0.064	0.249
	Standard deviation	0.57	0.54	1.33			
	N (%)	10 (66.66%)	10 (66.66%)	12 (80%)			
%T2	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T3	Mean	0.16	0.26	0.07	0.462	0.343	0.655
	Standard deviation	0.45	0.52	0.28			
	N (%)	2 (13.33%)	4 (26.66%)	1 (6.66%)			
%T4	Mean	0.13	0.38	0.07	0.021*	0.048*	0.293
	Standard deviation	0.20	0.50	0.20			
	N (%)	5 (33.33%)	8 (53.33%)	2 (13.33%)			
%T5	Mean	0.13	0.44	0.22	0.020*	0.137	0.733
	Standard deviation	0.20	0.44	0.45			
	N (%)	5 (33.33%)	9 (60%)	4 (26.66%)			
%T6	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T7	Mean	0.00	0.17	0.19	0.034*	0.450	0.180
	Standard deviation	0.00	0.28	0.66			
	N (%)	0 (0%)	5 (33.33%)	2 (13.33%)			
%T8	Mean	0.16	0.00	0.44	0.034*	0.026*	0.788
	Standard deviation	0.25	0.00	0.75			
	N (%)	5 (33.33%)	0 (0%)	6 (40%)			

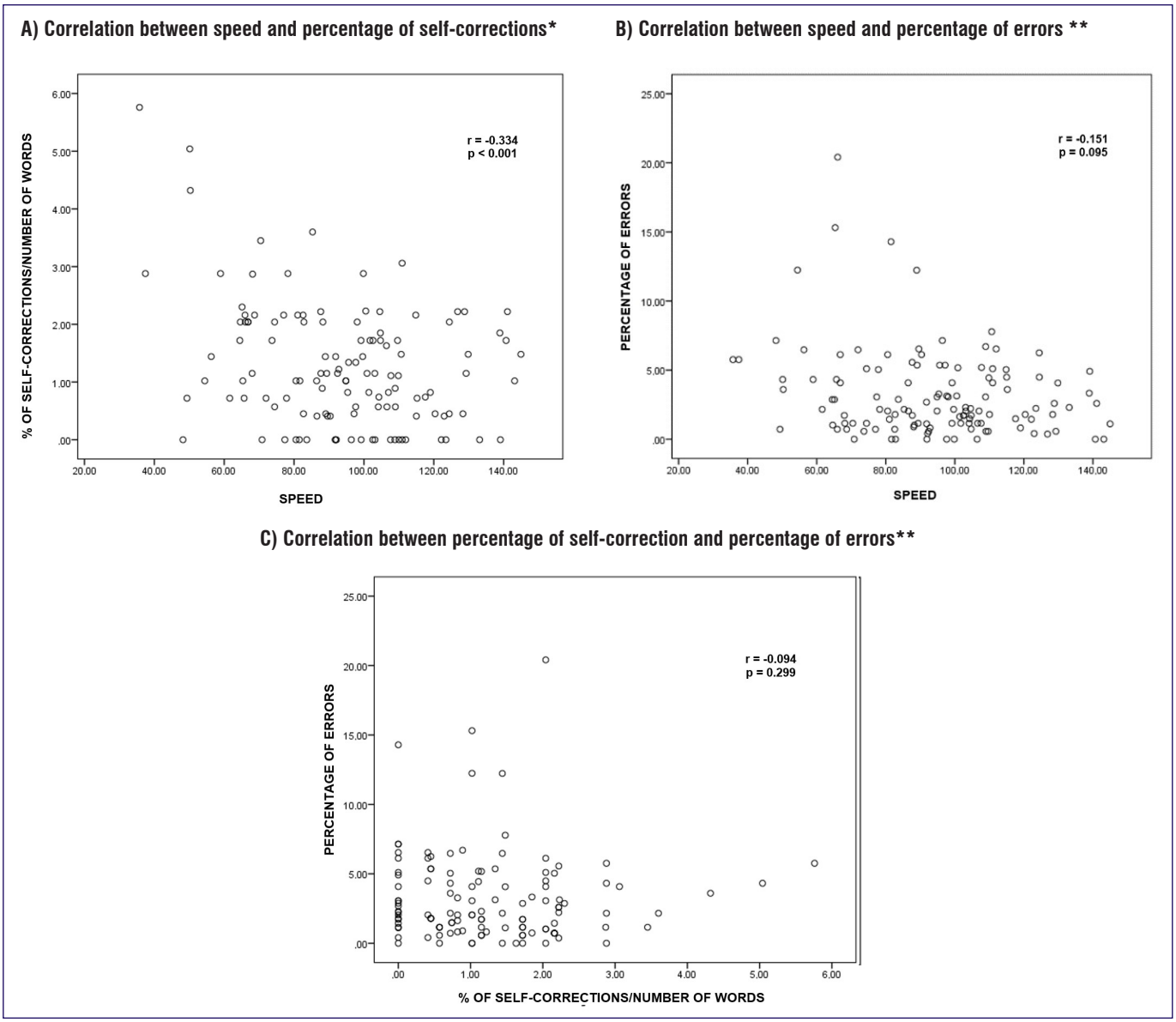
Error types	Measures	Sept 2020 (T1)	Mar 2021 (T2)	Sept 2021 (T3)	p-value T1 x T2	p-value T2 x T3	p-value T1 x T3
%T9	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T10	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T11	Mean	0.02	0.17	0.00	0.655	0.317	0.317
	Standard deviation	0.10	0.69	0.00			
	N (%)	1 (6.66%)	1 (6.66%)	0 (0%)			
%T12	Mean	1.22	0.77	0.39	0.683	0.008*	0.086
	Standard deviation	1.76	0.76	0.43			
	N (%)	10 (66.66%)	10 (66.66%)	9 (60%)			
%T13	Mean	0.00	0.00	0.00	1.000	1.000	1.000
	Standard deviation	0.00	0.00	0.00			
	N (%)	0 (0%)	0 (0%)	0 (0%)			
%T14	Mean	0.29	0.44	0.37	0.167	0.386	0.859
	Standard deviation	0.44	0.53	0.59			
	N (%)	6 (40%)	8 (53.33%)	7 (46.66%)			
%T15	Mean	0.10	0.29	0.00	0.063	0.026*	0.046*
	Standard deviation	0.18	0.43	0.00			
	N (%)	4 (26.66%)	6 (40%)	0 (0%)			
%T16	Mean	0.02	0.00	0.00	0.317	1.000	0.317
	Standard deviation	0.10	0.00	0.00			
	N (%)	1 (6.66%)	0 (0%)	0 (0%)			

Captions: Sept = September; Mar = March; * p-value < 0.05; N = number of students who made the error; Wilcoxon test

The percentage of T8 errors had a statistically significant decrease, and that of T4, T5, and T7 errors had a statistically significant increase, from September 2020 to March 2021. The percentage of T4, T12, and T15 errors had a statistically significant decrease, and that of T8 errors had a statistically significant increase, from March 2021 to September 2021. Also, the percentage of T15 errors had a statistically significant decrease from September 2020 to September 2021. The other percentages of error types had no statistically significant difference.

Correlation between self-correction, speed, and percentage of errors

Figure 1 shows the correlation between self-correction, speed, and percentage of errors in the entire sample. It was decided to combine groups 1 and 2 to verify possible correlations and not to use accuracy (WCPM) in the correlation because this measure is directly related to the speed and number of errors during reading.



*Pearson's correlation / ** Spearman's correlation

Figure 1. Correlation between words correct per minute, percentage of self-correction, and percentage of errors

Speed was significantly negatively correlated with the percentage of self-correction – i.e., speed tends to increase as the percentage of self-correction decreases, and vice versa. However, speed was not significantly linearly correlated with the percentage of errors, neither was the percentage of errors with the percentage of self-correction.

Table 5 presents the comparison results between the groups in each of the three assessments: between the second and fifth grades in September 2020, between the third and sixth grades in March 2021, and between the third and sixth grades in September 2021 regarding the percentages of errors and self-corrections.

Table 5. Cross-sectional analysis between second and fifth graders in September 2020, between third and sixth graders in March 2021, and between third and sixth graders in September 2021

Grade in school	n	% of self-corrections		% of errors	
		Mean	Standard deviation	Mean	Standard deviation
2nd grade/Sept 2020	26	1.05	0.93	5.06	5.17
5th grade/Sept 2020	15	0.68	0.59	2.91	2.32
p-value		0.167		0.314	
3rd grade/Mar 2021	26	2.04	1.46	3.26	2.74
6th grade/Mar 2021	15	0.62	0.62	3.54	1.91
p-value		< 0.001*		0.398	
3rd grade/Sept 2021	26	1.28	0.83	1.43	1.06
6th grade/Sept 2021	15	1.52	0.68	2.93	2.10
p-value		0.332		0.030*	

Captions: Mar = March; Sept = September; * p-value < 0.05; t-test for variables with a normal distribution and Mann-Whitney test for asymmetrical variables (% of errors)

The comparison of performance between the second and fifth graders in September 2020 shows no statistically significant difference in the percentages of self-corrections and errors.

Data comparing the performance of third and sixth graders in March 2021 showed that the percentage of self-corrections decreased. The percentage of errors did not show a statistically significant difference between the periods.

The comparison of performance between third and sixth graders in September 2021 showed that the percentage of errors increased. The percentage of self-corrections had no statistically significant difference between the periods analyzed.

DISCUSSION

This study aimed to verify the progress of error typology and the percentage of self-correction in text reading and their association with reading fluency in second/third and fifth/sixth graders and verify the influence of education level on error typology and the percentage of self-correction in text reading. Hence, it used the following measures: percentage of self-correction, percentage of errors, typology of errors, WPM, and WCPM.

Second/third graders increased their reading speed (WPM) and accuracy (WCPM) and reduced their percentage of errors as the school year progressed. These data corroborate the literature, which states that reading performance improves with academic development[21-26]. However, the results decreased from September 2020 to March 2021, which can be explained by summer learning loss[27] (i.e., the risk of impaired or stagnated learning processes during the summer vacation) or the continuity of remote teaching – which may have demotivated students for academic activities, increased screen time, and decreased reading time. The students' reading speed progressed from a mean of 75.7 WPM in March 2021 (still in remote mode) to 96.3 WPM in September 2021 (in-person classes), when their accuracy also increased from 73.4 WCPM to 95.0 WCPM. This finding likewise reinforces this hypothesis since it is a continuous period of classes, with a short break for the winter vacation.

The percentage of self-correction had a statistically significant increase from September 2020 to March 2021 and decreased from March 2021 to September 2021. Students initially read irregular words more slowly and with less accuracy, mainly due to the regularity effect; therefore, they tend to self-correct these words more often[7]. But as reading skills develop, they can perform more accurate grapheme-phoneme decoding and have already built a larger orthographic lexicon, requiring less self-correction.

The mean percentage of errors decreased as the school year progressed, which may also indicate less difficulty in word decoding skills. The speed, accuracy, and percentage of self-corrections and errors in group 2 (fifth/sixth graders) did not statistically significantly vary from September 2020 to March 2021. This finding may show stable reading skills and decreased regularity effect – i.e., they master irregular words better by the end of elementary school[28].

The means of WPM, WCPM, and the percentage of self-correction statistically significantly increased in the following period – from March 2021 to September 2021. This increase in self-corrections can be seen

as a positive aspect in this group, considering the relationship that the literature[3,11] establishes between self-correction and executive functions (e.g., attention), which indicates a good use of cognitive skills.

Another observation was that, unlike group 1, the WPM and WCPM did not worsen during school closure in group 2. This corroborates the idea that emergency remote teaching had a greater negative impact on the reading fluency of initial grades[17].

The occurrence of each error type in isolated word reading tends to decrease with the progression of schooling[1], and it was expected to follow the same pattern in reading in context. However, it was not so in this study sample, as the occurrence of some types of errors increased with school progression.

However, Frederiksen's study[29] demonstrated that the number of errors in reading words in context, as a rule, does not distinguish between groups of readers with high and low skills – which may justify the greater occurrence of some types of errors in more advanced grades. Another factor that may have contributed to this greater occurrence is the accumulation of negative effects resulting from prolonged remote teaching.

Besides the quantitative one, the study performed a qualitative analysis of the most frequent errors in more advanced periods. Hence, the qualitative analysis found that the text favored T5 errors (misspelling) in the word "distinguish". Most students with a T5 error made it in this word, which is repeated twice throughout the text. Moreover, the qualitative analysis shows that the text also favored T7 errors (stress errors) in the word "distinguish" ("*distinguem*", in Portuguese), read by most as [dis.ti.'gu.˜e].

The analysis led to the belief that the predominant type of error at each reading moment is greatly influenced by the text – i.e., each text has a set of words, sometimes less common, other times more complex to decode, which favors the occurrence of a specific type of student error[1,7-9]. Furthermore, school closure during the pandemic may have had a negative impact on reading accuracy[17].

Given the suitability of the text to the grades in school, students in more advanced grades are expected to perform better or similarly in reading parameters with higher education levels and more developed reading skills[17,25,30].

The comparison between students in September 2020 shows that fifth graders had higher speed (WPM) and accuracy (WCPM) than second graders, and the percentages of self-corrections and of errors were not statistically significantly different between the periods. Despite the lack of statistically significant values, the mean percentage of errors was considerably higher in second grade than in fifth grade, reinforcing the idea that students at the end of elementary school have a greater ability to deal with the occurrence of irregular words[28].

The same occurred when comparing the performance of third and sixth graders in March 2021. Speed (WPM) and accuracy (WCPM) increased, and the percentage of errors was not statistically significantly different between the periods, whereas the percentage of self-corrections increased.

The reading process through the phonological route is suitable for reading regular words and pseudowords. However, it increases the reaction time and/or the errors when reading irregular words[7]. Generally, phonological strategies are used in the initial phase of learning to read and are replaced with lexical or orthographic strategies at the end of the first cycle[28]. This may explain the greater speed (WPM) and accuracy (WCPM) in fifth graders than in second graders in September 2020, as well as in sixth graders than in third graders in March 2021.

The increase in self-correction at the beginning of middle school can be explained by a reduction in attentional mechanisms. With the increase in reading speed (considering that reading is an easy task), some words are commonly read incorrectly and even decoded inaccurately at first. However, the student can notice the error with self-monitoring skills and more developed reading and comprehension and self-correct quickly, so as not to interfere so much with reading speed[2,3,11].

Comparison data between third and sixth graders in September 2021 show that the percentage of errors was higher in sixth graders than in third graders, which was not initially expected. This result may be due to the size of the study sample. Another probable justification is that the greater number of errors comes from a failure in the top-down reading process, with anticipation from the macrostructure to the microstructure of the text, not done accurately by the students because the text was more complex and had less common words[31].

The findings also reinforce the need for students to have contact with different types of text, with a diversity of high and low-frequency words in the language, to ensure continuous reading training and accuracy in academic development.

Furthermore, phonological skills must be trained from the initial grades, with an emphasis on

grapheme-phoneme correspondence, to develop reading skills better.

Lastly, further studies should investigate students' performance using the same text for all grades, with a representative sample of the population, to analyze the correlation between the typology of errors, self-correction, and reading fluency with less interference from the context.

CONCLUSION

This study verified that children at the beginning of elementary school improved their reading parameters. On the other hand, their reading fluency parameters decreased in March 2021, probably due to the stagnation of learning processes during summer vacation and the negative effects of the sudden and prolonged school closure.

Students transitioning from elementary to middle school tend to have more stable reading fluency measures, possibly with less impact from emergency remote teaching. It was also noted that the error typology is greatly influenced by the context and does not seem to correlate directly with the other reading parameters.

The inherent limitation of this study is the generalization of the results since the sample was limited to a private school during and after emergency remote teaching.

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VOMR: Data analysis; Funding Acquisition; Writing - Review & editing.

LSCF: Data curation; Writing - Original draft.

IMC: Data curation; Writing - Review & editing.

GLR: Data curation.

CMMC: Writing - Review & editing.

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LCC: Conceptualization; Data analysis; Writing - Review & editing.

Data sharing statement:

The data from this research will not be available for sharing.