



Correlations between handwriting and spelling in Elementary School students

Correlações entre o traçado da escrita manual e o desempenho ortográfico de escolares do Fundamental I

Correlaciones entre el trazado de la escritura manual y el desempeño ortográfico de escolares de primaria

*Esmeralda Sandra Santos Damasceno**

*Clara Regina Brandão de Avila**

*Mirian Aratangy Arnaut**

Abstract

Objective: To characterize the handwriting and spelling performance of elementary school students and to investigate correlations between these variables according to school grade and system. **Method:** The researchers analyzed 34 noun phrases written from dictation by 80 elementary school children aged 2-5 years, 20 attending each grade (10 from public schools and 10 from private schools per grade). The children were recommended by their own teacher for performing well at school. The analysis of the children's handwriting took into account the position of the writing in space, irregularities in letter formation, and irregularities in the spacing between letters. Writing errors were classified as either phonological or orthographic in nature. The performances of students of each grade were compared, as were those of children attending public and private schools. Correlations between performance variables were investigated. A likelihood ratio test was conducted, and the Spearman's rank correlation coefficient was used, with statistical significance set to 0.05. **Results:** No differences were observed among the different grades as to the occurrence of dysgraphia or dysorthographia. Both disorders were more common in the public school system than in the private one. The most frequent types of spelling errors found were the switching of graphemes corresponding to voiced-voiceless phonemes and the omission of codas.

**Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brasil.*

Conflito de interesses: Não.

Authors' Contribution: ESSD and MAA were in charge of data collection, tabulation and analysis, and participated in the drafting and critical review of the manuscript. CRBA was responsible for the study project and design, and for general orientation of execution and elaboration of the manuscript. ia: Esmeralda Sandra Santos Damasceno. São Paulo (SP), Brasil.

Correspondence address: hesksandra@gmail.com

Received: 03/03/2015 **Accepted:** 18/09/2015



Dysgraphia and spelling performance were positively correlated. **Conclusion:** The writing performances were similar among children of all grades, in terms of both handwriting and spelling. The more features of dysgraphia were present, the greater the number of errors found in the writing of elementary school children, particularly in the public school system.

Keywords: Handwriting; Speech Language Pathology and Audiology; Assessment.

Resumo

Objetivo: Caracterizar o desempenho ortográfico e o traçado da escrita manual de escolares do Ensino Fundamental I e investigar correlações entre essas variáveis segundo o ano escolar e a rede de ensino. Método: Analisaram-se amostras de escrita sob ditado de 34 sintagmas nominais de 80 prontuários de crianças matriculadas de 2º a 5º ano do Ensino Fundamental, 20 de cada ano escolar (10 da rede pública e 10 da rede particular por ano). As crianças foram indicadas pelas professoras por apresentarem bom rendimento escolar. A análise do traçado gráfico foi realizada segundo critérios de posição da escrita no espaço, irregularidade e características do traçado da letra e irregularidade do espaço entre as letras. Os erros de escrita foram classificados segundo a natureza fonológica ou ortográfica. Os desempenhos foram comparados por ano escolar e correlações foram investigadas. Aplicou-se o Teste da Razão de Verossimilhança e calculou-se o Coeficiente de Correlação de Spearman, com significância estatística fixada em 0,05. Resultados: Não foram observadas diferenças entre os desempenhos em função dos anos escolares, quanto à disgrafia ou disortografia. Ambas foram mais frequentes na rede pública de ensino. Os tipos de erros de escrita mais encontrados foram trocas na codificação de grafemas correspondentes aos fonemas 'surdo-sonoro' e 'omissão de coda'. Disgrafia e o desempenho ortográfico correlacionaram-se positivamente. Conclusão: O desempenho em escrita foi semelhante nos diferentes anos escolares, tanto no traçado quanto na ortografia. Quanto mais características de disgrafia maior o número de erros encontrados na escrita, principalmente na rede pública de ensino.

Palavras-chave: Escrita manual; Fonoaudiologia; Avaliação

Resumen

Objetivo: caracterizar el trazado de la escritura manual y el desempeño ortográfico de escolares de la primaria y investigar correlaciones entre esas variables de acuerdo al año escolar y la red de enseñanza. Método: Se analizaron muestras de escritura producidas bajo dictado de 34 sintagmas nominales de 80 registros de niños, inscritos desde el 2º hasta el 5º año de la enseñanza primaria, 20 de cada año escolar (10 de la red pública y 10 de la red particular por año). Los niños fueron elegidos por sus maestros por buen desempeño escolar. El análisis del trazado gráfico consideró: la posición de la escritura en el espacio, la irregularidad y las características del trazado de la letra, y irregularidades del espacio entre las letras. Los errores de la escritura fueron clasificados según su naturaleza fonológica u ortográfica. Los desempeños fueron comparados según el año escolar y correlaciones fueron investigadas. Se aplicó el Teste de la Razón de Verosimilitud y se calculó el Coeficiente de Correlación de Spearman con significación estadística de 0.05. Resultados: No se observaron diferencias entre los desempeños, en función de los años escolares, entre disgrafía y disortografía. Ambas fueron más frecuentes en la red de enseñanza pública. Los tipos de errores de escritura más frecuentes fueron cambios en la codificación de grafemas correspondientes a los fonemas 'sordo-sonoro' y 'omisión de coda'. Disgrafía y desempeño ortográfico se correlacionaron positivamente. Conclusión: El desempeño en la escritura fue semejante en los distintos años escolares tanto en el trazado cuanto en la ortografía. Cuanto más habían características de disgrafía, más numerosos eran los errores encontrados en la escritura, principalmente en la Red Pública de enseñanza.

Palabras clave: Escritura manual; Fonoaudiología; Evaluación.

Introduction

Writing is an expressive means of communication acquired from formal instruction. It requires the development of a series of specific skills, from automatic ones (for instance, visual and motor skills), to perceptive and even metacognitive skills. Writing with competency requires the development of specific skills in order to form the letters rapidly and efficiently, and display them linear and consecutively to represent words selected to express thought fluently¹.

Writing texts that are orthographically accurate, cohesive and coherent demands the orchestration of different abilities: it takes a mastery of the alphabetic system principle, control over spelling, predicting the sequencing of ideas, and formalizing the discourse in the absence of an interlocutor². One may understand writing as expression with meaning, produced according to grammatical and orthographic rules and conventions. Cognitive skills (for metagraphic analyses, for instance) and language skills (phonological processing and phoneme-grapheme association) also contribute to the intended product of an orthographically correct and fluent writing, indicative that the schoolchild has developed his abilities of self-expression through writing³.

The orthographic mastery of writing is achieved throughout the school years. According to the Brazilian National Curriculum Parameters (Parâmetros Curriculares Nacionais or PCN), at the end of the first cycle of elementary school (1st, 2nd and 3rd grades) learners must be able to recognize the orthographic regularities while becoming aware of their language's irregularities, in addition to correctly separating words in space. At the end of the second cycle, they need to correctly use the orthographic accentuation rules and verbal and nominal inflections⁴. Therefore, schoolchildren who reach the end of the 5th grade of elementary school are expected to have mastered the orthography of familiar words, both with regular or irregular orthographies.

The regularity and precision in letter formation, the layout of the letters in space, and the time spent executing that task are all integral parts of written language production, and must also be analyzed when an issue is detected in a schoolchild's writing. Precise, effortless handwriting allows the learner to focus attention primarily to the correct

orthography of words, the familiarity of which will, with learning, allow the learner to achieve an attentive, self-monitored accomplishment of what he or she wants to write. A precise and regular handwriting should facilitate self-monitoring and self-correction, thus leading to correct spelling.

An understanding of precise letter formation entails admitting that fine motor skills are an indispensable tool for executing tasks that require dexterity^{5,6}. The motor act of writing is a complex process, which involves continuous changes in the pressure, direction, speed, and acceleration of the hand's movements. These skills will benefit the learning process, the mastery of the alphabetic principle and the orthographic rules that will allow the writing of words, sentences and texts to legibly express the human thought and knowledge. As school learning progresses, the learning of writing is expected to integrate the knowledge of orthography into the domain of proprioceptive and visual abilities, fine motor control and planning, tactile and kinesthetic sensitivities, and sustained attention^{8,9}.

Succinctly speaking, in order to achieve as final product a legible, orthographically accurate writing, an individual must have a well-orchestrated and simultaneous processing of sensory-motor, linguistic and perceptual skills^{5,10}.

It is fair to state that to master orthography one needs to develop attention, metagraphic analysis and self-correction (error identification), which depend on the legibility of writing. Thus, the latter may interfere in the learning of orthographic writing¹¹. Consequently, there may be associations between both the perceptual-visual-motor and the orthographic developments. Indeed, the literature has evidenced the presence of correlations between handwriting and orthographic writing^{8,6,12}, whether in regular or irregular development.

When they begin school, children with fine-motor coordination disorders may have their school and even their daily activities compromised⁶. Alterations in fine-motor coordination may interfere in the acquisition of legible handwriting, with consequences for the learning of orthography (even though it also depends on the habit of reading and on the optimal processing of phonological information)^{6,12}.

It may be said that the deviations identified in writing can be categorized into two types of disorders: dysorthographia and dysgraphia.

Dysorthographia is the inability to correctly spell words; dysgraphia is impairment in handwriting. In both conditions it is possible to notice deviations in written expressions, which compromise skills such as automatically identifying words and writing without alterations in the actual handwriting, switching letters, undue joining or separation of words, confusing syllables, omitting or inverting letters, deficiencies in the shape of letters, and extra spacing, in addition to realizing graphic signs such as paragraphs, accentuation and punctuation¹²⁻¹⁶.

Some studies have investigated features of children's handwriting and their use of orthographic rules under different learning conditions. One study on dysgraphia¹⁷ analyzed the traces of children with and without writing difficulties, from different socioeconomic status, and from both public and private schools. The Study Group was composed of children attending public schools, with and without learning difficulties, with family incomes of up to three minimum wages. The Control Groups (CG1 and CG2) were composed of children attending public schools without learning difficulties, and with family incomes of between eight and 12 minimum wages, and by children attending private schools, without learning difficulties, with family incomes of between 15 and 30 minimum wages, respectively. The results showed that 24% of the children in the Study Group were dysgraphic, versus 20% in CG1 and 0.8% in CG2. The author justified the study's findings by stating that family income was a significant factor in the prevalence of dysgraphia, and suggesting that the use and the consequent encouragement of writing are limited among families with lower incomes; i.e., children who are not encouraged to write may present difficulties in developing and using writing.

In a study about the characterization of orthographic errors among children with different learning disorders, the researchers found a small number of dysgraphic children, and several types of orthographic errors, multiple representations being the most recurring of these errors¹⁸. According to the authors, this category of errors involves orthographic imprecisions that do not result from a failure or inadequacy in making correspondences between phonemes and graphemes, but from the fact that one phoneme may be represented by several different letters, or that the same letter may represent several phonemes. Therefore, these errors stem from deficiencies related to the processing of

orthographic information, whether due to development issues, poor instruction or a low exposure to reading.

An analysis of written production must take into account everything from the instruction needed for its learning and competent use, to understanding the complexity of the brain structures and functions involved in the motor act of writing, in the integration between codes and cognitive, metacognitive, and metalinguistic processes to master orthography, and strategic and pragmatic processes associated with formulating and producing text. Taking the early school years into consideration, the first signs of writing disorders may be noticed in the features related to the use of space and letter formation, both associated with perceptual-visual-motor development. Orthographic deficiencies must be considered throughout children's school years, even though some rules are learned during the early years of elementary education⁴. Regarding the features associated with the handwriting itself, the disorders may manifest in both domains, either in isolation or in association: in letter formation and in orthography^{5,16}.

Learning is evidently a process. Different studies conducted with Brazilian schoolchildren have shown that learning to write in Portuguese, even though it is a reasonably orthographically transparent language, is a process that implies making errors, the frequency of which, determined by the orthographic complexity, should decrease as schooling progresses, and in time should disappear^{5,12,18,19}. However, little importance is attached to the issues regarding the precision of letter formation and the possibility of there being an association between this and orthographic errors. Learning to write correctly depends, above all, on self-correction. Children who still need to think about how to form a letter focus their attention on that process, which will certainly have a negative impact on the fluency of their writing, the quality of its content, and the orthographic accuracy¹⁰.

Therefore, it is believed that as schooling progresses, errors should decrease, and letter formation should improve. The hypothesis that the features of letter formation and orthographic learning may be correlated in the handwriting of schoolchildren has underpinned the objectives of the present study. The arguments stated in this introduction raise the following questions: do children with the poorest

handwriting make more writing errors? Are these errors orthographic or phonological in nature? Is the handwriting of children who attend public schools poorer than those who attend private schools? Does letter formation really improve as schooling progresses?

In order to answer these questions, this study proposes to classify the handwriting and the orthographic performance of elementary schoolchildren and to investigate the correlations between these variables according to school grade and system.

Materials and Method

This is a retrospective, transversal, observational study, approved by the Research Ethics Committee under number 1768/11.

For this study, the researchers analyzed the protocols of the 80 subjects of the initial research. These protocols contained the samples of 34 noun phrases written from dictation. The noun phrases were chosen so as to allow comparison between the schoolchildren's handwriting: instead of the heterogeneous nature of regular written text production, it was possible to obtain homogeneous writing samples.

Initially, this study took into consideration the variables "level of schooling" and "school system" (public or private). The protocols were grouped according to the school grade (2nd to 5th) and whether the schoolchildren attended public (PU) or private (PA) schools.

The following groups were formed, composed of 10 protocols each: **2nd grade:** PU2 and PA2; **3rd grade:** PU3 and PA3; **4th grade:** PU4 and PA4; **5th grade:** PU5 and PA5. The children, both boys and girls, aged 7-11 years, were recommended by their teachers for performing well at school, i.e., according to the teachers, these children had above-average grades in Portuguese and Math. Twenty children per each school year were selected (10 from public schools and 10 from private schools), and dictations were only conducted once the children's parents had signed an informed consent form.

The general criteria for inclusion of schoolchildren in the study were the following: absence of complaints or signs of hearing, or (uncorrected) visual impairments; absence of neurological, behavioral or cognitive disorders; and no history of grade retentions.

The subjects were told to write 34 noun phrases from dictation, composed of sequences of three to seven words of different lengths. The words chosen included all the graphemes and types of syllables in the Portuguese language. The list of phrases was prepared by a panel composed of two speech therapists and one linguist.

The subjects received a sheet of paper with a space to write their names, the date and the grade they were in, in addition to a space in which to write the dictated noun phrases, and a pencil. The children received the following instruction: "*I will say a small sentence, and you will write it on the sheet of paper. If necessary, I will say it one more time. If you make a mistake, cross the word and write it again in the space next to it. You must not erase it.*" The subjects were evaluated as a group of no more than 10 children.

The optimal condition for evaluation included noises that did not prevent the children from hearing the researcher's voice and understanding the spoken message.

Analyses of the written productions

The samples of writing (80 dictations of noun phrases) analyzed were written in pencil no. 2, on sheets of A4 ruled paper with 10mm spaces between lines and left and right margins of 25mm.

Analysis of the handwriting

The writings were initially analyzed by a panel composed of three judges selected for their experience working with assessment or rehabilitation of writing disorders in schoolchildren. The three judges' reports were statistically analyzed by applying the Wilcoxon Signed-Rank Test, which compares pairs of data. The result showed that the judges had different analyses of the material. Since their experiences dealing with writing disorders were equivalent, the researchers chose the analysis of the judge with the largest number of hours of training in the use of Lorenzini's Dysgraphia Scale²⁰, which was the scale used to analyze the handwriting of the material under study. This scale is composed of 10 items that enable the analysis of the following aspects of handwriting: a. floating lines; b. descending and/or ascending lines; c. Irregular spaces between words; d. touched up letters; e. Curves and

angles in the arches of the letters m, n, u, and v; f. Junction points (when the letters of a word were not joined together); g. Collisions and adhesions; h. Jerky movements; i. Irregular letter sizes; j. Poor letter formation.

The scoring criterion adopted for assessing the writing performance of schoolchildren was the one proposed by Lorenzini²⁰. The global scoring varied from zero to 17 points, and children who scored 8.5 points or more (50% of the overall score) were considered dysgraphic.

Analysis of orthography

The error classification proposed by Arnaut, Avila and Hackerott²¹ was adopted to analyze and classify the writing errors found in the dictation task:

1. errors of a phonological nature: switching in the coding of graphemes corresponding to the voiced/voiceless phonemes, switching of graphemes corresponding to phonemes with different places and manners of articulation; changes in the syllable structure (omission of graphemes corresponding to liquid phonemes in a consonant cluster; omission of graphemes corresponding to phonemes in a coda position); omission of syllables; undue word separation or junction, and contamination; **2. errors of an orthographic nature:** disrespect for the accentuation rules, codification supported by spoken language, omission of voiceless letters,

and undue use of letters (s/ss/ç/c; x/ch, s/z; j/g); **3. errors of a mixed nature:** indicate a likely phonological alteration in words – intervocalic “s” reproducing as the phoneme [z] instead of [s]; use of the letter “r” instead of “rr”; use of the letter “g” instead of “gu”; hypercorrection; letter insertion; other words (words spelled correctly, but which were not dictated). In this study, only the errors of a phonological nature were considered, due to its more fundamental source. For the analysis of data, the variable school grade was considered.

Statistical method

The Likelihood-Ratio Test was applied with the purpose of investigating possible differences between the grades and the public and private school systems. Spearman’s Rank Correlation Coefficient was calculated to find the degree of correlation between the desired variables.

The statistical significance was set to 0.05.

Results

Table 1 shows that dysgraphia was evenly distributed among school grades, and that there was a statistically significant difference in the number of dysgraphic children between the public and the private school systems, with a larger number of dysgraphics in public schools than in private ones.

TABLE 1. DISTRIBUTION OF SCHOOLCHILDREN ACCORDING TO THE SCHOOL SYSTEM OR SCHOOL GRADE AND THE PRESENCE OR ABSENCE OF DYSGRAPHIA

Variable	Category	Dysgraphia				p-value
		yes		no		
		Frequency	%	Frequency	%	
Grade	2 nd	10	50,00	10	50,00	0,164
	3 rd	16	80,00	4	20,00	
	4 th	11	55,00	9	45,00	
	5 th	10	50,00	10	50,00	
System	Public	29	72,50	11	27,50	0,012
	Private	18	45,00	22	55,00	

Likelihood-ratio test; significance level set to 0.05.
Legend: %=percentage

Table 2, in turn, shows the types of errors present or absent in the writing samples of the 80 schoolchildren per school system. Except for the “syllable addition” type of error, the comparison

between the two school systems showed that there were statistically significant differences between them, with a greater number of errors being committed by children attending public schools..

TABLE 2. DISTRIBUTION OF WRITING ERROR TYPES ACCORDING TO SCHOOL SYSTEM

Type of writing error	Category	School System				p-value
		Public		Private		
		Freq.	%	Freq.	%	
Voiced-voiceless switch	Yes	30	75,00	16	40,00	0,002
	No	10	25,00	24	60,00	
Syllable omission	Yes	8	20,00	2	5,00	0,043
	No	32	80,00	38	95,00	
Syllable addition	Yes	5	12,50	2	5,00	0,235
	No	35	87,50	38	95,00	
Undue separation	Yes	21	52,50	8	20,00	0,002
	No	19	47,50	32	80,00	
Coda omission	Yes	33	82,50	13	32,50	<0,001
	No	7	17,50	27	67,50	
Word junction	Yes	14	35,00	6	15,00	0,039
	No	26	65,00	34	85,00	

Likelihood-ratio test; significance level set to 0.05.

Legend: Freq.= Frequency; %=percentage

Table 3 shows the distribution of the total number of writing samples according to the type of error and the school grade. As may be seen in

the table, the different types of errors are evenly distributed among the grades..

TABLE 3. DISTRIBUTION OF SCHOOLCHILDREN ACCORDING TO THE PRESENCE OR ABSENCE AND THE TYPE OF WRITING ERROR, AND THE SCHOOL GRADE

Type of writing error	Category	School grade								
		2 nd grade		3 rd grade		4 th grade		5 th grade		
		Freq.	%	Freq.	%	Freq.	%	Freq.	%.	
Voiced-voiceless switch	Yes	12	60,00	14	70,00	11	55,00	9	45,00	0,447
	No	8	40,00	6	30,00	9	45,00	11	55,00	
Syllable omission	Yes	2	10,00	5	25,00	3	15,00	0	0,00	0,114
	No	18	90,00	15	75,00	17	85,00	20	100,00	
Syllable addition	Yes	2	10,00	3	15,00	1	5,00	1	5,00	0,632
	No	18	90,00	17	85,00	19	95,00	19	95,00	
Undue separation	Yes	9	45,00	8	40,00	8	40,00	4	20,00	0,363
	No	11	55,00	12	60,00	12	60,00	16	80,00	
Coda omission	Yes	15	75,00	14	70,00	9	45,00	8	40,00	0,056
	No	5	25,00	6	30,00	11	55,00	12	60,00	
Word junction	Yes	8	40,00	7	35,00	2	10,00	3	15,00	0,074
	No	12	60,00	13	65,00	18	90,00	17	85,00	

Likelihood-ratio test; significance level set to 0.05.

Legend: Freq.= Frequency; %=percentage

Table 4 shows the presence of different positive correlations between handwriting errors (except for “syllable addition” and “word junction”) and dysgraphia.

TABLE 4. CORRELATIONS BETWEEN DYSGRAPHIA AND ORTHOGRAPHIC ERRORS IN THE OVERALL SAMPLE

Variable	Statistics	Total score Dysgraphia	
		Public school	Private school
Voiced-voiceless	Rank coefficient (r)	+0,434	
	Calculated significance (p)	< 0,001	
	N	80	
Syllable omission	Rank coefficient (r)	+0,269	
	Calculated significance (p)	0,016	
	N	80	
Syllable addition	Rank coefficient (r)	+0,072	
	Calculated significance (p)	0,524	
	N	80	
Undue separation	Rank coefficient (r)	+0,293	
	Calculated significance (p)	0,008	
	N	80	
Coda omission	Rank coefficient (r)	+0,371	
	Calculated significance (p)	0,001	
	N	80	
Word junction	Rank coefficient (r)	+0,205	
	Calculated significance (p)	0,069	
	N	80	

Spearman’s Rank Coefficient (r); significance level set to: 0.05

Table 5 shows that dysgraphia was positively and moderately correlated with the presence of errors of the “voiceless/voiced” type, in both school systems. Differently from that result, “undue separation” errors were correlated with dysgraphia only among public school children, and “coda omission” and “word junction”, only among private school children..

TABLE 5. CORRELATIONS BETWEEN DYSGRAPHIA AND ORTHOGRAPHIC ERRORS ACCORDING TO THE SCHOOL SYSTEM

Variable	Statistics	Total score Dysgraphia	
		Public school	Private school
Voiced-voiceless	Rank coefficient (r)	+0,408	+0,450
	Calculated significance (p)	0,009	0,004
	N	40	40
Syllable omission	Rank coefficient (r)	+0,255	+0,234
	Calculated significance (p)	0,112	0,146
	N	40	40

Syllable addition	Rank coefficient (r)	-0,045	+0,189
	Calculated significance (p)	0,783	0,242
	N	40	40
Undue separation	Rank coefficient (r)	+0,329	+0,104
	Calculated significance (p)	0,038	0,522
	N	40	40
Coda omission	Rank coefficient (r)	+0,069	+0,594
	Calculated significance (p)	0,671	< 0,001
	N	40	40
Word junction	Rank coefficient (r)	+0,051	+0,356
	Calculated significance (p)	0,756	0,024
	N	40	40

Spearman's Rank Coefficient (r); significance level set to: 0.05

Discussion

Handwriting activities depend on the development of fine motor coordination and perceptual-visual-motor skills. Under ideal learning conditions, we may notice a progressive improvement in handwriting, with the consequent increase in readability of written production, which in turn will allow self-correction skills (and consequently self-learning) to lead to a progressive decrease in the number of orthographic mistakes and to an effective learning of the orthographic standard of writing^{5,10,11}.

However, in the sample under analysis, the number of schoolchildren whose writing showed features of dysgraphia did not vary as schooling progressed. I.e., a comparison of the frequency of dysgraphia among school grades evidenced similar performances. This uniform distribution of schoolchildren whose writing was considered dysgraphic seems to confirm the fact that they are indeed dysgraphic, otherwise the frequency would have decreased as schooling progressed from the 2nd to the 5th grade.

This result corroborates other studies on dysgraphia^{12,22,23}. The first one confirmed the presence of dysgraphia in children's writing from the moment of learning to read and write until the end of the first five years of elementary school. When

thinking about dysgraphia as a developmental disorder, often associated with Coordination Development Disorder, one must look closely at the epidemiologic information regarding the prevalence of individuals with this disorder. Therefore, it may be said that the frequency with which dysgraphia was found in all four grades followed the usual distribution of this disorder among schoolchildren. Another study²² found signs of dysgraphia in 24% of the children enrolled in the 3rd grade of public elementary schools. Signs of dysgraphia were also found in 22% of the writing samples produced by students enrolled in the 6th grade of São Paulo state schools²³. Despite being higher than the one reported by the authors, the findings of this study regarding the correlations between handwriting and orthographic performance have shown that it remains stable throughout the school grades.

In order to determine whether the handwriting of students attending public school is poorer than those attending private schools, this study analyzed the distribution of children along all school grades, according to the school system and the presence or absence of dysgraphia. The results showed a larger number of dysgraphic schoolchildren in public schools than in private ones, and this difference was statistically significant.

The handwriting of children with and without writing difficulties from different socioeconomic status and from public and private schools was

analyzed¹⁷. This analysis showed a decrease in the number of dysgraphic children as the family income increased, from 24% of dysgraphic students in the public school system to 8% in the private school system.

Despite these results, it is important to note that dysgraphia can occur even among students without learning complaints, as were the subjects of this study^{5,12}, as it was a prerequisite for inclusion in the research. Moreover, learning orthography is a gradual process^{5,12} and, as to writing errors, it was possible to notice that those of the “voiceless/voiced” and “coda omission” types were the most frequent (57.50%), the least frequent being “syllable addition” (8.80%).

A study on voiced/voiceless phoneme switches within the context of orthographic deficiencies found a high percentage of this type of error in the first four grades of elementary school: 55.9% among first graders, 48.8% among second graders, 38.8% among third graders, and 29% among fourth graders²⁴.

Except for the “syllable addition” type of errors, the differences between the distributions of the types of orthographic errors among school systems for the total samples proved to be statistically significant; i.e., the “voiced/voiceless switches”, “syllable omission”, “undue word separation”, “coda omission” and “undue word junction” types of errors showed the different performances between public and private schools, with a higher prevalence in the public school samples. A lower frequency of syllable or letter additions and a higher frequency of “omission of consonant in coda” and “voiced/voiceless switches” was also found^{11,24}. However, if on the one hand it was possible to identify differences between the school systems, on the other hand the comparative analysis of orthographic errors showed an even distribution throughout the four school grades, with no differences between the grades.

Tables 2 and 3 show that the frequency of errors was low, which is compatible with the criterion for selection of subjects, which ruled out schoolchildren who presented reading difficulties or disorders. This may explain the fact that these results differ from those found in the literature.

A study on the classification of orthographic errors according to school grade found writing errors in children enrolled in the 2nd through 5th

grades of elementary school, with a higher prevalence among 3rd graders²⁴.

When investigating the correlations between dysgraphia and orthographic errors in the overall sample (table 4), it was possible to notice a correlation between writing errors and dysgraphia, except for “syllable addition” and “junction of words” errors. Other studies found a low frequency of these errors in their samples^{11,24}.

The correlation between orthographic errors (word junction) and dysgraphia did not occur in the overall sample. The size of the sample may have influenced this result. Moreover, it was composed of students without complaints or signs of learning disabilities. On the contrary, the children were recommended by their teachers for presenting a good academic performance. It bears stressing that word junction is a type of error that does not occur often in the writing of typical schoolchildren²⁴. In a study on orthographic deficiencies, word junction/undue separation ranked 4th in the table showing the frequency of orthographic errors made in the first 4 grades of elementary school, at 7.8%.

Some authors associate the occurrence of orthographic errors of the “word junction” or “undue separation” type with those children who still seek support for their writing in the spoken language^{11,24}.

Diversely, the results found that the number of children who presented “letter switches in the codification of graphemes corresponding to voiced/voiceless phonemes” in their writing grew in proportion to the increase in dysgraphic writings, in both school systems. Weaker positive correlations were found among the variables “syllable omission”, “undue separation”, and “coda omission”.

It must be taken into consideration that in this study the sample was composed of schoolchildren without learning difficulties. On the other hand, the 80 participants obviously had varied performances, which explains the presence of errors that may be associated with irregular and imprecise handwriting. In addition, it bears stressing that there was no difference among the grades regarding the frequency of errors, i.e., the number of errors did not decrease as schooling progressed. Thus, it may be said that the errors found are, indeed, characteristic of schoolchildren with poorer handwriting and orthographic performances.

The search for correlations between dysgraphia and other types of orthographic errors might

confirm the results found. This is a limitation of this study. Even though participants' motor function was not assessed here, the literature indicates that the better the fine and global motor performances, the lower the frequency of dysgraphia²⁵. Therefore, one cannot state that the participants' fine motor function is altered, and that the large number of dysgraphic schoolchildren found is due to deficiencies in that motor function.

In order to clarify this finding, it will be necessary to assess the schoolchildren's performances with the help of an interdisciplinary team, including a speech therapist, a neurologist, a neuropsychologist and an educator, to rule out any possible disorders such as dyslexia and/or other language disorders.

It is worth emphasizing that one of the criteria for inclusion in the study was the absence of a history of learning difficulties. Among these schoolchildren, the research found that 72.50% of public schools students and 45% of private school students were dysgraphic.

This study's findings reinforce the importance of identifying the factors leading to dysgraphia, so that it will not compromise these students' academic performances, given that dysgraphia may, like other disorders, be considered a source of psycho-emotional difficulties for the individual¹².

Conclusion

After analyzing the results of this research, we were able to determine that the distribution of dysgraphia was similar throughout the school grades, with a higher frequency among public school students. Regarding the types of writing errors, the switches in the codification of graphemes corresponding to the "voiced/voiceless" phonemes and "coda omission" were the most frequent, having occurred in (57.50%) of the sample, and made by students of both school systems, with a higher prevalence among public school students. We also identified a statistically significant correlation between dysgraphia and dysorthographia, as students who made more orthographic errors also scored higher for dysgraphia. All the findings were statistically significant, but it was not possible to determine what led to the large number of dysgraphic students. Thus, we suggest that other researchers include, in the methodology of their studies on dysgraphia, the influence of factors such

as: socioeconomic and sociocultural status, fine motor skill disorders, sensory disorders, visual-motor disorders, time-space orientation disorders, dyslexia, and other learning disorders..

References

1. Gombert, JE. Préface – L'apprentissage de l'écrit: La recherche avance. In: Marec-Breton, N.; Besse, A-S.; De La Haye, F.; Bonneton-Botté, Bonjour, E. (dir.), *L'apprentissage de la langue écrite*. Presses Universitaires de Rennes, 2009.
2. Fayol, M. *L'acquisition de l'écrit. Que sais-je?* Paris: PUF-Presses Universitaires de France. 2013.
3. Dias RS, Avila CRB. Uso e conhecimento ortográfico no transtorno específico da leitura. *Rev. soc. bras. fonoaudiol.* 2008; 13. (4): 381-90.
4. Parâmetros curriculares nacionais: língua portuguesa / Secretaria de Educação Fundamental. Brasília: MEC/SEF; 1997: Acesso em abr/2015; 92 pág. Disponível em: <http://portal.mec.gov.br/seb/arquivos/pdf/livro02.pdf>.
5. Rosenblum S, Aloni T, Josman N. Relationships between handwriting performance and organizational abilities among children with and without dysgraphia: A preliminary study. *Res Dev Disabil.* 2010; 31(2): 502-9.
6. Okuda PMM, Lourencetti MD, Santos LCA, Padula NAMR, Capellini SA. Coordenação motora fina de escolares com dislexia e transtorno do déficit de atenção e hiperatividade. *Rev CEFAC.* 2011; 13(5): 876-85.
7. Rosenblum S, Parush S, Weiss PL. Computerized temporal handwriting characteristics of proficient and non-proficient hand writers. *Am J Occup Ther.* 2003; 57 (2); 129-38.
8. Feder KP, Majnemer A. Handwriting development, competency, and intervention. *Dev Med Child Neurol.* 2007; 49 (1):312-7.
9. Coppede AC, Okuda PMM, Capellini AS. Performance of children with learning difficulties in fine motor function and handwriting. *Rev. bras. crescimentodesenvolv. hum.* 2012; 22(3): 297-306.
10. Jones D, Christensen C. Relationship between automaticity in handwriting and students' ability to generate written text. *J Educ Psychol.* 1999; 91(1): 44-9.
11. Nobile GG, Barrera, SD. Análise de erros ortográficos em alunos do ensino público fundamental que apresentam dificuldades na escrita. *Psicologia em Revista.* 2009; 15(2): 36-55.
12. Paiva EC, Gomes ES, Martins MCV, Ferreira AB. O transtorno da disgrafia no ensino aprendizagem. 07/12/2011. Acesso em out/2014; 5 pág. Disponível em: www.recantodasletras.com.br.2011.
13. Nicolson R, Fawcett AJ. Dyslexia, dysgraphia, procedural learning and the cerebellum. *Cortex.* 2011; 47 (1):117-27.
14. Caraciki AM. Letra feia é desleixo?. 2006: Acesso em out/2014; 1 pág. Disponível em: www.opoderenergeticodavoz.fnd.br/disgrafia.htm.
15. Domingues CS. Dislexia, disgrafia, disortografia e discalculia: diagnóstico e intervenção psicopedagógica. [Monografia]. Vila Velha (ES): Escola Superior Aberta do Brasil- ESAB; 2010.
16. Zorzi JL. Aprendizagem e Distúrbios da linguagem escrita: questões clínicas e educacionais. Porto Alegre: Artmed; 2003.
17. Oliveira RMSG. Aplicação da escala de disgrafia em crianças com e sem dificuldade na escrita [Dissertação]. Marília (SP): Universidade de Marília; 2000.



- 18.Zorzi JL, Ciasca SMA. Caracterização dos erros ortográficos em crianças com transtornos de aprendizagem. Rev CEFAC. 2008; 10 (3): 321-31.
- 19.Gonçalves BAG, Capellini SA. Desempenho de escolares de 1ª Série na bateria de identificação de erros de reversão e inversão na escrita: estudo preliminar. Rev CEFAC. 2010; 12 (6): 998-1008.
- 20.Lorenzini MV. Uma escala para detectar a disgrafia baseada na escala de Ajuriaguerra [Dissertação]. (São Carlos): Universidade Federal de São Carlos; 2003.
- 21.Arnault MA, Avila CRB, Hackerott MMS. Entre a ortografia e a patologia. 13º Congresso Brasileiro de Língua Portuguesa; 29,30 de abril e 1º de maio de 2010; PUC. São Paulo: Anais IP; 2010.
- 22.Rodrigues SD, Castro MJ, Ciasca SM. Correlation between indication of dysgraphia and scholarship performance. Rev CEFAC. 2009; 11 (2): 221-7.
- 23.Martins MRI, Bastos JA, Cecato AT, Araújo MLS, Magro RR, Alaminos, V. Screening for motor dysgraphia in public schools. J Pediatr (Rio J). 2013;89(1): 70-4.
- 24.Zorzi JL. As Trocas Surdas Sonoras no Contexto das Alterações Ortográficas. Soletas. 2008; 15 (8): 1-18.
- 25.Capellini, AS, Coppede, AC, Valle TR. Função motora fina de escolares com dislexia, distúrbios e dificuldades de aprendizagem. Pro Fono. 2010; 22.