ORIGINAL ARTICLE

THE ROLE OF WRITING ACQUISITION IN THE REPRESENTATION OF BRAZILIAN PORTUGUESE SYLLABIC CODA: FROM CHILD TO ADULT PHONOLOGY

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▪ ABSTRACT: The acquisition of writing has been considered an important source of change in the learner's mind/brain, especially in the way language is processed. There are several aspects of this kind of change that have been studied; however, few works have addressed changes specifically in phonological representation. This article seeks to provide that discussion, focusing on the representation of the syllabic coda in Brazilian Portuguese. To this end, we analyze spelling data from 166 Brazilian monolingual children, who study in the first four years of Elementary School. The results show that children have trouble when spelling the nasal and lateral consonants more than the fricative and the rhotic in this syllabic position. This is mainly attributed to an asymmetry between child and adult phonology, which is reflected in the orthographic system. Due to this conflict, we argue that the representation of the coda may changed in the phonological system of Brazilian children, resulting in its alignment of the coda with the target grammar.

▪ KEYWORDS: Coda; Syllable; Brazilian Portuguese; Writing acquisition; Phonological acquisition.

Introduction

It is well known that alphabetic writing systems, even those with orthographic depth, require conscious access from the learner to his/her phonological knowledge, since the operational principle of these systems relies on relations between phonemes and graphemes (Coulmas, 1989, 2003; Landsmann, 1993; Treiman; Kessler, 2014). The learner needs to understand that his/her language is formed by meaningless units, which can be analyzed into more and more small pieces in different layers of

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organization (Liberman *et al*., 1974; Morais *et al*., 1979; Gombert, 1992). Learning to spell, in this sense, can be assumed as a reassessment of the phonological knowledge. Also, it creates conditions for the actualization[1] of language in an alternative way to speech (Miranda, 2017; Lyons, 1968). We then may expect a degree of representational change in one's phonological knowledge through the course of writing acquisition, especially when children's phonology is not well reflected in the orthographic system as the target grammar is (Miranda, 2017; Veloso, 2006, 2019; Karmiloff-Smith, 1992). Therefore, the development patterns of speech and writing can be seen as a relevant empirical basis for discussions regarding not only children's phonological knowledge, but also the target phonological system. This view is followed by this article, so that we can argue in favor of a particular kind of change in the phonological representation of Brazilian children who are learning to spell, i.e., on the representation of the coda in Brazilian Portuguese (BP).

There is no general agreement on the phonological status of this syllabic structure. Authors disagree on the number and the kind of segments that may compose the coda in BP, especially on whether there is or not a nasal and a lateral consonant. The most widespread proposal is the one which addresses four consonantal segments to this syllabic position, namely /S, N, L, R/ (Bisol, 1999). It should be noted, however, that this discussion concerns the target grammar, i.e., the (literate) adult grammar. In BP phonological acquisition, things can be slightly different. Although some authors, like Mezzomo (2004), assume that Brazilian children acquire the four consonantal segments as proposed by Bisol (1999), others question this assumption. One of them is Miranda, who notes that children may not acquire a nasal and a lateral coda – at least not until they learn to spell, a process capable of tuning the developing grammar with the target grammar.

The present article follows Miranda's position, aiming to contribute to the discussion on the representational status of BP coda and to show the potential of spelling acquisition data on this kind of discussion. To this end, the sections that follow provide more detail on the discussion of BP coda and review the existing studies on the theme, including adult grammar, phonological acquisition and writing acquisition. Some comments on the matter of representational change are also made. Then, the method procedures are clarified, followed by the results and their discussion, which contains some limitations of our work and also some implications of the findings for the three fields involved in this article, that is, phonological theory, phonological acquisition and writing acquisition.

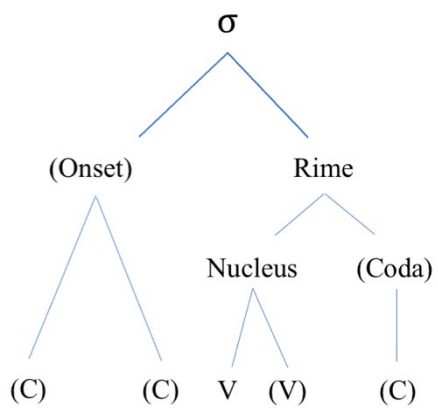
[1] The term actualization corresponds to its formal linguistic conception, which refers to the idea of realization of abstract linguistic units (e.g., phonemes) in a physical substance – primary or secondary, sound or writing (Crystal, 1988; Lyons, 1968).

Syllable structure in BP: phonology and orthography

BP is a romance language with quite a predictable segmental and syllabic organization. It clearly follows the Sonority Sequencing Principle (SSP), avoiding plateaus and preferring smooth changes of sonority within the syllables (Bisol, 1999; Collischonn; Wetzels, 2016). BP also has the classic bias to a CV pattern, which is present in more than half of the lexicon (Viaro; Guimarães-Filho, 2007). Despite this predictability, there are many controversial topics on the representation of BP phonology. One of them is on the coda, when the matter is syllabic structure.

There are three main analyses for the syllabic structure and for determining the principles of syllabification in BP in a generative background: Collischonn (1997), who follows Ito's (1986) templatic proposal; Bisol (1999), whose approach is based on the metric phonology, and Lee (1999), based on the Optimality Theory (OT). Despite their differences, it is generally assumed by these authors that the syllable is composed by the subunits Onset and Rime, according to Selkirk (1982): the former is optional, and the latter has an obligatory Nucleus and an optional Coda (Figure 1). In this paper we will only mention the differences and/or similarities regarding the segmental composition of the coda, leaving aside details on the way syllabification is done.

Figure 1 – Representation of the syllable (σ) in BP.
The parenthesis indicates optional elements



Source: Designed by the authors based on Selkirk (1982)

Collischonn (1997) and Bisol (1999) argue that the coda is composed of four consonantal segments, namely /R/, /L/, /N/, /S/, as in *carta* ['kaɾ.tə] /kaRta/ 'letter', *calma* ['kaw.mə] /kaLma/ 'calm', *banco* ['bãŋ.kʊ] /baNko/ 'bank, seat', and *pasta* ['pas.tə] /paSta/ 'folder'. The asyllabic glides [j, w] are also assumed as coda by the

authors. In BP, glides are combined with vowels to form diphthongs, e.g. *leite* [‘lej.tʃɪ] /leite/ ‘milk’ and *pauta* [‘paw.tə] /pauta/ ‘agenda’. Phonologically, they would be derived from high vowels in the syllabification process and mapped as syllable codas according to the latter authors.

On the other hand, Lee (1999) proposes that glides are not mapped as codas, but as Complex Nucleus instead. Moreover, /l/ does not exist in coda, but only in onset. This position on /l/ considers the fact that this segment is produced majorly as [w] in BP, e.g., *calma* [‘kaw.mə] /kaLma/ ‘calm’. Few dialects in Brazil produce /l/ as a liquid in post-vocalic position, and those who produce are influenced by heritage minority languages, mainly present in southern Brazil (Callou; Moraes; Leite, 2013 [1999]).

In summary, Collischonn (1997), Bisol (1999) and Lee (1999) agree on the segmental composition of the BP medial coda, except for /l/ and glides cases. It is important to note that these authors assume a biphonemic approach for the nasality case. This view is not unanimous among others like Couto (1978), Callou and Leite (1990) and Cristófaro-Silva (1999), who adopt a phonetic-based approach and who understand that the nasality is represented in a monophonemic way, i.e., with nasal vowels, as in *banco* [‘bã.kʊ] /bãku/ ‘bank’. Then, we would not have a nasal consonant in coda position, and we would have a more extensive vowel inventory in BP.

The biphonemic view is supported by Collischonn (1997), Bisol (1999) and Lee (1999) based on some language facts, most of them first observed by the pioneer Brazilian linguist Joaquim Camara Jr. (1969), who worked on a structuralist approach and also defended a biphonemic structure for the nasality in BP:

(i) in BP, closed syllables are followed by the “strong-r” /χ/, as in ***Is**rael* [iz.χa.‘ɛw] /iSχaEl/ ‘Israel’, *gue**l**ra* [‘gɛw.χa] /gElχa/ ‘gill’ and *ho**n**ra* [‘õ^{ŋ}.χə] / oNχa/ ‘honor’, while open syllables are followed by the “weak-r” /R/, as in *aurora* [aw.‘ɾɔ.ɾə] /auɾɔɾa / ‘dawn’;

(ii) in the derivations of forms ending in a stressed nasal vowel, the nasal segment emerges, as in *irmã* /iɾmaN/ → *irma**n**ar* ‘sister → to pair up’;

(iii) the ‘in-’ prefix loses the nasal segment before lateral and strong-R by assimilation, emerging as an oral vowel, as in *i**l**legal* [i.le.‘gaw] /ilegal/ ‘ilegal’ and *i**rr**egular* [i.χe.gu.‘laɾ] /iXegulaR/ *‘irregular’,* in contrast with *infeliz* ‘unhappy’ and *inabalável* ‘unshakable’, instances where the nasal is maintained and produced;

(iv) the sandhi process is blocked between a nasalized vowel and an oral vowel, as in *sótão antigo* ‘old attic’ vs. **sótãntigo/sótontigo* – word boundary, unstressed syllables, e.g. → *casa amarela* [kazama’rela] ‘yellow house’.

It is worth mentioning that the medial coda in BP is, as in many languages, a *locus* of variability. If we consider Bisol’s (1999) proposal, each of the four consonantal segments which occupy this position have at least two different possibilities of phonetic

realization registered, through which we can observe either neutralization or allophonic processes. This is why these consonants are frequently represented as archiphonemes[2] . Thus, depending on the dialect, /S/ may be realized as [s], [z], [ʃ] or [ʒ]; /R/ as [ɾ], [h], [ɦ] and many others; /L/ as [w] or [ɬ], and /N/ as [Ṽ], [Ṽⁿ], [Ṽᵐ] and so on ('V' meaning 'vowel').

In BP orthography, the spelling of these four consonants in coda position is quite predictable, taken that we are considering a more abstract level of representation: the relations are between *phonemes* and graphemes, not between *sounds* and letters. Notice that to be in coda is already a *position conditioning* for a segment's spelling, in Treiman and Kessler's (2014) terms. Hence, in another word and/or syllable position, the spelling of the same consonants may be either simpler or more complex – as is the case for the rhotic and the fricative in BP.

Being in coda, the rhotic has a *one-to-one* relation, where /R/ is always spelled as <r>, e.g. /pɔRta/ → <porta> 'door'. The same is true for the lateral, where /L/ is always spelled as <l>, e.g. /baLde/ → <balde> 'bucket'[3]. For the nasal, there is a *one-to-many* relation, conditioned by an *onset-to-coda* link which helps the speller to predict the correct grapheme: /N/ is spelled as <m> only when it precedes a labial consonant, e.g. /kaNpu/ → <campo> 'field'; in any other case, it is spelled as <n>, e.g. /poNte/ → <ponte> 'bridge'. Finally, the fricative has a *one-to-many* relation, with some help from context conditioning, but not in a sufficient way to give full predictability to the speller. After any vowel, aside from /e/ and /E/, /S/ is spelled as <s>, e.g. /paSta/ → <pasta> 'folder'. If there is an /e/ or /E/, there remains an arbitrary competition between <s> and <x>, e.g. /eStudo/ → <estudo> 'I/The study' and /eSplɔde/ → <explode> 'it explodes'.

What happens in the acquisition of phonology?

Brazilian children are likely to obey the following order of acquisition regarding syllabic structure (Lamprecht *et al.*, 2004; Ferreira-Gonçalves; Freitas, 2016):

(1) CV ~ V < CVG < CVC(C) < CCV(C)(C)

The coda, then, is the penultimate structure acquired, followed only by the Complex Onset. The ages of acquisition can vary according to the specific segment which occupy each syllabic structure. In general, the most recurrent repair strategies reported for the coda production are consonant deletion, e.g. ['siŋ.kʊ] → ['si.kU] *cinco* 'five'; coalescence, e.g. ['kaw.sə] → ['kɔ.sə] *calça* 'pants'; metathesis, e.g. [boɾ.bo.'le.tə]

[2] Although the archiphoneme reflects a structuralist approach when neutralization occurs in the system, it is still used as a form to represent segments in the grammar (lexicon) which are not specified until there is a phonological process in the derivation to define their output form.

[3] Although the phonetic realization of /l/ as [w] in BP may cause certain ambiguity, because of its resulting similarity with the falling diphthongs, e.g. /kalda/ ['kawda] 'sauce' and /kauda/ ['kawda] 'tail'.

→ [bo.boɾ.ʻle.tə] *borboleta* 'butterfly', and consonant gliding, e.g. [ʻpɔɾ.tə] → [ʻpɔj.tə] *porta* 'door'. With respect to CVC structures, the order of acquisition of the last C would be:

(2) nasal (2:00) < lateral (2:2) < fricative (2:8) < rhotic (3:10)

This order considers an average between the presence of these segments in medial and final word position (Lamprecht *et al*., 2004; Mezzomo, 2004; Ceron *et al*., 2022 – cross-sectional samples; Mezzomo *et al.*, 2010 – comparison between cross-sectional and longitudinal samples). There are reported alternations for nasal and lateral depending on the study and the position in the word under consideration, but the observed trend is for both to be acquired earlier than fricative and rhotic. The rhotic is unanimous on being the later one.

It is also important to note that this order reflects the view that Brazilian children acquire four consonantal codas, including nasal and lateral, and excluding glides. Hernandorena (1990) and Bonilha (2005) are authors who question whether the acquisition of a lateral coda occurs, since this segment seems to be interpreted by children as a glide that forms a falling diphthong with the antecedent vowel. This hypothesis is suggested due to three main facts:

(i) the precocity observed in the acquisition of the supposed lateral segment when compared to the *other consonants of the liquid class* in the different positions they may occupy in BP syllabic structure;
(ii) the precocity observed on the acquisition of the lateral in relation to the *other consonants that compose the coda*, especially /S/ and /R/,
(iii) and the coincidence between the age of acquisition of the lateral, in average, with the age of acquisition observed for the other falling diphthongs in the language, which are composed by glides and are acquired earlier (Bonilha, 2000; Ferreira-Gonçalves; Freitas, 2016; see the order in (1)).

In addition, Miranda (2009, 2019) and Pachalski (2020) draw attention to the fact that children's phonetic input is a glide [w] in most Brazilian dialects, as in [ʻpaw.ku] /paLko/ *palco* 'stage' (see later section for more detail). According to the authors, the contact with the consonant form generally comes through the literacy process, which will provide a conflicting visual input. These facts make it even more difficult to assume that there is a lateral representation in the children's system. Thus, what Hernandorena (1990), Bonilha (2005), Miranda (2009) and Pachalski (2020) propose as phonological representation would be that of a glide in a branched nucleus, in line with analyses for the adult system such as those by Câmara Jr. (1969) and Lee (1999), mentioned in the previous section.

Miranda (2009, 2019) and Pachalski (2020) also make a similar claim regarding the nasal representation. The authors sustain that Brazilian children do not acquire a

nasal consonant in coda position; instead, they acquire nasal vowels. In this sense, they point out to analogous facts to the lateral case:

(i) the precocity observed in the acquisition of the supposed nasal segment in relation to the other consonants that compose the coda, especially /S/ and /R/, and
(ii) the closeness to the completion of the (oral) vowel inventory acquisition (Rangel, 2002; Lamprecht *et al.*, 2004; Ferreira-Gonçalves; Freitas, 2016).

That being the case, there would be an asymmetry between child phonology and what is described for adult phonology in BP, especially under Bisol's (1999) analysis. If lateral and nasal consonants are not part of the children's coda paradigm, how can they be so in the adult system? A way to solve – and to heat up a little more – this puzzle is to consider what happens in spelling acquisition, a path followed by Miranda and Pachalski – and the object of the next section.

Representational change by the acquisition of writing in BP

Miranda (2019) analyzes the spelling of what would be the four consonants of the medial coda in BP, according to Bisol (1999). Her data were extracted from 2024 spontaneous texts produced by children in the first four years of public and private Brazilian Elementary Schools and were analyzed descriptively. In summary, the author found more errors in the spelling of lateral and nasal contexts in comparison to fricative and rhotic ones, in both public and private schools. Miranda also points out a decrease in errors as the school grades advance, a change that occurs more timidly in the public school.

Pachalski (2020) found very similar results, in a statistical driven analysis of spontaneous texts produced by 280 children in the first five years of Brazilian public Elementary School. Her results showed that there were significantly more errors in the spelling of lateral and nasal than in the spelling of rhotic and fricative segments. There was no significant difference between the frequency of errors in lateral and nasal spelling, and between rhotic and fricative spelling. Another interesting result was that consonant deletion was the most frequent type of error in the nasal spelling, and consonant substitution was the most frequent in the lateral spelling, matching Miranda's results again, who also found a great incidence of nasal deletion. With respect to the school grade variable, errors presented the tendency to decrease as the grades advance, but with no significancy. Pachalski demonstrated, however, that there was a negative correlation between schooling and spelling errors *if* the nature of the errors was considered, in which case, she followed Miranda's proposal. Pachalski then found that errors of phonological nature were more frequent in the first three years of school (the so-called "literacy cycle" in Brazil) and reduced significantly in the two final grades

(4th and 5th), giving way to the errors of orthographic nature (for an explanation of these error categories, see the Method section).

The first thing to note is that the data analyzed by Miranda and Pachalski reveal an opposite behavior to what is observed in BP phonological acquisition, since nasal and lateral codas are supposed to be acquired early in relation to the fricative and the rhotic (see previous section). If the common-sense hypothesis is assumed, i.e., that writing acquisition follows the same script as phonological acquisition, what would be expected in writing is that children would present more errors in the representation of the rhotic and fricative segments, because these segments are acquired later.

Indeed, Miranda and Pachalski interpret this asymmetry as an indication that laterals and nasals are not considered as codas by children in early writing development – consequently, neither are they during phonological acquisition. However, they consider that, with the course of schooling and spelling development of children, the representation of nasality and glide in syllabic nucleus can be reprocessed and, therefore, restructured as nasal and lateral consonants in coda.

The authors support the position that representational change is possible based on two assumptions, also assigned in this article:

(i) language acquisition is a process of *gradual construction* of linguistic structures (Kiparsky; Menn, 1977; Vihman; Croft, 2013). Since the acquisition of writing is viewed as an integral part of this process, although with its own properties, it is plausible to assume that there is not exactly the creation of new structures, but rather some type of remodeling of those that already exist;
(ii) the flexible character of the representations that characterize the different specific cognitive domains of the mind, which is why it is possible for human beings to take their own knowledge as an object of cognitive attention, as pointed out by Karmiloff-Smith (1992).

According to Karmiloff-Smith (1992), metacognitive development results from a cyclical and progressive process of representational redescription, which transforms implicit information *in* the mind into explicit knowledge *for* the mind. Thus, different levels of knowledge representation take place in cognition, as the redescription process happens, motivated by both endogenous and exogenous aspects of the individual.[4]

As Frith (1998) points out, the fact of discovering that language operates with minimal and abstract units such as phonemes substantially modifies language processing itself, since what was previously processed as an indivisible unit is now processed in an

[4] Considering our discussion purposes, we will not describe Karmiloff Smith's Representational Redescription Model (MRR) in detail. It is only necessary to keep in mind the general idea from the model: the possibility of representational redescription and that this process is gradual and may happen at any point of (meta)cognitive development. In Miranda and Cunha (2013), and Pachalski and Miranda (2021) there is a more detailed discussion on the use of MRR to explain spelling acquisition data in the approach we address here.

analyzed way. In this sense, representational change targets both *linguistic structures* and the *degree of awareness* that one has concerning these structures.

In summary, when Pachalski and Miranda consider spelling data to the discussion, they do this from a point of view that considers the acquisition of writing as a part of the language acquisition process. When children understand the alphabetic principle, their phonological knowledge is required, i.e., they need to reassess their linguistic representation already established and put it into use in a refreshing way. In line with the classical view of Saussure [1912] (2012) and Lyons (1968), writing becomes an alternative way of language actualization. Thereby, a new window is opened to analyze the language, beyond speech alone. The idea that writing can, so to speak, influence the structuring of phonological representations is then crucial to our claims.[5]

Method

Subjects and sample

We analyzed a total of 843 tokens of controlled spelling data produced by 166 children. They were students from 1st to 4th grade, aged six to ten years old.[6] The children attended a public school located in Pelotas-RS-Brazil. All were native speakers of BP and had typical language development. The data were collected between 2014 and 2015 and are part of the 7th stratum of BATALE[7], a database created and maintained by GEALE[8].

Instrument/stimuli

The data were obtained by the application of one data collection instrument called *balanced word dictation*, as proposed by Moojen (2009). This instrument was constructed by the author with the aim of evaluating the general spelling knowledge of Brazilian children. The selection of words was made by Moojen according to the following criteria: words in current use that present the most frequent letters in Portuguese and the evaluation of a linguist judge. Originally, the dictation had 50

[5] See Veloso (2019) for a discussion based on this perspective using data from European Portuguese, and Hamman and Colombo (2017) for a proposal to formalize the phonology-orthography relationship based on the BiPhon-OT model.

[6] The data analyzed in this study were collected between 2014 and 2015 in a school setting, when it was not yet a well-established practice in the fields of Education and Literature in Brazil to submit research involving children's written works to Research Ethics Committees. Even so, all procedures followed basic ethical principles: participation was authorized by the school and their guardians, the children's anonymity was guaranteed, and there was no harm to them because of the research.

[7] Acronym in Portuguese for *Banco de Textos de Aquisição da Linguagem Escrita.*

[8] Research group of the authors. Acronym in Portuguese for *Grupo de Estudos sobre Aquisição da Linguagem Escrita.*

words. To avoid fatigue especially among the younger children, we decided to reduce the dictation to 25 words for its application in 1st and 2nd grades. For the 3rd to 4th grade application, the 50 original words were maintained, but collected in two separate sections, with 25 words for each. No more than 2 weeks separated both sections. The words were dictated orally by the research group fellows, who had the same accent and linguistic background of the children. The application was made in the students' classrooms, following the school class division. The words taken into consideration in this study were: cambalhota ('somersault'), fazenda ('*farm'*), horror ('*horror'*), explosão ('*explosion'*), desfile ('*parade*'), and alguém ('*someone'*). These words were selected because they have one syllable with consonantal coda and they are present in both lists of words dictated for 1st and 2nd grades, and for 3rd and 4th grades.

It is worth mentioning a limitation of the instrument used. Moojen's (2009) original dictation list contains an item with a medial rhotic coda (exército – *'army'*), but this was not administered to children in the 1st and 2nd grades. To ensure comparability between grades, we chose to include the word 'horror' as a representative of the rhotic coda, albeit in final position. We recognize that this decision constitutes a methodological restriction, resulting from the use of a standardized instrument originally designed for another purpose. However, we believe it is possible to maintain the item in the analysis, since rhotic coda in BP exhibits stable phonological behavior in nouns (non-verbs) regardless of syllabic position – unlike what is observed, for example, for nasality, whose phonological realizations and analyses vary considerably according to position in the word. Furthermore, it should be noted that two lexical items with nasal coda and two items with fricative coda were included in the analyses, in order to consider the different orthographic options available for these segments in the system (<m>, <n>; <s>, <x>, respectively).

Data organization and categories of analysis

Once the coda spellings were extracted from the dictations, the data were organized in *xlsx* sheets and were separated into two large categories: correct spellings and errors. The latter were classified and analyzed according to their nature, defined in the terms of Miranda's (2020) proposal[9]. The author argues in favor of three major sources of knowledge mobilized by children in spelling errors, namely: phonology, orthography and phonography. This article focuses on errors of phonological nature since its discussion interests are on the effects of writing acquisition in phonological representation. Therefore, only data classified in this category will be addressed in the results section, with exceptions being explicitly mentioned. Chart 1 displays a description and examples of errors of the three main categories proposed by Miranda.

[9] We are aware that there are several proposals in the literature regarding spelling errors classification, like those reported and summarized by Treiman and Kessler (2014). Since its exploration would exceed the space limit we have in this article, we cannot discuss this topic with more detail.

Chart 1 – Descriptive frame of the categories of orthographic errors used in this study

Error nature	*Phonological*	*Orthographic*	*Phonographic*
Description	Related to the phonological complexity inherent to certain segmental and prosodic units, and/or to speech phenomena	Related to the orthographic complexity established by the contextual and arbitrary rules of the orthographic system	Related to phoneme-grapheme processing and/or the motor and mechanical aspects of writing (free from phonological and/or orthographic complexity)
Main types of errors	Certain types of deletion, substitution, insertion and transposition of graphemes, attested in phonological processes observed in language acquisition or variation	Misuse of grapheme that competes with another(s) in the same context in contextual and/or arbitrary rules	Misuse of graphemes due to similarity or greater complexity of the letter's outline; sequencing, omission, and insertion of letters and syllables not attested in phonological processes observed in language acquisition or variation
Examples of errors	horro**r** (*horror*) → 'orro'; a**l**guém (*someone*) → 'a**u**gei'; **des**file (*parade*) → 'dis**i**file'; **ex**plosão (*explosion*) → '**si**trosão'	'ca**m**balhota' (*somersault*) → 'ca**n**balhota'; 'e**x**plosão' (*explosion*) → e**s**plosão	'horror' (*horror*) → 'orr**ete**'; 'fa**zen**da' (*farm*) → 'feda'

Source: Adapted from Miranda (2020) and Pachalski (2020)

It is important to note that the phonological category considers the representational complexity of certain melodic and prosodic units of phonological grammar, which may raise doubts regarding their graphic representation, even though phonographemic relations are one-to-one in most cases. This is the case of branched onset and rime, which have a complex phonological representation at the syllable level, but which, except for /N/ and /S/ in coda, have a simple orthographic representation. Usually, the type of errors included in this category resemble phonological processes reported in phonological acquisition or even in variation (see previous sections).

When more than one coda spelling error was identified in the same word, each one was counted separately, as different tokens. For example, in *cambalhota* (somersault) → 'cã bada', three different errors in the spelling of nasality were computed: the use of the diacritic mark of nasality, the nasal consonant omission and the hypersegmentation (use of white space in a place not foreseen by the orthographic rules; for a discussion on this phenomenon in BP, see Cunha and Miranda, 2009). In this case, it should be noted that we consider errors that affect not only the consonant but also the vowel, especially in the register of nasality. This approach is supported by the view that vowels (Nucleus) and final consonants (Coda) have a solidary behavior within the syllable structure, forming a cohesive unit called Rime. Moreover, the nasality in BP presents a spreading characteristic, usually affecting neighboring segments.

Questions and hypotheses

Three main questions guided our analysis, followed by their hypotheses:

I. Does the segment type influence spelling errors of phonological nature in coda position?
    a. Yes, the segment type is a predictor for spelling errors of phonological nature in coda position. Specifically, /L/ and /N/ increase the probability of errors in comparison with /R/ and /S/.

II. Does the school grade influence spelling errors of phonological nature in coda position?
    a. Yes, the school grade type is a predictor for spelling errors of phonological nature in coda position. The more grades advance the less errors occur.

III. Does the segment type influence the quality of spelling errors of phonological nature?
    a. Yes, the segment type is a predictor for the quality of spelling errors of phonological nature in coda position. Substitution is more probable to occur in /L/ and omission is more probable to occur in /N/.

The results section ahead is organized by these questions.

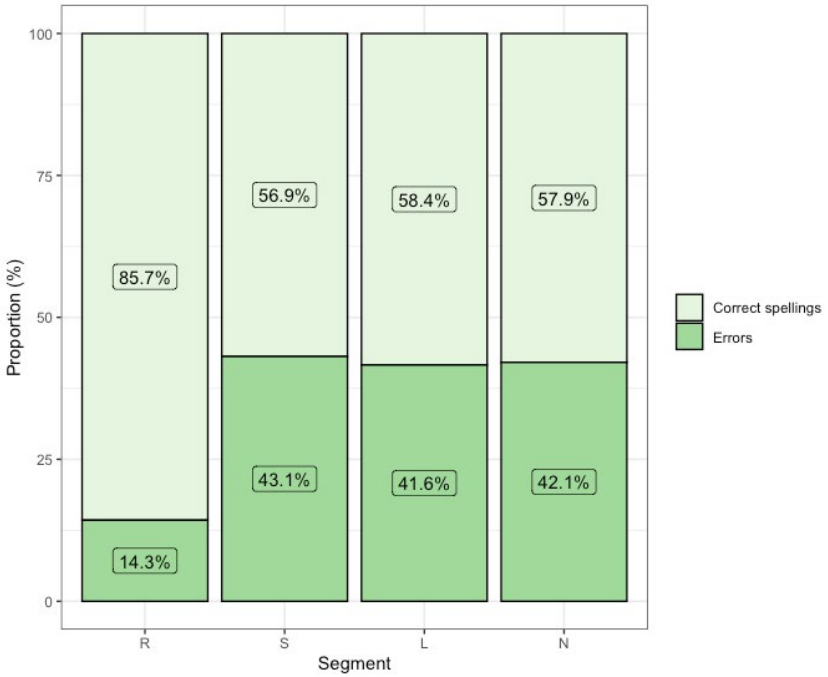
Results

Questions I – ***Does the segment type influence spelling errors of phonological nature in coda position?*** – and II – ***Does the school grade influence spelling errors of phonological nature in coda position?***

Figure 2 shows the distribution of correct and incorrect spellings found in the sample, by the type of segment in coda. Notice that the error distribution includes all

error categories: phonological, orthographic, and phonographic, following Miranda's proposal.

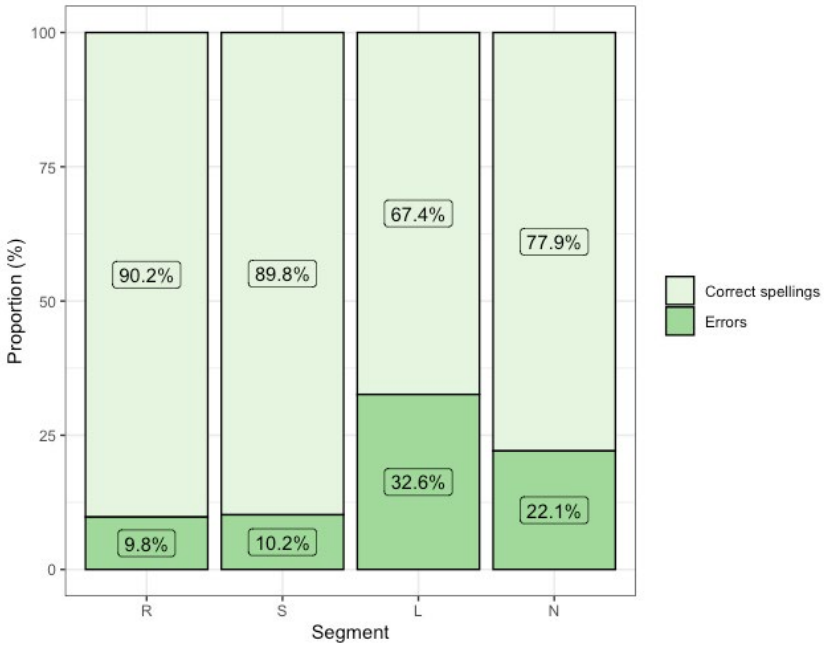
Figure 2 – Bar plot of the distribution of correct and incorrect spellings by type of segment in coda (all error categories)



Source: Designed by the authors, with *ggplot2 R* package (Wickham, 2016)

With just a quick look at the bar plot, we can capture that the rhotic seems not to be a spelling issue as the other coda segments are. However, according to the literature reported, the expected result was that the higher error frequencies were concentrated in /L/ and /N/ alone, not /S/ as well. This may be due to two factors. First, our sample comes from controlled data, which 'forces' children to spell some kinds of words they would spontaneously avoid, because the words are more complex in some sense – this is the case for the arbitrary /S/ spelling with <x>. Second, all error categories are being considered, which turns the comparison opaquer. In fact, if we withdraw the ortho and phonographic errors and keep only the phonological ones – which makes sense considering our discussion interests – we have some important differences and a distribution more similar to what is found in the literature:

Figure 3 – Bar plot of the distribution of correct and incorrect spellings by type of segment in coda (only phonological errors)

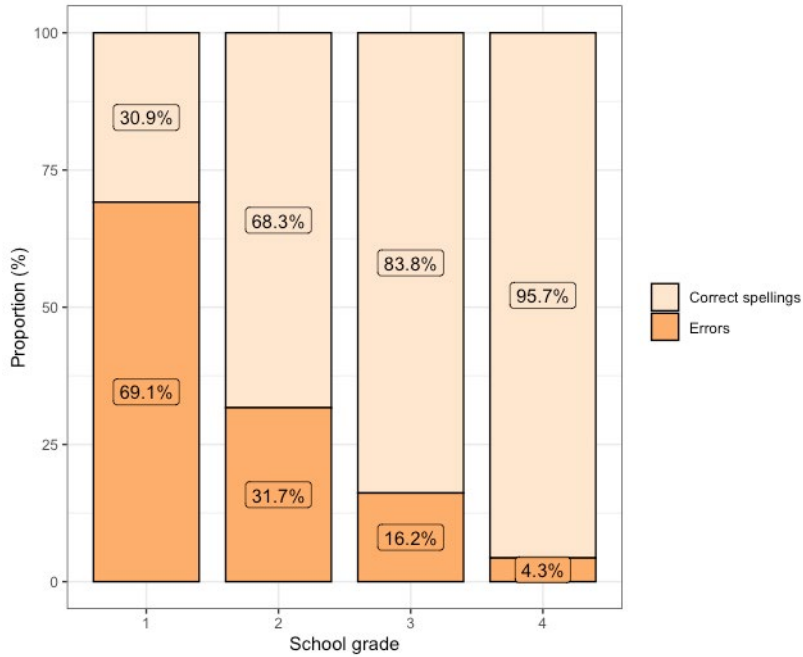


Source: Designed by the authors, with *ggplot2 R* package (Wickham, 2016)

By comparing only the phonological complexity involving the coda spelling, we can see other data behavior: /R/ and /S/ function, similarly, forming a less complex spelling group in comparison to /L/ and /N/, these turning out as a more complex domain. This is now in accordance with what Miranda (2019) and Pachalski (2020) found in spontaneous texts and constitutes the base for our first prediction for statistic modeling.

A second prediction is related to the role of school grades. As shown in previous sections, this extralinguistic variable has been tested and proved as an important one for the analysis of early spelling data, not only on the matter of complex syllables but in several other structures of BP system. The prediction is that the spelling errors decrease as school grades advance, assuming the positive role of schooling in the learning process. Figure 4 exhibits the distribution of correct and incorrect spellings in coda position by school grade:

Figure 4 – Bar plot of the distribution of correct and incorrect spellings by school grade (only phonological errors)



Source: Designed by the authors, with *ggplot2 R* package (Wickham, 2016)

A mixed model analysis of the data presented in Figures 2 and 3 was conducted with random interceptions for participants. This and other mixed model analyses were carried out in R version 4.2.3 (R Core Team, 2024) using the package lme4 (Bates *et al.*, 2013). Given that the response variable was binary (correct spellings/errors), binomial distribution with logit link function was used. The fixed factors were segment (R, S, L, N) and school grade (1st to 4th), both treated as categorical and non-ordered variables, and with no interaction between them. Three alternative models were tested also: one with interaction between segment and school grade, one with segment as the only predictor, and one with school grade as the only predictor. Table 1 presents the results of the best mixed model tested, i.e., the one with segment and school grade as fixed factors, but with no interaction between these variables.

Table 1 – Results of the mixed model analysis: predictors 'segment' + 'school grade' + random effects 'participants' for VD 'correct spellings/ errors' → VD ~ SEGMENT + SCHOOL.GRADE (1 | PARTICIPANT)

Predictors	Odds Ratios	Confidence interval	p-value	Correct spellings n (%)	Errors n (%)	Total Occurrences n
Segment /R/	–	–	–	114 (87%)	17 (13%)	131
Segment /S/	0.73	0.31 – 1.74	0.477	161 (85.6%)	27 (14.4%)	188
Segment /L/	12.08***	5.06 – 28.83	**<0.001**	80 (58.4%)	57 (41.6%)	137
Segment /N/	2.64*	1.21 – 5.76	**0.015**	168 (71.5%)	67 (28.5%)	235
				523 (75.7%)	168 (24.3%)	691
School Grade 1	–	–	–	29 (30.9%)	65 (69.1%)	94
School Grade 2	0.06***	0.02 – 0.18	**<0.001**			
	0.02***	0.01 – 0.07	**<0.001**	192 (83.8%)	37 (16.2%)	229
School Grade 4	0.00***	0.00 – 0.01	**<0.001**	177 (95.7%)	8 (4.32%)	185
				523 (75.7%)	168 (24.3%)	691
Random Effects						
σ^2	3.29					
τ_{00}	3.00					
ICC	0.48					
N	138					
Observations	691					
Marginal R^2 / Conditional R^2	0.406 / 0.689					
AIC	533.391					
* p<0.05 ** p<0.01 *** p<0.001						

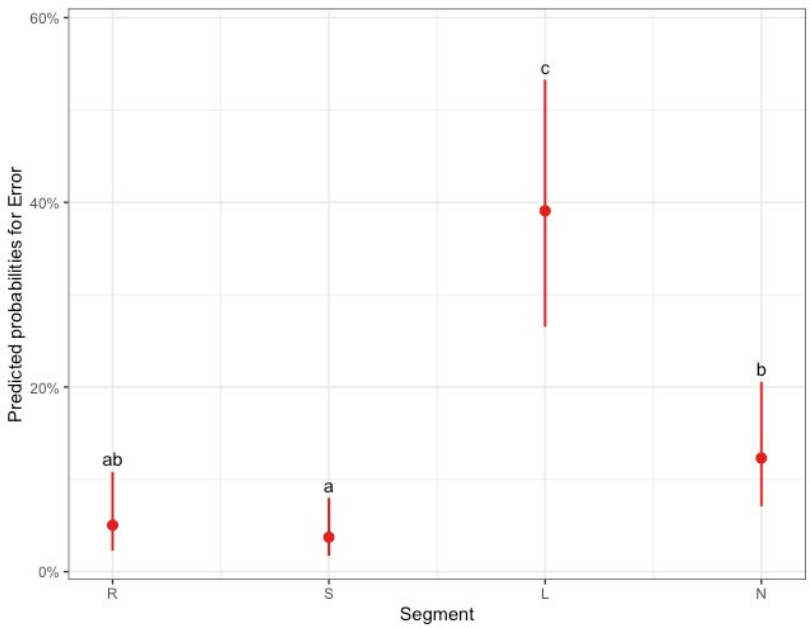
Source: Designed by the author

This model was revealed to be more explanatory than the others because its AIC value is smaller and its Conditional R^2 value is higher. It is interesting to note that the ICC value is smaller in the model presented as well, revealing a decrease on the power of random effects to explain variance in data when both predictors are considered and consequently reinforcing the power of fixed effects.

Considering the segment effect, we can see that /S/ does not raise the chance of spelling errors with respect to the reference category (/R/), but /L/ and /N/ do raise, with a highlight to /L/, which increases 12,08 times the chance of spelling errors in coda position (in relation to /R/). Regarding school grade, model 2 shows that second, third and fourth grades each decrease the chance of spelling errors in comparison to the first grade, the reference category.

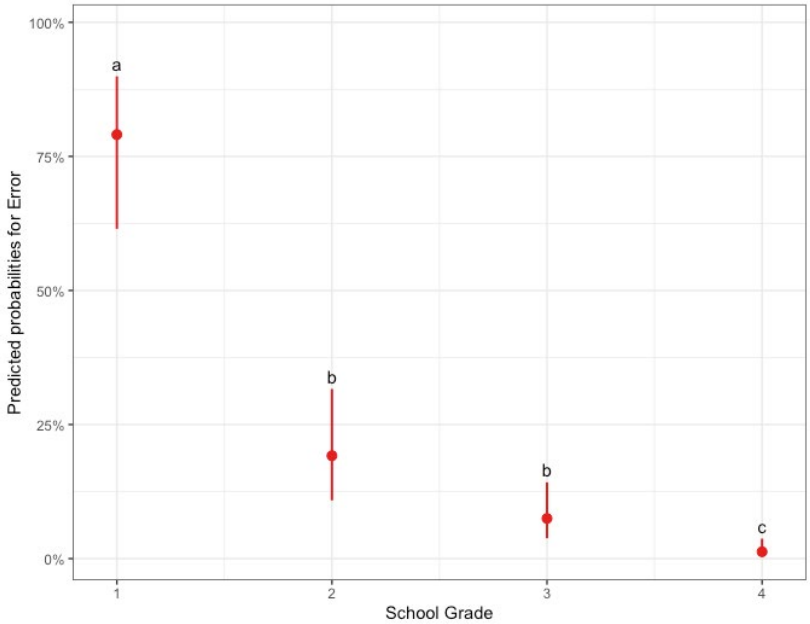
Pairwise comparisons of the estimated marginal means, with Tukey correction, were conducted to check the differences between each segment and each school grade. The differences can be visualized in Figures 5 and 6.

Figure 5 – Plot of the predicted probabilities for spelling errors in coda position by type of segment. The differences can be checked by the letters above the bars. The vertical lines correspond to the 95% confidence interval for the predicted probabilities. Different letters indicate statistically significant differences between groups according to pairwise comparisons of the estimated marginal means with Tukey adjustment



Source: Designed by the authors, with *sjPlot R* package (Lüdeck, 2023)

Figure 6 – Plot of the predicted probabilities for spelling errors in coda position by school grade. The differences can be checked by the letters above the bars. The vertical lines correspond to the 95% confidence interval for the predicted probabilities. Different letters indicate statistically significant differences between groups according to pairwise comparisons of the estimated marginal means with Tukey adjustment



Source: Designed by the authors, with *sjPlot R* package (Lüdeck, 2023)

In Figure 5 we can see a higher error probability in /L/ in relation to any other segment. /N/ comes in second place, sharing differences with /L/ and /S/ but not with /R/, with less probability of errors in relation to /L/ but higher probabilities in relation to /S/. The /R/ and /S/ do not present differences between each other.

Figure 6, for its turn, shows that the first grade presents higher probability for errors than all other grades, fact already shown in Table 1. The only pair that does not exhibit difference in its predicted probabilities for errors is the comparison between second and third grade. All other grades point out differences among each other.

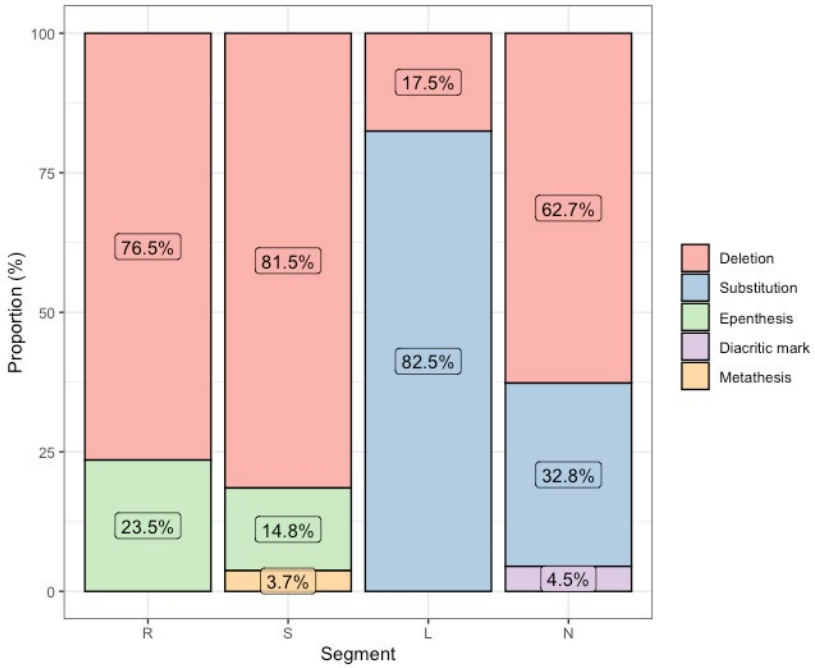
With these results, our first two questions have been answered, corroborating the hypothesis: the segment type does influence spelling errors of phonological nature in coda position, where /L/ and /N/ increases the probability of errors in comparison to /R/ and /S/, and the school grade does influence spelling errors of phonological nature in coda position, where the more the grades advance, the fewer errors occur. It is important to note that in the mixed effects model presented in Table 1, there is a significant

difference verified between /R/ and /N/. When performing pairwise comparisons between the segments, this difference disappears. We attribute this to some specific characteristic of our sample, since this type of difference has already been verified in previous works mentioned in this article.

Question III – Does the segment type influence the quality of spelling errors of phonological nature?

Figure 7 exhibits the distribution of spelling errors of phonological nature in coda position by the type of segment. Mixed model analyses were not successful with these data. They failed to converge, and the alternative ones turned out to be too poor. This convergence problem is expected given data profile: not all segments have all error categories, and some categories are very infrequent. For this question, then, our analysis will be only descriptive.

Figure 7 – Bar plot of the distribution of spelling errors of phonological nature by type in coda position by type of segment



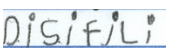
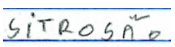
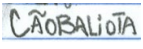
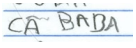
Source: Designed by the authors, *ggplot2 R* package (Wickham, 2016)

The plot shows that consonant deletion is the prevailing strategy in all segments except for /L/, for which substitution is notably more frequent (83.1%), which appears in data as *alguém* ('someone') → 'agei'. Substitution is also checked in /N/ spelling

in a considerable amount (33.8%), e.g., *cambalhota* (‘somersault’) → ‘cãobaliota’. Epenthesis appears in the third place overall, in the spelling of /R/ and /S/, e.g. *horror* (‘horror’) → ‘ororo’ and *desfile* (‘parade’) → ‘disifile’. The use of a diacritic mark to represent the nasality appears episodically for /N/ – *cambalhota* → ‘cã bada’ – as well as the metathesis, which was verified only once in the spelling of /S/ – *explosão* (explosion) → ‘sitrosão’.

Below, Chart 2 exhibits some examples of the spellings extracted directly from the dictations, which illustrate each error category present in the plot of Figure 6.

Chart 2 – Examples of errors of phonological nature present in the sample

	Deletion	**Substitution**	**Epenthesis**	**Diacritic mark**	**Metathesis**
/R/		–		–	–
/S/		–		–	
/L/			–	–	–
/N/			–		–

Source: Designed by the authors using research data

It is interesting to compare the quality of the substitution strategy between the two phonological contexts in which it occurs, that is, between lateral and nasal consonants. The auditory input, which, in this case, is in a one-to-one relationship with the organization of children’s phonology, since the production is semi vocalized and the corresponding phonological form would be a high vowel that results in a semivowel, is possibly at the base of the observed index. However, although there are fewer cases of substitution for the nasal spelling, there is more heterogeneity in the way in which the substitution can manifest itself in this environment: either as a nasal or an oral diphthong registration (e.g., ‘fazeida’, ‘cãobaliota’, as presented in the table) or as a change in the quality of the vowel involved in the VN sequence (e.g., ‘fazanda’).

For Miranda (2009), the change on the vowel quality reveals the child’s sensitivity to distinct phonetic characteristics that vowels assume in this context: their nasalized production, which in itself already distinguishes them from oral vowels, also perceptually approximates some vowel segments, especially /a/ and /e/ (Berti; Chacon; Santos, 2008), which would explain, for example, the spelling of <a> instead of <e> in ‘fazanda’ for ‘fazenda’. The author also established a comparison between the incidence of errors in the spelling of nasality according to the different qualities of vowels involved, through which she found that the vowels /a/ and /e/ are those that most favor errors, concentrating, together, 58% of the total occurrences.

Although with only descriptive data, the segment type seems to influence the quality of phonological error found in the spelling of coda position, at least in this sample, in accordance with the other studies reported (Miranda, 2009; Pachalski, 2020; Pachalski; Miranda, 2021). The tendency appears to be a predominance of deletion in all coda segments except /L/, which is more prone to substitution errors. Substitution errors are also observed in /N/ spelling, though to a lesser extent.

We believe these data reinforce the distinct behavior of children in the spelling of these structures. Lateral and nasal consonants not only concentrate more errors compared to rhotic and fricative consonants in general but also differ from the latter in terms of the quality of phonological errors.

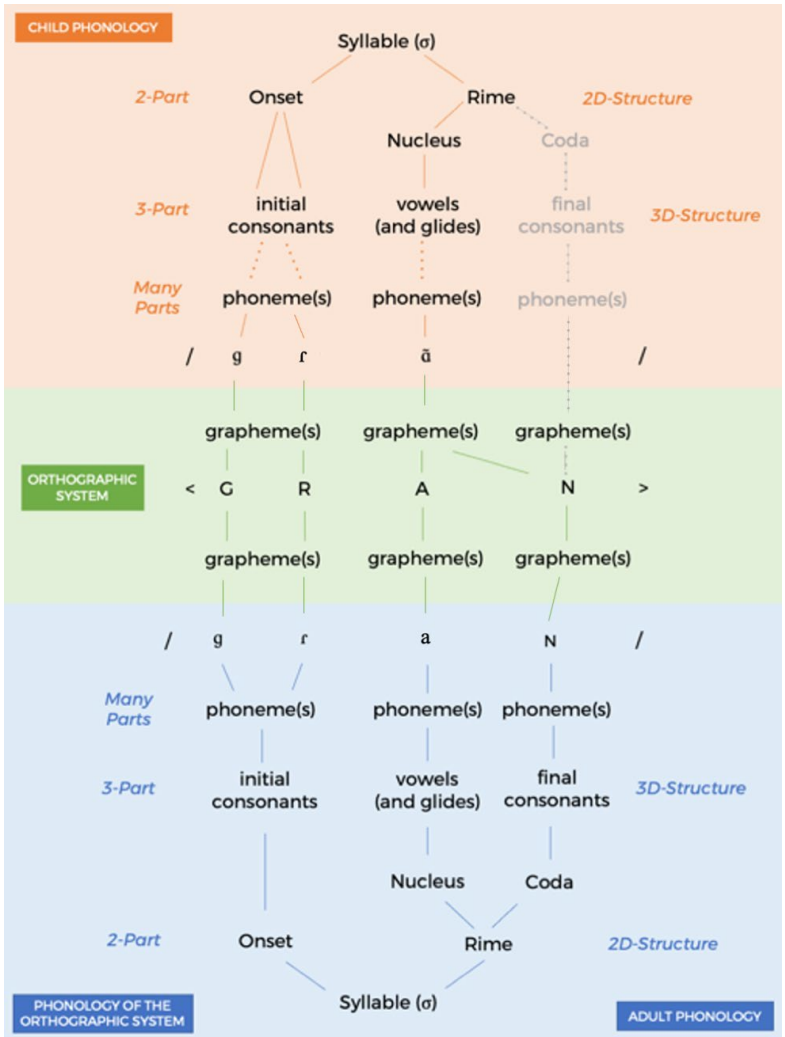
Discussion

One could ask whether these results could not be interpreted as an effect of other factors such as letter name, in the light of Treiman's (1992) analysis of the spelling of rimes by young native English speakers. Treiman shows that first graders use letter-name knowledge to spell the rime when the vowel-consonant sequence of a rime corresponds to a letter name. Thus, in 'farm', children sometimes spelled 'frm', or in 'helped' the output was 'hlpt'. In BP, however, the rime in CVC sequences do not match letter names, especially because of the consonants. Their pronunciation ends with vowels and follows a V.CV template – e.g., <s> ['E.sI], <r> ['E.XI], <l> ['E.lI], <n> ['e.nI]. Furthermore, this variable might not explain the differences found in spelling errors between each segment. Why do the lateral and nasal present more errors than rhotic and fricative if they have the same "letter name phonological template"? And why does the quality of the spelling errors differ between them?

We understand that these questions are better answered if we follow the view that Brazilian children do not interpret the lateral liquid and the nasal consonant as members of the coda, and that this interpretation will add a particular challenge when children face spelling acquisition (Miranda, 2019; Pachalski, 2020). This is the case because the Brazilian orthographic system seems to represent those segments reflecting what is posited for (literate) adult phonology, considering the analyses of Bisol (1999) and Collischonn and Wetzels (2016). For a nasal consonant, there is <n> or <m>, e.g. *ta**m**pa* /'taNpa/ 'lid' (not a diacritic '~' on top of the vowel as we have for other nasality cases, such as *maçã* /masaN/ 'apple'). For a lateral consonant, there is the <l>, e.g. *pa**l**co* /paLko/ 'stage' (not an <u> as we have for true diphthongs cases, such as *ca**u**le* /kaule/ 'stalk'). Given this conflict between the way children have represented these specific segments and the way the orthographic systems do, more phonological errors are registered in the spelling of <l> and <m, n> when compared to the others in the same position – <s, x> for the fricative and <r> for the rhotic, which doesn't present this kind of asymmetry.

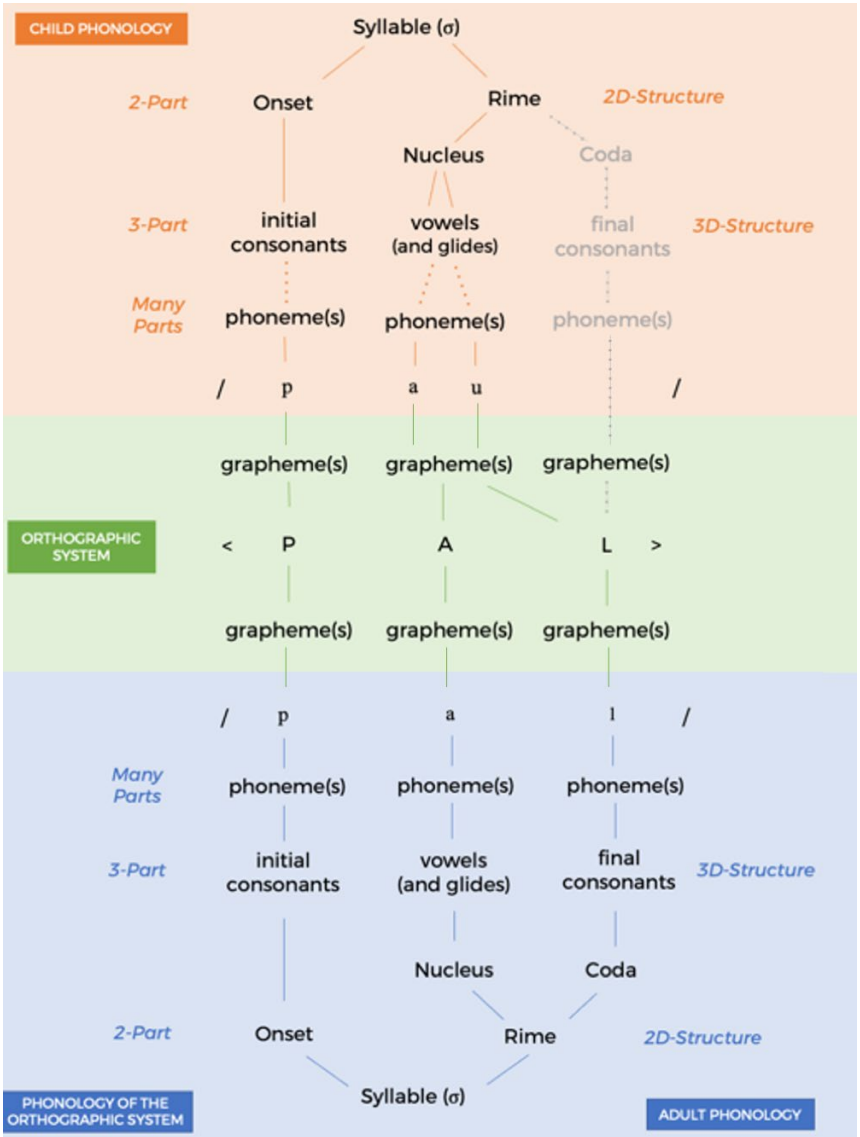
The Figures 8 and 9 below aim to formalize and consequently illustrate the conflict we are arguing in favor of, the first for the nasality case and the second for the lateral/ glide case.

Figure 8 – Formalization of the conflict between children's phonology and the "phonology of the orthographic system" (corresponding to literate adult phonology), which results in the process of representational change of medial nasality (example with the syllables /grã/ vs. /graN/ of the word *grande* 'big')



Source: The syllable representation is adapted from Seymour (1997). Original figure in Pachalski (2020), adapted with permission

Figure 9 – Formalization of the conflict between children's phonology and the "phonology of the orthographic system" (corresponding to literate adult phonology), which results in the representational change process of the glide, derived from a high vowel, in a branched nucleus (example with the syllables /pau/ vs. /pal/ from the word *palco* 'stage')



Source: The syllable representation is adapted from Seymour (1997). Original figure in Pachalski (2020), adapted with permission

Figures 8 and 9 are structured in the same way: on top, in orange, there is what we suggest it is the representation of the syllable in child phonology, dominating a given sequence of segments. In the middle, in green, it is the alphabetic/orthographic representation of the given sequence of phonemes. Below, in blue, it is the representation of the syllable in adult phonology, which is in parallel with what we call "the phonology of the orthographic system". With this expression, we want to express the fact that every orthographic system relies on a phonological system, since it establishes representations between phonemes and graphemes. And, usually, the phonological system represented by an orthographic system correspond to the analyses proposed for adult phonologies.

In Figure 8, we are considering the nasality case. In our view, what is represented in child phonology is a nasal vowel, which occupies the syllabic nucleus, as already claimed by Miranda (2019) and Pachalski (2020). There is (still) no coda, and that's why this position is grey colored in the figure. This representation conflicts with the information the child receives from the orthographic system, which represents this particular case of nasality with a sequence of two graphemes – <a, e, i, o, u> followed by <n, m> – indicating that it is working with a biphonemic representation formed by an oral vowel + nasal consonant (VN) (the same as adult phonology).

This would be the reason why the omission of <n, m> is the most frequent type of error registered in the spelling of the nasal coda. In this case, the child's doubt should be "*is there something* in the post-vocalic position?". This kind of doubt is based on the way we interpret spelling errors, especially the phonological ones. It follows a classical view of the child as a *task-solver* when facing the acquisition of writing or even phonology (Kiparsky; Menn, 1977; Ferreiro; Teberosky, 1984; Vihman; Croft, 2013). In this sense, he/she is active in the developmental process and formulates hypothesis to a problem. In the case we are discussing here, it is a specific problem, in the format of the abovementioned child's doubt. Or, in other words, a representational problem.

Figure 9 presents the lateral case. What is represented in child phonology is a diphthong formed by two vowels, as is claimed by Hernandorena (1990), Bonilha (2005), Miranda (2019) and Pachalski (2020). These vowels occupy a branched syllabic nucleus and one of them will become a glide in the syllabification process. Here, there is also (still) no coda, but the important difference is that *there is something* in the post-vocalic position. This representation conflicts with the information the child receives from the orthographic system, which represents this sequence with two graphemes – <a, e, i, o, u> followed by <l> – indicating that it is working with a lateral consonant representation for the post-vocalic position (the same as adult phonology). In our account, that is why the substitution of <l> for <u> is the most frequent type of error registered in the spelling of the lateral coda. In this case, the child's doubt may be "*what is this something* in the post-vocalic position?". And, again, this kind of doubt is based on the way we account for spelling errors, especially phonological ones, following the view of the child as a *task-solver*.

This conflict creates the context for children to work on their own phonological representations. Treiman (1992) already showed that intrasyllabic units might play a

significant role in reading and spelling American English. Since these units function cohesively, children show more difficulty analyzing onsets and rimes in their phonemic parts, increasing the probability of errors when spelling these units. We understand that this fact also underlies our data. However, in addition, what we propose here is that the phonological knowledge is not only made explicit via spelling acquisition, but it can also be restructured, in the sense of Karmiloff-Smith's (1992) concept of representational redescription.

As reviewed previously in this article, this cognitive process refers to a change in the format of representations through development, as they demand cognitive attention or conscious access. In the case we are discussing, as the child has access to new ways of representing the segments in the branched rhyme, via learning the orthographic system, with a consonantal grapheme corresponding to a consonant phoneme, attention is demanded on the phonemic and syllabic structures involved, since there is a conflict between its representational structure and that of the orthographic system. This demand for attention can thus trigger a process of representational redescription, causing the representation of nasality and of diphthong in the child phonological system to be redescribed (or restructured) in accordance with the model presented to it.

Conclusions

The findings we have reported reinforce those presented by Abaurre (1988), Miranda (2019) and Pachalski (202), and we believe they shed light on the discussion about BP syllabic structure and its representation, not only in children, but also in adult phonology. Our empirical contribution is that we bring more robustness to the results available in the literature by the statistical treatment given to the data. We also bring a way to represent and formalize this phenomenon of representational redescription specifically on the coda paradigm in Brazilian phonological development. In addition, the data is of a controlled nature, different from the spontaneous ones analyzed in the work of the previous authors. However, our data comes from an instrument that was not built specifically to study the coda spelling, which may have limited our results, or turned them less accurate. Further research should pay attention to this point, providing data from a specific instrument focusing on criteria relevant to analyzing BP coda. It would also be interesting if the early spelling data could be compared with speech data, not only from children but from adults too, to have more empiric material to the discussion on the asymmetries between child and adult phonology.

In the light of our discussion, we believe that in a literate society like the one we live in nowadays, it makes sense to ponder that there may be a difference between those who have acquired writing and those who have not, linguistically speaking. In our view, it is crucial and necessary to consider the acquisition of writing as part of the language acquisition process, and take spelling data more seriously in phonological

discussions, to sustain a middle path between a binarism of discontinuity vs. continuity between child and adult grammar (Vihman; Croft, 2013).

Acknowledgments

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PACHALSKI, Lissa; MIRANDA, Ana Ruth Moresco. O papel da aquisição da escrita na representação da coda silábica do Português Brasileiro: da fonologia infantil à fonologia adulta. **Alfa**, São Paulo, v. 70, 2025.

- RESUMO: A aquisição da escrita tem sido considerada uma importante fonte de mudança na mente/cérebro do aprendiz, especialmente na maneira como a linguagem é processada. Vários aspectos desse tipo de mudança têm sido estudados, entretanto poucos trabalhos abordam mudanças especificamente na representação fonológica. Este artigo busca promover esta discussão, com foco na representação da coda silábica do Português Brasileiro. Para tanto, são analisados dados de escrita de 166 crianças brasileiras monolíngues, estudantes dos quatro primeiros anos do Ensino Fundamental. Os resultados mostram que as crianças produzem mais erros na escrita das consoantes nasal e lateral em relação à fricativa e à rótica nesta posição silábica. Este resultado é atribuído principalmente a uma assimetria entre a fonologia infantil e a fonologia adulta, que é refletida no sistema ortográfico. Em razão desse conflito, argumenta-se que a representação da coda pode ser alterada no sistema fonológico das crianças brasileiras, tendo como resultado o seu alinhamento com a gramática alvo.

- PALAVRAS-CHAVE: Coda; Sílaba; Português Brasileiro; Aquisição da Escrita; Aquisição fonológica.

Author Contributions (according to CRediT taxonomy)

Lissa Pachalski: Conceptualization, Data curation, Formal analysis, Funding Acquisition, Investigation, Writing – original draft, Visualization, Project Administration, Methodology.
Ana Ruth Moresco Miranda: Conceptualization, Resources, Supervision, Writing – review & editing, Funding acquisition.

Data Availability Statement

All data supporting the results of this study are available in a personal file upon request from the author(s).

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