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Acoustic Evidences about the Setting of the Coda Parameter in Brazilian Portuguese

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1. Introduction

The research on the acquisition of the rhotic consonants by Brazilian children developed by Miranda (1996)[1], which presents a detailed analysis of the process of acquisition of the rhotic sounds in all the syllabic positions, discussing their phonological status in the system of Brazilian Portuguese, left out a question related to the acquisition of the rhotic in the coda position for further development. The results of the work showed that there is a big difference in the process of acquisition of the medial coda and the final coda. The children who were analysed produced the 'r' of final coda, while the production of the rhotic in medial coda only occurs much later. This fact favoured the hypothesis of a possible compensatory lengthening of the vowel in non final CVC syllables in words like *'porco'* (pig) and *'perna'* (leg), for example.

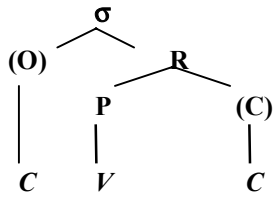
This lengthening of the vowel[2], phenomenon already referred by Jakobson (1941/68), has a clear explanation in non-linear phonology as proposed by Clements & Keyser (1983) and can clearly show that the parameter of the coda has already been set by the child. To test this hypothesis on the lengthening of the vowel, the data from Miranda (1996) underwent an acoustic analysis with the help of the Phonédit programme, to verify whether there is the lengthening of the vowel or not when the child does not produce the rhotic, and the consequent maintenance of the position in the skeletal tier in the speech of children who produce the rhotic in the final coda, but do not produce it in the medial position.

2. The acquisition of rhotic consonants

Jakobson (1941/68), in his seminal study on acquisition and loss of language, shows that in various analysed languages, the non lateral liquid is the last one to be acquired by children and the first to be lost in cases of aphasia because of its complexity. Confirming this study, the work on the acquisition of phonology of Brazilian children, like those of Teixeira (1985), Yavas (1988), Lamprecht (1990), and Hernandorena (1990), show that the liquid consonants are those which are the last ones to be mastered.

The research done by Miranda (1996) offers a detailed and organized description in relation to the acquisition of the non-lateral liquids, the so called rhotic consonants, and is based on the idea that the structural position occupied by the segment is decisive to consider the process of phonological acquisition complete.

The syllable had to be incorporated into the analysis, as the 'r' can occupy several positions in the syllabic structure. The model used to represent the syllabic unit sees the syllable as a linguistic unit with an internal structure, the constituents of which are organized in a hierarchic relation. According to the formalisation below, based on Selkirk (1982), a structure of the type ***CVC***, has the following representation[3]:



In Brazilian Portuguese, the minimum syllable is formed by a vowel, and a maximum syllable is formed by a CCVCC sequence and there are constraints in relation to the filling of these positions. The second position of the onset can only be occupied by /l/ and /r/; the first position of the coda, by the consonants /r/, /l/, /n/ or by the glides [j] and [w] and by coronal fricative /s/. In the cases in which there is the filling of the second position of the coda, only the /S/ is licensed. The rhotics, with exception of the peak, can occupy all the other syllabic positions, as can be seen in the distribution, as follows:

Onset position

'strong-r' [R]	*'weak-r'* [r]
[R]ato	—
ca[R]o	ca[r]o
is[R]ael-en[R]olar-guel[R]a	—
—	p[r]ato

Coda position

po[R]ta	~	po[r]ta
ma[R]	~	ma[r]

It is important to observe that, although the 'r' presents variation in coda position, produced in some Brazilian regions as a weak-'r' (flap) and in others as

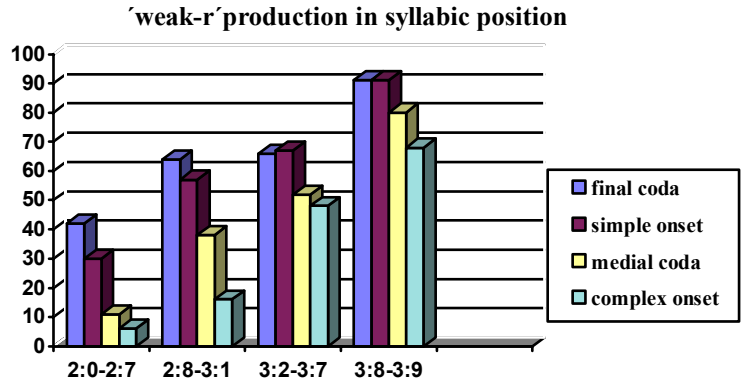
a strong-'r', in the data studied it is always produced as a weak non-lateral alveolar liquid.

The results of research on the acquisition of rhotics (Miranda,1996) showed that in the process of phonological development there are meaningful differences between the acquisition of the final coda and medial coda. The table below shows that the rhotic emerges earlier in final coda position.

Productoin of 'r' in final and medial coda, by age group .

	GROUP1 2:0 – 2:7	**GROUP2 2:8 – 3:1**	**GROUP3 3:2 – 3:7**	**GROUP4 3:8 – 3:9**
medial	42/366	143/373	118/228	99/124
coda	**11%**	**38%**	**52%**	**80%**
final	33/79	63/98	42/64	29/32
coda	**42%**	**64%**	**66%**	**91%**

The results related to the acquisition of 'weak-r' in each syllabic position, can be seen in the following diagram:

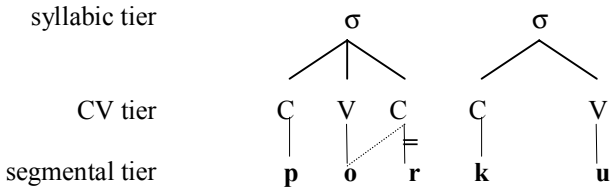


The above diagram shows that children between 2:0 and 2:7 (Group 1) produce more rhotic consonants in final coda than in onset, the latter usually being a syllabic parameter acquired earlier than the former. If we compare the results in relation to the ‘r’ in medial coda and in final coda, we can observe that the ‘r’ will only be produced with the same frequency achieved by final coda in children of 3:2 (Group 3). The evidence of this important chronological difference between the acquisition of medial and final coda seems to be an indication that medial coda position has already been acquired, though the

phonetic production of the rhotic segment has not occurred. The literature on phonological acquisition mentions similar phenomena. Jakobson (1941/68:14) refers to the studies on acquisition of French by Russian children, in which there is a register that 'r' in medial coda is not produced, but the position is preserved through the lengthening of the vowel. Presenting a case study, Maia (1981) also states that the subject of his research produces a long vowel at a particular stage instead of a coda 'r'.

A clear explanation for this lengthening of the vowel can be found in non linear phonology. Clements & Keyser (1983) propose the existence of a CV tier, that can be found between the syllabic tier and the segmental tier. According to the authors, the syllabic representation is a sequence that corresponds to a structure composed of these three tiers. The CV tier defines the primitive units of timing on the sub-syllabic level. The assumption of this tier allows the phonetic form of the segment to be omitted without causing any damage to the time unit. For example, if the rhotic of the medial coda is omitted, a long vowel can appear:

'porco' (pig) - /porko/ → [po**:** ku]



The hypothesis that the medial coda position is not just ignored by children seems attractive because in the data studied by Miranda (1996), the rate of deletion of the rhotic consonant in medial coda position, in the production of children between the ages of 2:0 and 2:7 involved 85% of the cases, while in final coda only 21% were registered. The high rate of deletion served as a motivation for some data to be reanalysed for this work. The data showed, once again, that some children produced the 'r' in final coda and did not produce it in medial coda, as can be seen in the examples below:

		Gabriela (2:3)	Joel (2:3)	Adriano (2:3)	Itiene (2:1)
abridor (opener)	/abɾidoɾ/	[abidoɾ]	[abidoɾ]	[abidoɾ]	[bidoɾ]
Trator (tractor)	/tɾatoɾ/	[tatoɾ]	[tatoɾ]	[tatoɾ]	[tatoɾ]
colher (spoon)	/koʎɛɾ/	[kuʎɛɾ]	[kuʎɛɾ]	[kuʎɛɾ]	[kuʎɛɾ]
perna (leg)	/pɛɾnɐ/	[pɛnɐ]	[pɛnɐ]	[pɛnɐ]	[pɛnɐ]
porta (door)	/pɔɾtɐ/	[pɔtɐ]	[pɔtɐ]	[pɔtɐ]	[pɔtɐ]

porco (pig)	/porko/	[poku]	[poku]	[poku]	[poku]

3. The acoustic analysis of the medial coda

For this study some of the analysed data described by Miranda (1996) were restudied. The choice of the children obeyed the following criteria: *produce the 'r' in final coda and do not produce in medial coda.*

After the choice of the subjects, made through the analysis of the files which contained phonetic transcriptions, the tapes with the interviews of 8 children were listened to and the ones with the best recording quality were selected. Some words in which 'r' was or should have been produced were copied. The data generated sound files for Windows with an extension WAV, and were processed by the phonetic program PHONÉDIT.

PHONÉDIT is a software that is at the disposal of researchers and permits acoustic analysis of previously recorded signs. The program offers the possibility to transform voiced sounds, for example, into frequency diagrams and spectrograms, from which several calculations can be made about height, duration and intensity of the sounds. In this study, as will be demonstrated below, the spectrogram of a wide band was used, so that the segmentation of the word could be done, as well as the measurement of the duration on the sounds. The spectrograms generated by the program permit the representation of the spectral distribution of an acoustic signal in relation to time.

In this study, we will discuss examples of the speech of three subjects: Andrio, Gabriela and Joel. The data on Andrio present the production of the rhotic in coda position and served to help in the setting of the parameters referring to the duration of the segments studied, in this case the /ɛ/ and the /ɔ/ of the stressed syllables, belonging to CV and CVC syllables. Of each child the words that contained the desired context were analysed, that is, each CVC syllable was analysed within the word and in stressed syllables (basically the words '*perna*' (leg) and '*porta*' (door)).

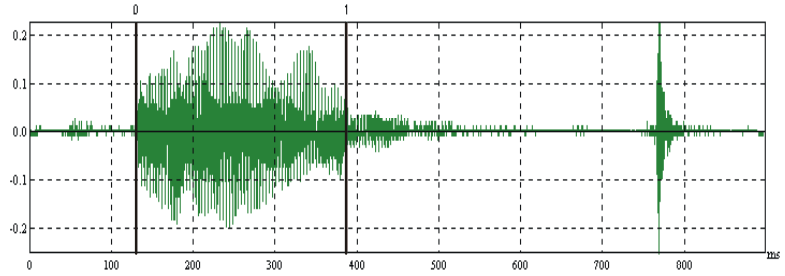
Other lexical items that had the same vowels in syllables CV within the word and in stressed syllables were chosen so that there could be a parameter of the duration of the vowels to be studied. It is a well-know fact that there is a variation in the duration of vowels because of the size of the vocal tract. Normally the vowels produced by children are longer than those produced by adults and among the adults the vowels produced by women are longer that those produced by men[4]. Because of this, an option was made for fixing the medial time for each vowel through the analysis of various words in which the vowel appeared in a medial, stressed and open syllable.

ANDRIO (age: 3:3 (group3))

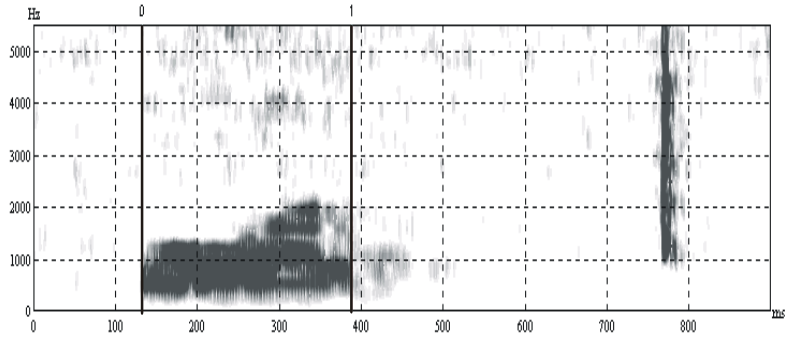
perna – (leg)	[ˊpɛɾ.nɐ]	[ɛɾ] 281.4 ms.
porta- (door)	[ˊpɔɾ̥.tɐ]	[ɔɾ] 251.9 ms.
pode – (3[a] p.s. 'can')	[ˊpɔ.dʃi]	[ɔ] 182.3 ms.
bota- (boot)	[ˊbɔ.tɐ]	[ɔ] 133 ms.
panela – (saucepan)	[pa.ˊnɛ.lɐ]	[ɛ] 137.2 ms.
janela – (window)	[ža.ˊnɛ.lɐ]	[ɛ] 125.3 ms.
vela- (candle)	[ˊvɛ.lɐ]	[ɛ] 108.2 ms.

Phonetic studies of Portuguese that deal with the duration of vowels in stressed syllables present results that show that the vowel /ɛ/ tends to be a little shorter that the vowel /ɔ/.The results of the measurement of the time of emission of the vowels produced by the children confirm these results in all the data studied.

The lists of analysed words can be observed below together with the time of duration of the low medial vowels (in ms.). The age of each one of the children is also in the table.



Frequency diagram – ['pɔɾtɐ]



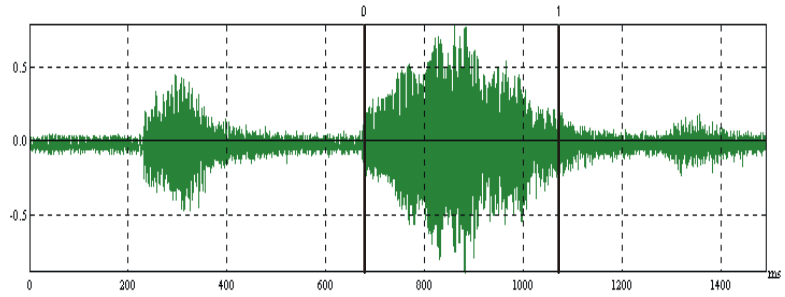
Spectrogram – [‘pɔɾ.tɐ] ’door’ [ɔɾ] (0-1 = **251.9** ms.)

The data from Andrio, who already produces the ´r´ of the medial coda, serve to strengthen the analysis done. It can be seen, in this case, that the production of a branching rhyme lasts 281.4 ms. in the word *´perna´* and 251.9 ms. in the word *´porta´*, while the production of the vowel in a CV syllable lasts on average 123 ms. and 157ms., the /ɛ/ and the /ɔ/, respectively. In the data from Andrio we can see that the difference between the production of the branching and non-branching rhyme is of an extra 140 ms., on average.

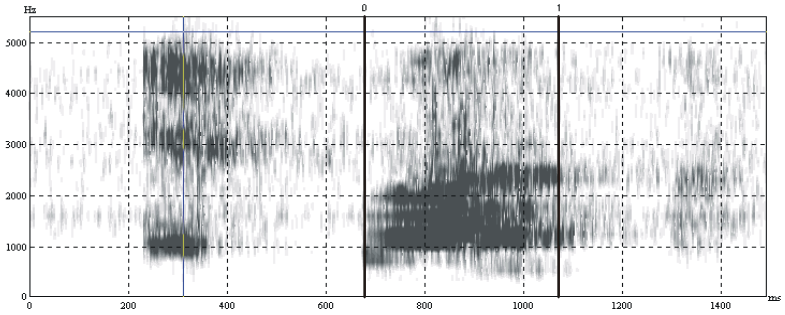
Below, we will present the results of the acoustic analysis of two subjects: Gabriela and Joel. Both produce the 'r' in final coda but not in medial coda. Here we show examples of the realization of vowels [ɛ] and [ɔ], in CV and CVC syllables in the target language, presented by the two subjects studied.

GABRIELA (age: 2:5 (group 1))

perna – (leg)	[´pɛ.nɐ]	[ɛ] **280.6** ms.
porta- (door)	[´pɔ.tɐ]	[ɔ] **399** ms.
coca – (coke)	[´kɔ.kɐ]	[ɔ] 204 ms.
bicicleta – (bike)	[´be.kɛ.tɐ]	[ɛ] 174.1 ms.
pedra – (stone)	[´pɛ. dɐ]	[ɛ] 184 ms.
seca – (3^{a} ps ‘to dry’)	[´sɛ.kɐ]	[ɛ] 192.8 ms.



Frequency diagram – [‘pɔːtɐ]

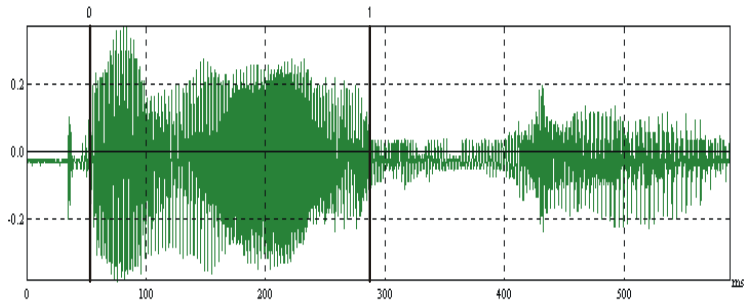


Spectrogram – [‘pɔː.tɐ] ’door’ [ɔː] (0-1 = **399** ms.)

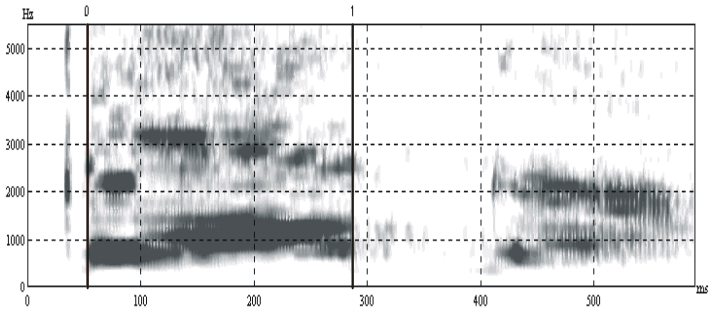
In Gabriela's data we can see that the vowels emitted in CV syllables are slightly longer than those emitted by Andrio on average. It is also possible to observe that there is a lengthening of the vowel in the production of the lexical item ‘*perna*’ as well as in the case of ‘*porta’*, as the difference of production time between the CV and CVC rhymes is approximately 100 ms. in the first case and 190 ms. in the second.

JOEL (age: 2:5 (group1))

perna – (leg)	[ˊpɛː.nɐ]	[ɛː] **239** ms.
porta- (door)	[ˊpɔɾ.tɐ]	[ɔɾ] **240.8** ms.
cola – (glue)	[ˊkɔ.lɐ]	[ɔ] 211.4 ms.
foto- (picture)	[ˊfɔ.tu]	[ɔ] 208.6 ms.
panela – (saucepan)	[pa.ˊnɛ.lɐ]	[ɛ] 208.2 ms.
janela – (window)	[ža.ˊnɛ.lɐ]	[ɛ] 200 ms.
parece- (3ª ps ‘to seem’)	[pa.ˊrɛ.si]	[ɛ] 185 ms
quero – (3ª ps ‘to want’)	[ˊsɛ.kɐ]	[ɛ] 212.9 ms.



Frequency diagram – [‘pɛːnɐ]



Spectrogram – [‘pɛːnɐ] ‘leg’ [ɛ] (0-1 = **239** ms.)

The first observation that can be made in relation to the data of Joel is that the vowels of CV syllables present a medial duration of 200 ms., numbers that are quite near those found in the production of CVC. Nevertheless, one should consider that in the case of ‘*porta*’, Joel produces an 'r' that can barely be heard, that is, it can only be perceived with the help of an acoustic analysis and the production of the rhyme is of 240 ms.. In the case of ‘*perna*’ there are no signs of a consonant and the vowel has a duration that is equal to the branching rhyme ([ɛ] **239** ms. versus [ɔɾ] **240.8** ms.). This difference although small, approximately 40 ms., could be a sign of some lengthening that shows evidence of the maintenance of the position of coda in the temporal tier.

4. Conclusions

The results of this research show that the acoustic analysis has much to add to phonological studies. The hypothesis that has guided this study, in which there is an increase in the duration of the vowel in the cases in which the child does not produce the liquid of the branching rhyme, preserving in this way the unity of time of the skeletal level, was confirmed based on the analysis of some

examples. The statements made do not intend to be generalisations; they are related to the results found, based on the investigation of the data of a few children. Nevertheless, they are important because they express differences related to the time and to the strategies used by the children in the process of acquisition.

Endnotes

1. The study is based on the language acquisition data of 110 children divided into 5 age groups. The age of the subjects range from 2:0 to 3:9 years of age. All of them live in the cities of Pelotas and Porto Alegre - Rio Grande do Sul, Brazil, presenting normal patterns of development. The data, collected transversely, were obtained with an instrument proposed by Yavas et al. (1991). The instrument contains thematic drawings which aim to acquire data from the spontaneous naming of words produced in isolation and not in utterances.
2. We have to consider that in Brazilian Portuguese there are not any long vowels, and that the lengthening of vowels is not a phenomenon found in the phonology of this language.
3. The onset 'O' and the rhyme 'R' are two immediate basic constituents. The onset is not obligatory and can be subdivided, and the rhyme is constituted obligatorily from a sonority peak, the peak 'P', and from a coda (C), which is optional.
4. Class notes from the *Acoustic Phonetics* course taught by Plínio Barbosa at ABRALIN-UFSC-Florianópolis-Brazil, in 1999.

References

Clements, G. N. & Keyser, S. J. (1983) *CV Phonology: a Generative Theory of the Syllable*, Cambridge, Massachussets, The Mit Press.

Hernandorena, C. L. M. (1990) *Aquisição da Fonologia do Português: Estabelecimento de Padrões com Base em Traços Distintivos,* Unpublished doctoral disertation, PUC/RS, Brasil.

Jakobson, R. (1941/1968) *Child Language, Aphasia and Phonological Universals*, The Hague, Mouton.

Lamprecht, R. (1990) *Perfil da Aquisição da Fonologia do Português,* Unpublished doctoral disertation, PUC/RS, Brasil.

Maia, E. A. M. (1981) *Uma estratégia morfofonológica para a aquisição do contraste l/r.* 5º ENL, Rio de Janeiro: PUC/RJ, Brasil.

Miranda, A. R. M. (1996) *A Aquisição do 'r': uma Contribuição à Discussão sobre seu Status Fonológico,* Unpublished, Dissertação de Mestrado, PUC/RS, Brasil.

Selkirk, E. O. (1982) 'The syllable'(337-379), In: H. Hulst & N. Smith (Eds.), *The structure of phonological representations*, Foris, Dordrecht.

Teixeira, E. (1985) *The acquisition of phonology in cases of phonological disability in Portuguese – speaking subjects*. Unpublished doctoral disertation, University of London.
Yavas, M. (1988) 'Padrões na Aquisição da Fonologia do Português'(7-30), *Letras de Hoje*, Porto Alegre, Edipucrs, v. 23, n.3.
Yavas, M.; Hernandorena, C. L. & Lamprecht, R. (1991) *Avaliação fonológica da criança, reeducação e terapia*, Porto Alegre, Artes Médicas.