Brazilian Portuguese Syllabic Structure Acquisition:
an analysis of the falling oral diphthongs

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December, 2000

Abstract: *The present work claims that the CVV syllable structure is acquired earlier than the CVC structure in Brazilian Portuguese. Such ordering stems from an analysis of the acquisition of falling oral diphthongs studied in the light of the Optimality Theory (OT) and the learning algorithm proposed by Tesar & Smolensky (2000).*

Key-words: Optimality Theory, phonology acquisition, diphthongs

1. Introduction

There are few studies carried out in Brazilian Portuguese (BP) that use the Optimality Theory (OT) as a theoretical basis. Among them are the studies of Battisti (1997, 1999), Lee (1999) and Collischonn (2000), as well as the ones concerning the language acquisition, Matzenauer-Hernandorena (1999, 2000), Matzenauer-Hernandorena & Lamprecht (1999). Thus, it is necessary to develop these studies since it is believed that OT is a versatile theory because it articulates areas such as Phonology, Syntax, Morphology, Semantics, Psycholinguistics and Artificial Intelligence, and it has contributed a lot for the analysis of how the languages work. Bernhardt & Stemberger (1998) believe that OT can tackle all phonological processes, either diachronic or synchronic, of children or adults acquiring their first or second language.

It is important to mention that OT has contributed to the linguistic analysis in a singular way, that is, the specific processes that could not be explained by previous phonological theories in a satisfactory way started being elucidated by OT. Some articles, such as the ones by Colina (1995), Costa & Freitas (1998), Matzenauer-Hernandorena (1999) and Collischonn (2000), highlight the advantages of using OT rather than a derivational theory.

By simply taking into consideration the ranking of universal constraints which make up UG, OT can come up with explanations concerning common patterns of acquisition, of individual and linguistic variations, and several other aspects. According to Gnanadesikan (1995, p. 42), *the application of OT to acquisition allows both child and adult language toe analyzed using the same model of phonology, and using the same constraints.*

In the light of OT, analyzing the data of acquisition means focusing on the process of building the hierarchy of constraints to be acquired by showing the various provisory hierarchies built by the learner. Such process is seen by means of a learning algorithm.

Therefore, the aim of the present work is to establish and explain the ordering of some syllabic structures of BP by analyzing the acquisition of falling oral diphthongs under the view of OT and through the learning algorithm presented by Tesar & Smolensky (2000).

2. Methodology

2.1.1   Subjects and data

The *corpus* used is constituted of cross-sectional longitudinal data of 86 normal children whose age ranged from 1:0 and 2:5:29 (years:months:days). Such data were taken from AQUIFONO and INIFONO databanks, coordinated by professors Carmen Lúcia Matzenauer-Hernadorena (UCPel) and Regina Ritter Lamprecht (PUCRS).

The subjects were classified into 15 age groups (AG): subjects belonging to AG1 through AG12 were divided into these groups every one month of difference in age; subjects were classified in AG13 through AG15 at every two months of age. Each age group comprises the corpora of 6 children – 3 boys and 3 girls. However, due to a reduced lexical production, some subjects were discarded. Thus, three age group have fewer subjects: AG1 has four subjects – 2 boys and 2 girls, AG2 has 5 girls and AG6 has 3 boys and 2 girls.

2.2 Data organization

In order to organize the data, all the oral production of each one of the subjects – a total of 7235 words – was analyzed. Then, all the possibilities of occurrence of falling oral diphthongs were checked. It is important to stress that repeated productions of the same word by the same subject were not taken into consideration, unless there was variation in its production.

The diphthongs were described according to the variables considered for this research.

The dependent variables are constituted by the 11 diphthongs of Portuguese, according to (1).

(1)

[aj] – *papai* (daddy)   [ɛj] – *anéis* (rings)   [ɔj] – *dodói* (boo-boo)

[aw] – *mau* (bad)   [ɛw] – *céu* (sky)   [iw] – *caiu* (it fell)

[ej] – *lei* (law)   [oj] – *boi* (ox)   [uj] – *fui* (I went)

[ew] – *seu* (your)   [ow] – *sou* (I'm)

Other forms of production employed by the learner when diphthongs were not produced were also controlled.

As to the independent variables, the following linguistic variables were controlled:

a) Classification of the diphthong: phonetic[1] or phonological.

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[1] Bisol (1994), when studying the output that forms the diphthongs [aj], [ej] and [ow], classifies the diphthongs in phonetic and phonological. She considers a phonological diphthong the one that is not possible to be reduced, being formed in the input by two vowels; the phonetic diphthong is the result of the spreading of the vocalic node of the consonant that follows it, having, therefore, just one vowel in the input.

b) Place of articulation diphthong base vowel: coronal, dorsal or labial dorsal.
c) Height of the diphthong base vowel: low, high, mid low or mid high vowels.
d) Place of articulation of the diphthong glide: coronal or dorsal.
e) Stress of the syllable containing the falling diphthong: tonic, pretonic or posttonic.

3. Data analysis

3.1 Acquisition of falling oral diphthongs

Freitas (1997, p. 215) notices that the structure VG, as syllabic nucleus, is acquired after a VC structure in the acquisition process of the European Portuguese (EP) syllable. It is important to mention that the author includes here the oral and nasal falling diphthongs. It is worth mentioning as well that the author discarded the fact that many diphthongs may not be being produced due to assimilation processes with subsequent palatal consonants, a fact that would reduce the production rate of the structure VG.

The acquisition of the diphthongs is considered to be late because, according to Freitas's data (op.cit), the child production is significantly different from the one presented by the adult. Even though the children quickly reach a rate of 50% in the production of the structures VGs, the percentage progression in its data is too slow.

In Brazilian Portuguese, the acquisition process is related to the segment sequences that form the structure VG. According to table 01, the acquisition seems to start with the low vowel, as a base vowel, followed by the dorsal glide which has the same place of articulation. The production of [aw] goes beyond 80% in the early age groups: AG1, 100%; AG2, 83.3%; AG3, 81.8% and AG4 84,2%. The high production rates are kept in all the age groups, as it can be observed on table 01. After that, the acquisition of the diphthong [aj] takes place, also with a low vowel: AG1, 50%; AG2, 80%; AG3, 85.7% and AG4 72.7%. So, it seems that the children first acquire the diphthongs formed by the low vowel followed by the dorsal glide, as the diphthong [aw] presents more meaningful production rates, and, after that, the diphthong [aj].

Table 01 – Production possibilities and occurrences of the phonological diphthongs

	aj		aw		ɛj		ɛw		ɔj		ej		ew		oj		uj		iw	
FE	Oc/P	%	Oc/P	%	Oc/	%	Oc/	%	Oc/	%	Oc/P	%	Oc/P	%	Oc/	%	Oc/	%	Oc/P	%
1	½	50	6/6	100	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1/1	100
2	4/5	80	5/6	83,3	*	*	*	*	*	*	*	*	*	*	2/2	100	*	*	*	*
3	6/7	85,7	18/22	81,8	*	*	*	*	*	*	0/1	0	*	*	*	*	*	*	*	*
4	8/11	72,7	16/19	84,2	*	*	*	*	*	*	1./1	100	2/2	100	*	*	*	*	1/3	33,3
5	6/6	100	13/14	92,8	*	*	2/3	66,6	*	*	0/2	0	3/5	60	1/1	100	*	*	6/6	100
6	¼	25	8./10	80	*	*	0/1	0	*	*	½	50	1/1	100	*	*	0/1	0	0/2	0
7	19/22	86,3	15/18	83,3	*	*	2/2	100	2/2	100	9/13	69,2	4/6	66,6	6/7	85,7	*	*	7/8	87,5
8	9/10	90	15/16	93,7	*	*	2/3	66,6	3/3	100	4/8	50	3/3	100	5/6	83,3	*	*	9/10	90
9	15/15	100	10/11	90,9	1./1	100	6/6	100	1/1	100	5/10	50	6/6	100	6/7	85,7	*	*	10/12	83,3
10	9/12	75	15/19	78,9	*	*	1/1	100	1/1	100	2/4	50	5/5	100	2/3	66,6	*	*	6/10	60
11	17/17	100	17/18	94,4	*	*	6/6	100	1/1	100	5/11	45,4	7/7	100	2/2	100	½	50	9./9	100
12	16/17	94,1	15/17	88,2	*	*	3/3	100	3/3	100	14/23	60,8	15/16	93,7	8/8	100	*	*	16/16	100
13	2/2	100	4/4	100	*	*	1/1	100	1/1	100	0/3	0	*	*	1/1	100	*	*	1/3	33,3
14	4/4	100	0/1	0	*	*	1/1	100	*	*	7/9	77,7	7/7	100	6./1	54,5	1/1	100	1/3	33,3
15	7/8	87,5	7/8	87,5	0/1	0	2/2	100	2/2	100	12/15	80	3/3	100	5/5	100	*	*	4/4	100

The diphthongs formed with low medium vowels also present a high production rate. As it can be seen on table 02:

Table 02 – Production possibilities and occurrences of the diphthongs as for the height of the base vowel

FE	Low		Mid Low		Mid High		High	
	Pos/O	%	Pos/O	%	Pos/O	%	Pos/O	%
1	7/8	87,5	0	*	0	*	1/1	100
2	9/11	81,8	0	*	2/2	100	0	*
3	24/29	82,7	0	*	1/0	0	0	*
4	24/30	80	0	*	3/3	100	1/3	33,3
5	19/20	95	3/2	66,6	8/4	50	6/6	100
6	9/14	64,2	1/0	0	3/2	66,6	3/0	0
7	34/40	85	4	100	26/20	76,9	8/7	87,5
8	24/26	92,3	6/5	83,3	17/13	76,4	10/9	90
9	25/26	96,1	8/8	100	23/17	73,9	12/10	83,3
10	24/31	77,4	2/2	100	12/9	75	10/6	60
11	34/35	97,1	7/7	100	20/14	70	10/9	90
12	31/34	91,1	6/6	100	47/37	78,7	16/16	100
13	6/6	100	2/2	100	1/1	100	3/1	33,3
14	4/5	80	1/1	100	27/21	77,7	4/2	50
15	14/16	87,5	5/4	80	23/20	86,9	4/4	100

The peculiarity about these diphthongs is that they seem to appear a little bit later, from AG05, following the acquisition of the mid low vowels[2]. The low quantity of production possibilities presented is probably related to the still restrict lexical universe of

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[2] According to Rangel (dissertation in progress), mid low vowels are the last ones to get stabilized in the process of vowel acquisition in Brazilian Portuguese.

the children, as the words *chapéu* (hat) and *dodói* (boo-boo) make up 91.4% of the production of the diphthongs formed by mid low vowels.

The diphthong [ɛj], in all the analyzed data, had only two production possibilities, with one production. The low number of production possibilities does not enable us to make considerations about their acquisition. It could be said that the child would be using here a selection strategy as it would not be able to produce this string; however, this does not seem to be true, as the language itself presents few words formed by this diphthong: according the records of the Aurélio Electronic Dictionary, just about 243 words of the language present the diphthong [ɛj], which means a very reduced number if compared to the 1837 words that present the diphthong [aw].

It is important to mention here that the non-production of the diphthong [ɛj] is related to, in the data, the word *papéis* (papers), which was produced as [pa'pɛws], and it seems to be related to morphophonemic restrictions. The diphthong [ɛw] presented rates inferior to 80% in just three age groups, in the AGs 05, 06 and 08: *chapéu* [Σa'pɛ] (hat), *chapéu* ['pɛ] and *chapeuzinho* [pɛ'zinu] (little hat). The diphthong [ɔj] produced from the AG07 – presented 100% of production in all the age groups in which it was produced, which shows a completely stabilized acquisition.

Besides the high rates presented on table 02, another factor that seems to corroborate the early acquisition of the diphthongs formed by low and mid low vowels is the fact that, when the strategy VG→VG is applied to the diphthongs formed by mid vowels, there is, usually, a tendency to lowering of the base vowel of the diphthong: *meu* (my) ['mɛw] – (Bruna – 1:06:08) and *meia* (sock) ['mɛja] – (Tatiara – 1:07:18).

In the gradual acquisition of the diphthongs, some strings suggest a more problematic acquisition. The diphthong [ej], for instance, was produced in 60 out of 102 possibilities of production (58,8%). It is not until AG14 that the rate of production of [ej] starts nearing 80%.

In relation to the diphthong [oj], it starts being produced from AG02, however, until AG06 the possibilities of production presented are not many. From AG07, they increase significantly and the production rate generally goes beyond 80%, except in the AGs 10 and 14.

Therefore, taking into account the data that form table 01 and the observations already mentioned, it seems that:

(i) The stabilization of falling diphthongs in Brazilian Portuguese is related to the sequence of segments that form the diphthongs;

(ii) The diphthongs formed by the low vowel and mid low ones, as base vowel, [aw], [aj], [ɛw] and [ɔj], get stabilized first; but the diphthongs formed by the mid high vowels, as base vowel, [ew], [ej] and [oj], get stabilized later on, as well as the ones formed by the high vowels;

(iii) The stabilization of falling diphthongs seems to be related to a bigger distance between the height of the base vowel and the glide that constitute the diphthongs;

(iv) It is not possible to state that the structure VG be acquired late in Brazilian Portuguese, as the significant production of the diphthongs formed by low and mid low vowels, with rates stabilized above 80%, serves as evidence for the fact that the structure VG has already been acquired since the early age groups.

3.1.1 Acquisition stages of the syllabic structure

According to Freitas (1997), the stages of acquisition of the Rhyme for the PE could be considered under two differentiated proposals: the first one, according to (2), would be based on the arranging proposed by Fikkert (1994), in which the structure of the branching nucleus is the last one to be acquired; the second one, according to (3), would consider the acquisition of the structure VG from stage II, as the data considered in the research point to the early production of the falling diphthongs.

(2):
      Stage I: production of nuclei V
      Stage II: production of codas associated to obstruints
      Stage III: production of nuclei VG

(3)
      Stage I: production of nuclei V
      Stage II: production of nuclei V and VG
      Stage III: production of Codas associated to obstruints

Freitas (1997) choses the first proposal, as:

(i)   the order V, VG and VC can demonstrate just phonetic structures, not being related to the phonological acquisition, i.e., the syllabic structure VG is interpreted by the child, in a first stage, as occupying just one position in the arboreal diagram – as we can observe in (4) – this way, considering (2), stage III would not come before stage II.

(4)
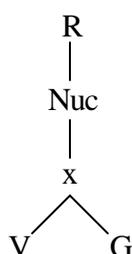
(ii)   The stabilization of the branching nucleus occurs too late, because until the most advanced ages the production is distant from the total rate of 100%.

(iii)   Errors like VG→ V are more frequent than other alterations, such as VG→ V.V or VG→CV.

(iv)   The stages proposed in (3) would not be in accordance with the universal arrangement in the syllable acquisition proposed by Fikkert (1994), in which the branching nucleus parameter would only be set after the branching rhyme

parameter. It would stop the establishment of a universal scale for the acquisition of the rhyme and for the setting of the Parameters.

(v) The second proposal would imply that the nucleus branched before the rhyme did.

However, when analyzing the data of the current research, the second proposal suggested by Freitas (1997) is chosen, in which a structure VG emerges in a stage prior to the VC structure. Therefore, some considerations must be made concerning the arguments raised by the author.

In relation to (i), from the early age groups, the data point to a phonological acquisition, and not just a phonetic one, as the children make use of the sequence VG in a distinctive way in the language: Matheus (1:03:25) constantly produces ['a], for the lexical item *água* (water), and ['aw] for the lexical item *au-au* (dog). When postulating that the diphthong occupies just one position in the diagram, Freitas (op.cit) considers that, before acquiring the coda, the children view diphthongs as complex segments. So, it is considered that the learner first acquires a phonological inventory bigger than the one that constitutes the target form, including the various types of diphthongs, in order to reduce this system later on, when the syllabic structure of the complex nucleus is acquired. Although it does not seem to be a very economic strategy, if it were really adopted in the data of BP, its generalization to other syllabic structures of late acquisition[3] would be expected. In BP, this strategy has not been observed so far, not even in the acquisition of the complex onset, which, according to Lamprecht (1990), is not yet stabilized by the age of five.

In relation to (ii), the acquisition of the falling diphthongs does not seem to indicate problems in the acquisition of VG syllabic structures, as the diphthongs formed by low and mid low vowels stabilize in the early age groups. According to what was shown in table 01, the acquisition of the falling diphthongs seems to be related, basically, to the different sequences of segments that constitute them, thus, not being the late stabilization of some diphthongs formed by low vowels – as base vowel – and of the diphthongs formed by a sequence coronal-coronal, evidence that the VG syllabic structure is acquired after the VC structure.

As for item (iii), the preference for the application of the repair strategy VG$\rightarrow$ V can occur only as a tendency of the language to preserve non-marked structures. If this structure attested to the fact that the diphthongs are formed by just one position in the diagram, it would expected to be replaced, during the phonological acquisition, by other strategies, such as VG$\rightarrow$ V.V or VG$\rightarrow$ CV, which was not observed in the data analyzed.

In relation to the fact that this proposal is in opposition to the universal scale proposed by Fikkert (1994), according to item (iv), it is believed that there are specific patterns in the different languages concerning the acquisition of falling diphthongs, such as the tendency to preserve the base vowel of the diphthong. But it is obvious that some variations are found due to the different types of diphthongs available in each system, the

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[3] According to Freitas (op.cit), clusters, in the PE, are also interpreted as complex segments by the child during the third stage of acquisition of the branching onset. This strategy would not be restricted to the acquisition of the branching nucleus. In the third stage of acquisition of the branching onset, the child: (i) produces both segments, as a complex segment; (ii) inserts an epenthetic vowel, producing the sequences CCV, CV.CV; (iii) produces the target form. Once more it is questioned here the cost that this strategy would have, taking into account the meaningful increase of the phonemic table of the language in a specific stage of acquisition.

syllabic structures allowed and the frequency of the VGs structures in each language. This view is shared by Steriade (2000)[4]: *(…) it is necessary to consider the differences that exist among the diphthongs of the two languages* and by Bernhardt & Stemberger (1998, p.154): *As long as the ranking be different for speakers of different languages, what is difficult and what is easy will change by the languages (in some degrees).*

In Fikkert & Freitas (1997), it is possible to find a similar way of thinking. By means of a comparative study among the stages of acquisition of the rhyme by Dutch and Portuguese children, the authors show that, in fact, the evidences contained in the input of each language will cause differences in the acquisition of the syllabic structure in such distinct languages like the PE and Dutch: *the similarities reflect properties of the UG, while the differences reflect the differences in the structure of the syllable and in the stress of the target languages.*

Moreover, the frequency of specific structures seems to have meaningful influence on the acquisition of these. It is valid to point out that, under the view of OT and the learning algorithm proposed by Tesar & Smolensky (2000), the reranking on the set of constraints, in search for the target system, is always triggered by the output of the adult that becomes the input for the child. Therefore, although they are not a determining factor, most frequent structures in the language probably trigger the ranking of the target grammar faster. According to Bernhardt & Stemberger (1998), it is possible to expect that the reranking is influenced by the most frequent elements of the languages. On the other hand, the fact that some rankings are more easily stored than others should not be discarded, showing that some words, even frequent ones, can demand difficult rankings, and these will only be done later on.

Even so, there is still the fact that the proposal in (3) can imply that the branching of the nucleus occurs before the branching of the rhyme, as the stages of acquisition of the rhyme in BP occur according to structures in (5):

(5)[5]

I stage: V

σ
╱╲
O   R
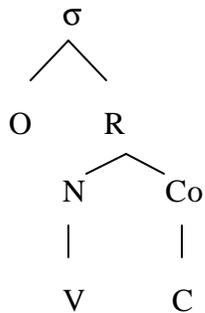 |
     N
     |
     V

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[4] Email from the author, when mentioning the possible differences that exist in the acquisition of the VG structure between BP and Dutch.

[5] It is important to mention that, given the fact that stage II supports the production of complex nucleus, stage III implies the acquisition of VC and VVC syllabic structures.
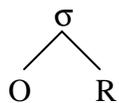
II stage: VG

```
            σ
           / \
          O   R
              |
              N
             / \
            V   G
```

III stage: VC

```
            σ
           / \
          O   R
             / \
            N   Co
            |   |
            V   C
```

A solution would be to claim that the first syllabic structure is biparted according to (6), taking into account that the child starts the acquisition of the syllabic structure just with the "*onset-rhyme*" representation.

(6)

```
            σ
           / \
          O   R
```

In this way, rhyme branching would occur before nucleus branching, even considering the acquisition of the VG structure, in the BP data, from Stage II, because according to the representation in (7), the productions of nuclei V and VG would also have binary representation, under the rhyme node, as the rhyme internal structure would not have been acquired yet. In fact, the rhyme would be composed, at first, just by vocalic elements, not yet separated categorically into nucleus and coda.

(7)

```
        σ                           σ
       / \                         / \
      O   R                       O   R
          |                          / \
          V                         V   G
```

       With the appearance of the syllabic coda, which involves the production of a closed syllable the child would branch the rhyme into nucleus and coda and keep the maximum structure bipositional (8).

(8)

```
          σ
         / \
        O   R
           / \
          N   Co
```
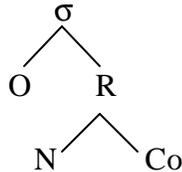
       Another possibility which would not cause the rhyme to branch before the nucleus would be to consider that the initial syllable is bipositional too, but formed just by the "*onset-nucleus*" constituent (9).

(9)

```
          σ
         / \
        O   N
            |
            V
```
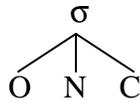
       This structure would enable the canonic syllable (C)V to emerge. After that, the nucleus would branch, making the production of VG structures possible. Observe the structure in (10):

(10)

```
          σ
         / \
        O   N
           / \
          V   G
```
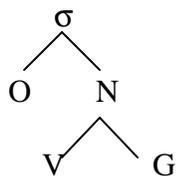
When the coda arises, the child starts to have a planar triparted[6] representation, made of *onset,* nucleus and coda (11):

(11)

```
            σ
         ╱  |  ╲
        O   N   C
```

The branching of the nucleus, represented in (11), would be possible and prior to the branching of the onset, as the production of a VG structure involves only vocalic elements, which would not occur in the onset branching. In fact, constraints related to segmental features would make the branching of the onset impossible in this stage. Bernhardt & Stemberger (1998, p.420) state that the diphthongs may be acquired before the complex onsets and complex codas *because the vowels usually come before the consonants in the development.*

According to Kager (1999, p.96), *complex onsets are universally marked when compared to simple onsets; complex codas are marked when compared to simple codas.* Thus, the same could be postulated in relation to the nucleus, i.e., complex nuclei are marked when compared to simple nuclei. In fact, a VG structure would be necessarily considered marked just when compared to a simple nucleus, not when compared to other structures, mainly to those involving the production of closed syllables like VC and VCC.

The three hypotheses for the acquisition of the VG structure found in the present research can be summarized in (12):
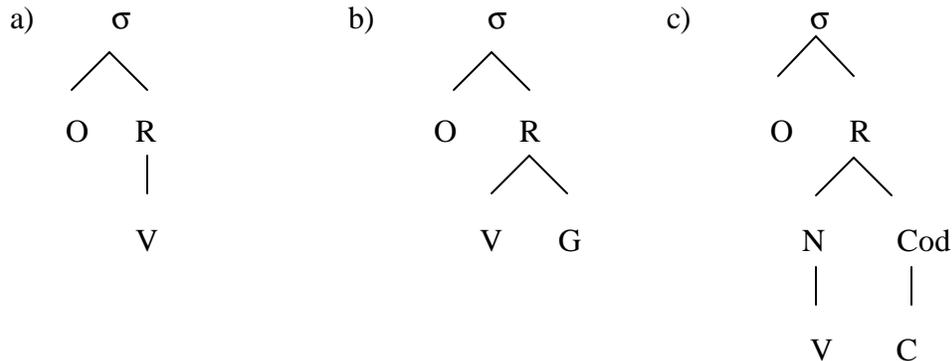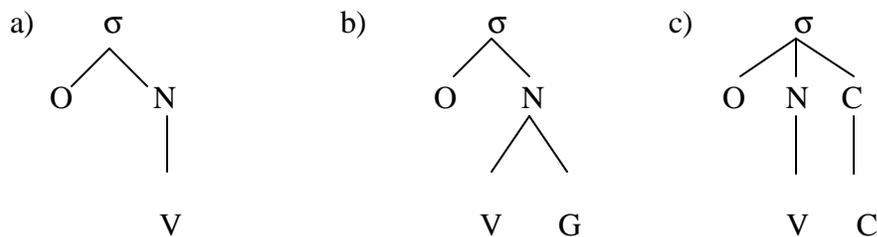
(12)
I Proposal

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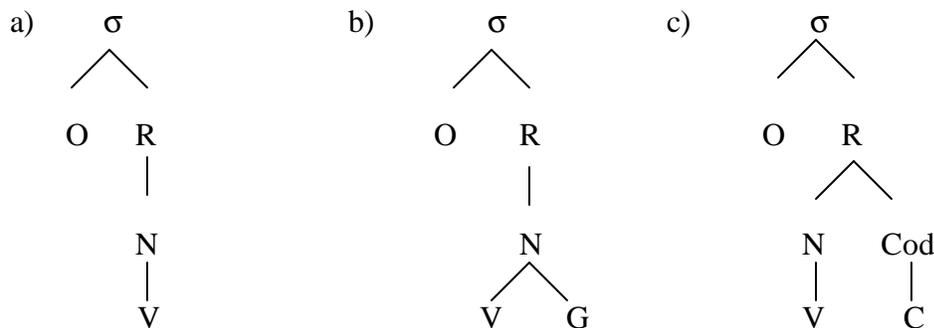
[6] It is possible to find syllabic structure in Collischonn's (1997) and in Prince & Smolensky's (1993) papers.

II Proposal

a) σ   b) σ   c) σ

```
a)        σ              b)         σ             c)          σ
         / \                       / \                       / \
        O   R                     O   R                     O   R
            |                        / \                       / \
            V                       V   G                     N   Cod
                                                              |    |
                                                              V    C
```

III Proposal

```
a)        σ              b)         σ             c)          σ
         / \                       / \                      /|\
        O   N                     O   N                    O N C
            |                         / \                     | |
            V                        V   G                    V C
                                                             V   C
```

       The differences that exist among the three proposals would be: (i) only the first proposal would imply that the nucleus would be branched before the rhyme; (ii) the second proposal would consider the possibility that the acquisition of the syllable would occur vertically, not implying that all the tiers be immediately specified – in II (b), the tier of nucleus and coda are still subespecified; the specification of these constituents only occurs in II (c) -; in this proposal the rhyme would not branch before the nucleus; (iii) the third proposal would not imply that the rhyme branches before the nucleus because it presents the planar triparted structure.

       However, the main point is that the three proposals suggested in this research are able to attest the fact the VG structure is acquired before the VC structure, which is being made evident by the acquisition data of this study.

3.1 Diphthongs and syllabic structure in the light of OT

       According to Stampe (1973, apud Bernhardt & Stemberger, 1998), there are two forces that act in the phonological acquisition: the first one is concerned to the need of the speaker to always search for the production of more simplified structures, demanding less articulatory strength, *the less content, the less diversity of features and combination of features, better;* the second one is related to the needs of the listener, which requires maximum difference among the segments of a sequence and differences in the lexical forms, as a way to *make it easier the lexical access and prohibit ambiguities*.

According to Bernhardt & Stemberger (op.cit) faithfulness constraints are motivated by the needs of the listener, whereas markedness constraints are motivated by the needs of the speaker. The former requires that all the lexical material be present in the production, whereas the latter requires the reduction in the cost of the production of a specific linguistic target.

The faithfulness constraints prohibit the insertion and deletion of segments and features, assuring that the input and output present maximum correspeondence. According to Bernhardt & Stemberger (op.cit, p.153), these constraints are the ones which will guarantee that different words be pronounced in a differentiated way.

The markedness constraints are associated to the search for the facility in the production of the elements; thus, constraints prohibiting the production of complex structures, for instance, will be ranked higher in the hierarchy in the beginning of the phonological acquisition.

Based on the OT, the acquisition stages proposed in (5) could be explained, in a simple way, by the use of markedness constraints Onset, NotComplex (nucleus) and NoCoda, and the faithfulness constraints MAX I/O and DEP I/O (13).

(13)
Onset: the syllables must have one onset.
Not Complex (nucleus)[7]: the nucleus must contain just one short vowel.
NoCoda: the syllables must not present coda.
DEP I/O (dependency input/output): segments of the output must have correspondents in the input.
MAX I/O (Maximality input/Output): segments of the input must have correspondents in the output[8].

It is important to say that all the constraints used in the current research were attested by other researchers, such as Prince & Smolensky (1993) and Bernhardt & Stemberger (1998). However, according to Núñez Cedeño & Morales-Front (1999, p.245), the creation of new constraints is welcome due to the fact that a closed set of constraints forming the UG has not been established. According to these authors, there are a number of constraints that are firm candidates to belong to the universal group that defines itself in Con, but the current studies in phonology are not interested in setting a fixed set of constraints. It will be done throughout the development of the theory, in a way in which it will be possible to consider which, among the proposed constraints, should be considered innate, as well as which ones should be considered redundant and be eliminated.

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[7] Gilbers and Den Ouden (1994) and D'Andrade (1998) use the constraint *DIPHHTHONGS, which goes against the formation of diphthongs. In this research, however, the use of Not Complex (nucleus) was chosen, as : (i)it constitutes itself in a less specific constraint and , therefore, more ecomnomic – considering the data of Freitas (1997), this constraint would take hold of the diphthongs and the post-vocalic consonants +sonorants in the PE; (ii) the acquisition of the diphthongs is linked to the sequence of segments that constitute them; (iii)it makes it possible to show the positioning of the glide in complex nucleus in the BP, as *DIPHTHONGS just prohibits the production of diphthongs, not specifying their syllabic structure.

[8] Kager (1999,p.102) points out that this constraint does not guarantee that the elements of the output will have the same features as the form of the input, i.e., the production of the lexical target /sei/, as [sɛj], would not violate the restriction MAX/IO, as there would not be the deletion of any segment. The lowering of the base vowel that forms the diphthong would violate another faithfulness constraint named IDENT-IO.

Apart from the constraints considered in (13), in order to show in which way the learner reaches each one of the stages proposed in (5), that is, which are the intermediate hierarchies involved in the acquisition process of the syllabic structure and how each one of these hierarchies is reached, it is also necessary to explain how the learning algorithm proposed by Tesar & Smolensky (1996) works. It is the algorithm that has the job to demote the constraints necessary to enable the target hierarchy to be reached.

3.1.2 Acquisition stage I

At the beginning of the acquisition, the child presents the hierarchy H0, according to (14):

(14)
H0 = {Onset, NotComplex (nucleus), NoCoda}>>{MAX I/O, DEP I/O}

It is pointed out that the initial Hierarchy H0 - where the markedness constraints dominate the faithfulness ones – allows the production of a CV syllabic structure, that is, in order to produce this structure it is not necessary to demote any makedness constraint that forms the UG[9]. It proves the universally non-marked character of the CV structure. In fact, it is suggested here that the markedness is also demonstrated in OT in accordance with the ordering of the demotions of constraints during the acquisition. The syllabic structure would be considered more or less marked according to the stage in which the demotion of the markedness constraints correspondent to each structure would occur.

Notice the hierarchy proposed in (14) placed in a *tableau*, according to (15):

(15)[10]

/aza/	NotComplex (nucleus)	NoCoda	Onset	DEP I/O	MAX I/O
a-) ☞ *za.za*				*	
b-) ☞ za					*
c-) a.za			*!		

According to (15), for an input to present the V structure, such as /aza/ (wing), the candidate selected as optimal will always present the CV structure, since in the current hierarchy presented by the child, the markedness constraints dominate the faithfulness ones.

According to Matzenauer-Hernandorena (1999), from the initial hierarchy H0, the first syllabic structure constraint to be demoted in the acquisition of the BP is the Onset, allowing not only the production of the syllabic structure CV, but also the syllabic structure V. So, it is suggested here that the Onset seems to have two functions in the hierarchy that

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[9] It is pertinent to say that a hierarchy that presented all the constraints sharing the same stratum, i.e., H0 = {Onset, Not Complex (nucleus), NoCoda, Max, Dep}, would also attest to a production of a syllable CV without the need to demove the markedness constraints.

[10] It's important to highlight that both candidates *a* and *b* are optimal because the constraints Dep I/O and Max I/O do not outrank each other. As both candidates are considered to be optimal, the learner might use the two forms. According to Tesar (1998:430), *such ties are more likely to occur early in learning, when many constraints do not have estalished relative rankings.*

forms the UG: (i) guarantee the production of syllables CV in languages that do not present syllables with empty onsets, being ranked higher in the hierarchy; (ii) make the production of syllables CV and V possible in languages that accept these structures, when demoted below the faithfulness constraints.

Therefore, the candidate potentially optimal, ['aza], is not chosen because it violates the markedness constraint Onset, which is ranked higher above the faithfulness constraints. The question is: how will the learner know that, for the production of the target form type V, the demotion of the constraint Onset will be necessary?

Through the analysis of suboptimal/optimal pairs, created by GEN, the learning algorithm[11] starts the process of demotion of constraints until the hierarchy, which supports the production of the optimal candidate, is reached. According to Tesar & Smolensky (2000), the quantity of informative pairs used for analysis can show the complexity of a structure. More complex structures will probably demand that a higher quantity of pairs be analyzed, as a bigger number of demotion of constraints will be necessary in order to reach the target form (16):

(16)

	loser < winner	loser marks	winner marks
a<c	za.za < a.za	DepI/O	Onset
b<c	za < a.za	Max I/O	Onset

The analysis of the suboptimal/optimal pairs shows which constrains are violated by the loser and winner candidates. After that, in case a constraint has been violated by both elements of the same pair, it is applied the process of *mark cancellation*. Only after the application of the *mark cancellation* is that the process of demotion of constraints starts.

According to (14), no constraint is violated by both elements of the pair; therefore, no mark (violation of constraint) will be cancelled. The process of demotion of constraints can then start to be applied. According to Tesar & Smolensky (2000), in this moment, the ranking of constraints must be adjusted so that, for each one of the candidates analyzed, all the constraints violated by the candidate potentially optimal be dominated by at least one constraint violated by the suboptimal candidate. It is emphasized that only the violation of constraints are relevant for the demotion process, as the satisfaction of the constraints in the candidate potentially optimal is not able to reflect their positioning in the hierarchy.

When analyzing the informative pair a<c, it is noticed that the constraint Onset must be dominated by the constraint DEP I/O, so that candidate *c* can be chosen as the optimal form. The hierarchy in (17) would show, then, the first acquisition stage of the syllable in BP.

(17)
Stage I – production of structures CV and V
Hierarchy H1
{NotComplex (nucleus), NoCoda}>>{Max, Dep}>>{Onset}

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[11] For further details on this algorithm, see Tesar & Smolensky (1993, 1996, 1998, 2000).

It is worth mentioning that the analysis of a suboptimal/optimal pair will not always bring alterations to the current hierarchy of the learner. When analyzing the pair b<c, it is observed that the constraint Onset, violated by the optimal candidate, must be demoted below the constraint Max I/O, violated by the suboptimal candidate. However, in the current hierarchy of the learner, H1, Onset already occupies a level below Max I/O. When the analysis of a specific pair does not bring alteration in the ranking of constraints, this pair is classified as a *non-informative pair*.

3.1.2 Acquisition stage II

To make it possible for the learner to reach the second acquisition stage of the syllabic structure of BP, according to (5), new analyses of informative pairs are needed.

As already mentioned in (17), in the first acquisition stage of the syllabic structure in BP, there is just the production of non-branching nuclei. So, when the child, in this stage, faces a lexical target such as /papai/, the optimal candidate will be selected according to the ranking of constraints presented in that acquisition stage (18):

(18)

/papai/	NotComplex (nucleus)	NoCoda	DEP I/O	MAX I/O	Onset
a-) pa.paj	*!				
b-)☞ pa.pa[12]				*	
c-)☞ pa.pa.pi			*		

According to (18), the second candidate is chosen as optimal because it does not violate the markedness constraint Not Complex (nucleus), which is ranked higher than the faithfulness constraints. This ranking, then, only allows the production of non-branching nuclei.

To produce the target form [pa.paj], a ranking in which the faithfulness constraints dominated the markedness constraint would be necessary (19):

(19)

/papai/	NoCoda	Dep I/O	Max I/O	Onset	Not complex (nucleus)
a-)☞ pa.paj					*
b-) pa.pa			*!		
c-) pa.pa.pi		*!			

When analyzing new informative pairs, according to (20), the learning algorithm will guide the learner so that the ranking proposed in (19) is reached.

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[12] That is Brazilian children´s most frequently produced.

(20)

	loser < winner	loser marks	winner marks
b<a	pa.pa < pa.paj	MAX I/O	Not Complex (nucleus)
c<a	pa.pa.pi < pa.paj	DEP I/O	Not Complex (nucleus)

Considering the suboptimal/optimal candidates, b<a, it is noticed that the constraint NotComplex (nucleus), violated by the potentially optimal candidate, [pa.'paj], must be ranked below the constraint MAX I/O, which in its turn is violated by the suboptimal candidate, [pa'pa], so that the winner candidate is considered to be the more harmonic. The hierarchy in (21) would show, then, the second acquisition stage in BP.

(21)
Stage II – production of structures VG
Hierarchy H2
{NoCoda}>>{MAX I/O, DEP I/O}>>{NoComplex (nucleus), Onset}

It is pertinent to state that when Not Complex (nucleus) is demoted, it occupies the same level as the constraint Onset, because the pairs analyzed do not demand the existence of a relation of dominance between these constraints. The demotion of the constraints must always be minimal, i.e., each constraint must be ranked, as much as possible, to the highest level in the hierarchy. According to Kager (1999), it is seen as a *conservative strategy* of demotion.

3.1.3 Acquisiton Stage III

Taking into account that in (20) the production of the structure CV occurs due to the demotion of the constraint NotComplex (nucleus), it is possible to say that, with the demotion of just two constraints, Onset and NotComplex (nucleus), the child can already produce CV, V and VG syllabic structures. Furthermore, the demotion of NotComplex (nucleus) in stage II reinforces the non-marked aspect of this structure in relation to a structure VC, as the constraint NoCoda would only be demoted in H3, according to (22). Once more, this supports Kager's (1999) claim that a complex structure is only considered "evidently" marked in relation to its simple constitution: simple nuclei are allowed in H1; complex nuclei, in H2.

(22)
Stage III – production of VC structures
Hierarchy H3
{MAX I/O, DEP I/O}>>{NoComplex (nucleus), Onset, NoCoda}

New informative pairs will be considered for analysis so as to enable the learner to reach the hierarchy shown in H3. According to Matzenauer-Hernandorena and Lamprecht (1999), besides the constraint NoCoda, the demotion of other constraints will be necessary

so that the syllabic structures containing coda in BP can be acquired, like *AlinP* and *AlinS* – which work for the acquisition of coda in final syllabic position before the acquisition of medial coda in BP – and the constraints of Coda Conditions, such as Codasil, Codavibr and Codanas[13], among others.

The analysis of informative pairs , in order to achieve H3, will not be demonstrated here due to the complexity of this process, since the great majority of constraints involved demands that many informative pairs be analyzed, which is not the central focus of this study.

4. Conclusion

Through the analysis of the acquisition of falling oral diphthongs, it was found that the VG syllabic structure is acquired before the VC structure in PB. This ordering in the stages of acquisition can be explained by OT and by Tesar & Smolensky's (2000) learning algorithm.

According to OT, the acquisition stages of the syllabic structure are not seen as a simple ordering in the acquisition of internal syllabic structures anymore. In fact, the constraints that form the UG are related to these internal structures, like *Onset, Not Complex* (nucleus) and *NoCoda*: it is the interaction of these constraints with others, such as the faithfulness constraints, that will determine the acquisition stages. These acquisition stages are demonstrated by the distinct hierarchies which are created with the demotion of the constraints. Therefore, the main focus is to take into consideration the position that specific constraints, involving the syllabic constituents, occupy in the different "temporary" hierarchies used by the children.

The fact that a VG sequence is acquired before a VC structure in BP can be explained by OT, without the need to refer to the rhyme. It could be said that this constituent does not seem to be necessary to explain the stages of acquisition of the VG syllabic structure. According to Kager (2000)[14,] the acquisition of the complex nucleus does not bring evidence for the existence of the rhyme; the rhyme will be duly accounted for in the acquisition of other phonological structures.

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[13] Codasil: the coda must be a sibilant segment; Codavibr: the coda must be a vibrant segment; Codanas: the coda must be a nasal segment. (Matzenauer-Herandorena & Lamprecht, 1999).
[14] Email from the author.

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