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What's the matter with |U| and |I|? On nasal vowel diphthongization and element asymmetry

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Abstract

In Element-Theory and similar approaches to the internal structure of segments, it is often assumed that the aperture element |A| is more sonorous and different in kind from the coloring elements |I| and |U| (Hulst 2015; Pöchtrager 2006; Schane 1984), while the latter are usually considered to be equally sonorous and display symmetrical behavior. As it has been previously noted, though, this formulation misses a recurrent crosslinguistic asymmetry. |I| and |U| do in fact have distinct behaviors (Carvalho & Klein 1996; Nevins 2012; Veloso 2013; Pimenta 2019; Pöchtrager 2015), and while typologically, rounding can be absent from a language inventory, "no language has been found that lacks both a front vowel and palatal glide" (Hyman 2008: 100 n. 11). As will be shown, this asymmetry is the source of several phenomena in Portuguese phonology, both synchronic and diachronic. Special attention will be given to nasal vowel diphthongization in non-standard European Portuguese, which reveals a preference for the front offglide over the back offglide, [j] appearing even in some contexts where [w] would be expected. This preference, as will be argued, has its origin in sonority asymmetry, |I| being less sonorous than |U|.

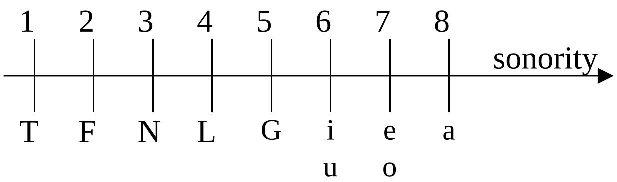
Keywords: element theory, element asymmetry, nasality, diphthongization, Portuguese.

1. Introduction

In Element Theory and similar approaches to internal segmental structure such as Particle Phonology and Dependency Phonology, the number of vocalic elements, which may also refer to consonantal place, can vary from three to six. The main three elements are |A| (aperture or RTR), |I| (palatality) and |U| (labiality), to which are sometimes added the element |Ɨ| (ATR) and the neutral element |v|, Kaye, Lowenstamm & Vergnaud's (1985) cold vowel[1].

The aperture element |A| is viewed as different from the coloring elements |I| and |U| (Hulst 2015; Pöchtrager 2006; Schane 1984), |A| being "naturally more vocalic than |I| or |U|" (Backley 2011: 175). Coloring elements |I| and |U| are usually treated as being equally vocalic (Harris & Lindsey 1995; Backley 2011), something that parallels most sonority scales, such as the one reproduced in Figure 1, where front and back vowels are equally sonorous.

Figure 1. Sonority scale



Source: Hyman (2008: 103)

Studies on such diverse topics as vowel harmony, vowel reduction, high vowel syllabification and diphthong frequency point, however, to asymmetries between the two coloring elements. Concerning vowel harmony, for example, it has been noted, for Turkic languages, that the spreading of |U| is more constrained that the spreading of |I| (Charette & Göksel 1994: 47). As for vowel reduction, Veloso (2013) has shown how front vowels /i e ɛ/ are reduced to an empty vowel in post-tonic position in EP, whereas the reduction of back vowels /u o ɔ/ leads to a back high vowel [u]. This asymmetry seems to be corroborated typologically, as Hyman postulates that "[e]very phonological system has at least one front vowel or the palatal glide" (Hyman 2008: 98), while the only rounding universal the author can postulate establishes that "[e]very phonological

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[1] In some approaches to internal segmental structure, labial and velar features are both encoded by |U|, the difference between them depending on headedness (Hulst 1989; Backley 2011). In other approaches, |U| encodes the labial feature while the velar feature is underspecified (Harris & Lindsey 1995; Carvalho 2013). More rarely, they can be represented by two different elements, e.g. |U| for the velar and |B| for the labial feature (Scheer 1998). As for the neutral element, it can also be represented by |@| (Harris & Lindsey 1995; Veloso 2013).

system has at least one unrounded vowel" (Hyman 2008: 96), but not necessarily a rounded vowel or a rounded glide.

This paper contributes to the question of the origin of this asymmetry by analyzing different kinds of data of European Portuguese (henceforth EP): (i) the still poorly studied phenomenon of synchronic diphthongization of lexical nasal vowels /ẽ ɐ̃ õ/ in non-final position in non-standard varieties (§0); (ii) oral homorganic diphthongs /ej/ and /ow/ and their resistance to monophthongization (§4.1); and (iii) historical case studies of nasal diphthong formation (§4.2). By analyzing data from different varieties of EP, our aim is to focus on the systemic tendencies of the language, which show, for a same process, which outcomes are more or less probable, and which should be impossible.

2. Asymmetry in diphthongs

Regarding the wellformedness of diphthongs, Sánchez Miret (1998) concludes, after analyzing the data of two typological corpora (UPSID and the Stanford Phonology Archive) and study data on diphthongs from Weeda (1983 *apud* Sánchez Miret 1998: 32), that "[t]he diphthongization of a vowel tends to increase its latent duality, and the best way of doing this is for it to develop into a falling diphthong with maximal distant endpoints" (Sánchez Miret 1998: 47). A conclusion that is in accordance with the fact that (a) falling sonority diphthongs are typologically more frequent than raising diphthongs, and that (b) "the majority of diphthongs and especially the most frequent ones tend to have a high glide" (Sánchez Miret 1998: 44).

Two parameters can be used to differentiate the two parts of a diphthong: the height dimension, which opposes the high sonority of the element |A| (aperture) against the lower sonority of elements |I| and |U|, and the front-back dimension, which opposes the coloring power of |I| (palatality) against that of |U| (labiality), *ceteris paribus*. It is usual for languages to use both dimensions, creating a polarization between sonority and color, as "[t]he syllabic is given the role of sonority-bearer and it is lowered and often bleached to maximize this sonority, while the non-syllabic, which retains its color, is raised and tensed to intensify this color" (Donegan 1978: 106). But it is also possible to see diphthongs where only one dimension is explored, usually height (Sánchez Miret 1998: 43). Interestingly, the fact that height is preferred over back/front reproduces the fact that for monophthongs there can exist a "vertical" system with no use of colouring elements, as in Kabardian, but there are no "horizontal" systems where only the back/front dimension would be used, with only one degree of height (Carvalho & Klein 1996: 101).

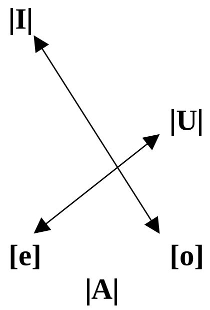
Regarding element asymmetry in diphthongs, Kubozono (2001) shows how [au] is less frequent and more prone to assimilation and monophthongization than [ai] in Japanese, and concludes that the back offglide is more marked than the front offglide[2]. At the same time, Pöchtrager (2015) brings up the fact that there is a gap in English diphthongs regarding the combination of elements |A I U|. As the author points out,

[2] Although Kubozono annotates Japanese diphthongs as [au] and [ai], the author makes reference to tautosyllabic sequences, which is made clear namely by the criterion of word accent shift (Kubozono 2001: 61).

amongst (British) English heavy diphthongs, elements |I| and |U| can both be the offglide when the nucleus contains only the element |A| (i.e. diphthongs *aj* and *aw*), but when the nucleus contains two elements combined, only |I| can form a non-homorganic diphthong, which means that *oj* exists (i.e. the combination of |A U| in the nucleus and |I| as an offglide), but not *ew* (i.e. the combination of |A I| in the nucleus and |U| as an offglide).

On this matter, Nevins (2012) affirms that the element "|I| is a more extreme (and hence, more contrastive) target than |U|" (Nevins 2012: 232), and that if [ew] is dispreferred in many languages as compared to [oj], it is because "the distance from |A,I| to |U| is shorter than that from |A,U| to |I|" (Nevins 2012: 232), as it can be seen in Figure 2.

Figure 2. Distance between the elements |I| and |U| and mid-vowels [o] and [e] respectively



Source: Nevins (2012: 232)

Finally, the data presented by Sánchez Miret (1998) show an asymmetry that was not discussed by the author: the fact that there are more diphthongs with a front offglide that with a back offglide, as we can see in Figure 3.

Figure 3. Diphthongs in UPSID 1992

	i	u	ɪ	ʊ	e	o	ɛ	ɔ	æ	a	ə
i	—	iu (2)			ie (6)	io	iɛ		ia̤	ia (5)	iə
u	ui (8)	—				uo (4)				ua (3)	uə (5)
ɪ			—		ɪe						
ʊ	ʊi			—							
e	ei (7)	eu 3			—	eo (3)				ea	eə
o	oi (6)	ou 5			oe	—				oa (2)	
ɛ	ɛi (3)					ɛo	—				
ɔ	ɔi (6)							—			
æ	æi (3)								—		
a	ai (19)	au (18)			ae (3)	ao (4)	aɛ			—	
ə	əi (2)	əu (4)									

Source: Sánchez Miret (1998: 34). Diphthongs under the central line have a falling sonority, while those over the center line have a raising sonority. The numbers of languages that have each diphthong is presented in brackets.

3. Nasal vowel diphthongization

EP is a language known for its nasal vowels /ĩ, ẽ, ɐ̃, õ, ũ/ (e.g. *quinto* [ˈkĩtu] ‘fifth’, *vento* [ˈvẽtu] ‘wind’, *canto* [ˈkɐ̃tu] ‘corner’, *onda* [ˈõdɐ] ‘wave’, *mundo* [ˈmũdu] ‘world’) and its nasal diphthongs /ɐ̃j̃, ɐ̃w̃, õj̃, ũj̃/ (e.g. *mãe* [mɐ̃j̃] ‘mother’, *limão* [liˈmɐ̃w̃] ‘lime’, *limões* [liˈmõj̃ʃ] ‘limes’, *muito* [ˈmũj̃tu] ‘a lot’), nasal rimes being the second most common syllable type in the language (Table 1).

Table 1. Relative frequency of different syllabic types in standard EP

Syllable types	***%***
Open syllable	64,37
Nasal rime	14,98
Closed syllable	14,42
Oral diphthongs	5,38
Other types	0,85

Source: Percentages were calculated based on the data presented by Vigário, Martins & Frota (2006: 681). “Closed syllables” includes both heavy syllables (ending in a rhotic) and light syllables (ending in extrametrical /S/), since no distinction was made by the authors; “Oral diphthongs” includes diphthongs followed by the plural morpheme /S/; “Nasal rime” includes nasal vowels and diphthongs followed by the plural morpheme /S/.

Regarding their distribution in standard EP (cf. Table 2), nasal vowels are present in all positions of the word, even if words ending in a post-tonic nasal vowel (e.g. *órfã* [ˈɔɾfɐ̃] ‘(f.) orphan, f.’) are not very numerous[3]. Nasal diphthongs, on the other hand, are found almost exclusively in stressed final position: they are entirely absent from prestressed positions, while non-final nasal diphthongs are extremely rare, existing only in a handful number of lexical items, all of which contain a front offglide [j] (e.g. *muito* [ˈmũj̃to] ‘a lot’, *cãibra* [ˈkɐ̃j̃bɾɐ] ‘cramp’, *zãibo* [ˈzɐ̃j̃bu] ‘lazy-eyed’). As for unstressed final nasal diphthongs, they do exist, but can undergo vowel reduction and be pronounced as an oral monophthong (e.g. *bênção* [ˈbẽsɐ̃w̃] ~ [ˈbẽsɐ] ‘benediction’)[4]. Regarded as exceptions, non-final nasal diphthongs are usually left unexplained in phonological analysis (Bisol 2013: 120), although understanding how they were formed and why they are so rare can help understanding nasal rime structure in general (Pimenta 2019).

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3 For a list of words ending in a post-tonic nasal vowel in Brazilian Portuguese (BP), cf. Battisti (2014: 1450), and for a comparison with European Portuguese, cf. Pimenta (2019: 10).

4 Unstressed final nasal diphthongs also exist in the 3rd person plural forms of verbs (e.g. *amam* [ˈɐmɐ̃w̃] ‘(they) love’), which considerably enhance their frequency. Just as in nouns, these diphthongs can be reduced (e.g. *foram* [ˈfoɾɐ̃w̃] ~ [ˈfoɾu] ‘(they) went’.

Table 2. Relative frequency of nasal nuclei in standard EP according to the position in the word

	Non-final position	***Final position***
Nasal vowel (C)Ṽ	65,75%	34,25%
Nasal diphthong CṼG̃	11,78%	88,22%

Source: Percentages were calculated based on the data presented by Vigário, Martins & Frota (2006: 682). In the present table, 'Non-final position' regroups the original 'Initial' and 'Internal' positions, while 'Final position' regroups the original 'Final position' and 'Monosyllabic words'. Finally, 'Nasal vowel (C)Ṽ' regroups the original syllable types 'CVN' and 'VN', while 'Nasal diphthongs' represent the original syllable type 'CVGN'. Unfortunately, the authors make no reference to stressed and unstressed positions.

In spite of the low number of words in standard EP containing a lexical nasal diphthong in non-final position, by studying dialectological data it is possible to find attested forms such as those in (1), where nasal vowels are pronounced as diphthongs[5], a process that doesn't occur with oral vowels, except for those standing before a palatal consonant, e.g. *espelho* [iʃˈpejʎu] 'mirror', in northern varieties of EP (Veloso 2019: 522). But what are the constraints defining the color of the offglide when a nasal vowel diphthongizes in EP, where standard nasal vowels correspond to phonological diphthongs (Pimenta 2019)?

(1) Some attested forms found in the ALEPG database[6]

a.	/ɐ̃/	*camba*	[ˈkɐ̃bɐ]	[ˈkɐ̃w̃bɐ]	[ˈkɐ̃j̃bɐ]	'rim'
		tangerina	[tɐ̃ʒiˈɾinɐ]		[tɐ̃j̃ʒiˈɾinɐ]	'tangerine'
b.	/ẽ/	*tempo*	[ˈtẽpu]	[ˈtẽw̃pu]	[ˈtɐ̃j̃pu]	'time'
		penso	[ˈpẽsu]	[ˈpẽw̃su]	[ˈpɐ̃j̃su]	'hay'
c.	/õ/	*lontra*	[ˈlõtɾɐ]	[ˈlõw̃tɾɐ]		'otter'
		lombo	[ˈlõbu]		[ˈlõj̃bu]	'loin'

[5] Diphthongization creates competing forms not only from one variety of EP to another, but also between different speakers of the same variety, or even for the same speaker, that can sometimes produce a lexical item with and without diphthongization.

[6] The phonetic transcriptions of ALEPG were adapted here to IPA-based usages, and simplified when this was not relevant for the analysis. When several attested forms are given for the same word, those in the left column show a pronunciation with a nasal vowel, which is similar to the one found in Standard EP, while the second (and eventually third) column show attested realizations with diphthongized forms.

According to Donegan, “[t]he original diphthongization of a simple vowel […] typically produces a falling diphthong” (Donegan 1978: 111), which is in accordance with the EP data that will be presented in this section. If the elements |I| and |U| behave symmetrically, one could expect the number of front and back off-glides to be balanced, which, as will be seen, is not the case. To investigate this question, 532 attested forms of diphthongized nasal vowels found in the ALEPG project corpus (cf. Saramago 2006) will be analyzed[7]. All forms analyzed here have a lexical nasal vowel /ẽ/, /ɐ̃/ or /õ/ in non-final position (i.e. in initial or internal position), no distinction being made between stressed and unstressed syllables, since this process of diphthongization can also happen in positions where lexical nasal diphthongs are absent in standard EP, such as pretonic position (e.g. *tangerine* [tɐ̃ʒɨˈɾinɐ] ~ [tɐ̃j̃ʒɨˈɾinɐ] ‘tangerine’.

3.1. Homorganicity with the vowel that diphthongizes

As it will be illustrated in the following subsections, the color of the offglide can often be attributed to the elements of a segment in the environment, which means that it can be homorganic (i) with the vowel that diphthongizes (§3.1), (ii) with the consonant that follows (§3.2), or (iii) with the last vowel, through metaphony (§3.3), in a way that all three possibilities can be combined, e.g. through an offglide that is at the same time homorganic with the vowel that diphthongizes and with the last vowel. In the cases where the offglide is homorganic with the vowel, dissimilation can take place: the nucleus is subject to bleaching, a process that removes coloring elements, in order to become more sonorous, while the offglide is subject to an enhance in coloring, leading to an increase in the polarity between the two halves of the diphthong (Donegan 1978: 106)[8]. In some cases, though, the color of the offglide is defined neither through homorganicity nor through metaphony, as it will be shown in §3.3. Let’s start by investigating the behavior of |I| and |U| through the rates of homorganicity with the vowel that diphthongizes.

(2) Examples of offglides homorganic with the vowel that diphthongizes

a.	/ẽ/	*amêndoa*	[ɐˈmẽdo.ɐ]	[ɐˈmẽj̃dwɐ]	‘almond’
		tempo	[ˈtẽpu]	[ˈtẽj̃pu]	‘time’
b.	/õ/	*concha*	[ˈkõʃɐ]	[ˈkõw̃ʃɐ]	‘shell’
		lontra	[ˈlõtɾɐ]	[ˈlõw̃tɾɐ]	‘otter’

When a front or a rounded vowel diphthongizes, the glide will be homorganic with that vowel if it is, respectively, a front offglide [j̃] and a labiovelar offglide [w̃], as in the examples in (2). If the vowel is /ɐ̃/, on the other hand, neither glide will be homorganic, except in some districts in the north of Portugal, where a few attested forms

7 Dialectological data analysed in this paper belongs to the ALEPG project - *Atlas Linguístico-Etnográfico de Portugal e da Galiza* (cf. Saramago 2006). The data was extracted in 2014, and since the corpus was not entirely transcribed yet, other realizations of diphthongized nasal vowels in non-final position may exist in their actual corpus.

8 Dissimilation through the bleaching of the vowel can be found, for example, in the diphthong /ej/ pronounced as [ɐj] in some varieties of EP (e.g. *beira* [ˈbejɾɐ] ~ [ˈbɐjɾɐ] ‘corner’).

had a velar(ized) low vowel followed by the labiovelar glide, e.g. *mangueira* [mɑ̃w̃ˈgɐjɾɐ] ‘flail’s handle’, *gansa* [ˈgɐ̃w̃sɐ] ‘goose (f.)’.

As it is shown in Table 3, when the vowel that diphthongizes is /ẽ/, the offglide is a front [j̃], i.e. a homorganic glide 98% of the time. When the vowel is /õ/, though, the offglide is homorganic, i.e. [w̃], only 35% of the time. Finally, when the vowel is /ɐ̃/, the distribution of front and back offglides is quite balanced, with 48% of front offglides and 52% of back offglides.

Table 3. Number and percentage of front and back offglides in the ALEPG corpus according to the vowel that diphthongizes[9]

	/ẽ/		/õ/[10]		/ɐ̃/	
	j̃	*w̃*	*j̃*	*w̃*	*j̃*	*w̃*
N° attested forms	279	6	15	8	108	116
Percentage	*98%*	*2%*	*65%*	*35%*	*48%*	*52%*
Total	285		23		224	

Interestingly, the six attested forms containing a front nasal vowel /ẽ/ and an offglide that is not front (i.e. 2% of the cases where /ẽ/ diphthongizes) are those in (3) and they are all attested in the north of Portugal (districts of Braga, Porto and Viana do Castelo). In all of them, the back offglide can be explained either by a homorganicity with the following consonant, by metaphony (see §3.3), or both.

Regarding the homorganicity of the offglide with the vowel that diphthongizes, it can be said that |I| and |U| do not show a symmetrical behavior.

(3) All the attested forms of a front nasal vowel /ẽ/ with an offglide non-homorganic with the vowel

a.	*tempo*	[ˈtẽw̃pu]	‘time’	Braga
b.	*penso*	[ˈpẽw̃su]	‘band-aid’	Porto
c.	*avenca*	[ɐˈβʲẽw̃kɐ]	‘venus hair fern’	Viana do Castelo
d.	*genro*	[ˈʒẽw̃ʀu]	‘son in law’	Viana do Castelo
e.	*lenço*	[ˈlẽw̃su]	‘hanky’	Viana do Castelo
f.	*centopeia*[11]	[sɐ̃w̃tuˈpɐjɐ]	‘centipede’	Viana do Castelo

3.2. Homorganicity with the following consonant

Let’s move now to the cases of homorganicity with the following consonant. Assuming that the place of articulation of palatal consonants is defined by the element |I| while the

[9] Those numbers include cases where the offglide: (a) is homorganic with the vowel that diphthongizes *only*; (b) is homorganic with the vowel that diphthongizes *and* with the following consonant; (c) is homorganic with the vowel that diphthongizes but is also subject to metaphony.

[10] The low number of attested forms of diphthongization of the back vowel simply shows that there is considerably less data of /õ/ in the database.

[11] In the word *centopeia* ‘centipede’, metaphony is due to the influence of the final vowel of *cento* ‘hundred’.

element |U| defines labials and possibly also velars[12], homorganicity induced by the consonant occupying the following onset should take the form of a front offglide [j̃] before palatal consonant and a back offglide [w̃] before a labial or a velar consonant, as exemplified in (4).

(4) Examples of offglides homorganic with the following consonant

a.	labials	*alambique*	[ɐlɐ̃ˈbikɨ]	[ɐlɐ̃w̃ˈbikɨ]	‘alembic’
		tempo	[ˈtẽpu]	[ˈtẽw̃pu]	‘time’
b.	palatals	*concha*	[ˈkõʃɐ]	[ˈkõj̃ʃɐ]	‘shell’
		longe	[ˈlõʒɨ]	[ˈlõj̃ʒɨ]	‘afar’
c.	velars	*canga*	[ˈkɐ̃gɐ]	[ˈkɐ̃w̃gɐ]	‘yoke’
		avenca	[ɐˈvẽkɐ]	[ɐˈβʲẽw̃kɐ]	‘venus hair fern’

As shown in Table 4, when the following consonant is palatal, the offglide is homorganic in 97% of the cases. When the consonant is velar, the offglide is homorganic in 45% of the cases. Finally, when the consonant is labial, a homorganic offglide is found in only 38% of the attested forms. Once again, the rate of homorganicity is much higher for the |I| element than for the |U| element.

Table 4. Number and percentage of front and back offglides in the ALEPG corpus according to the place of articulation of the consonant occupying the following onset[13]

	palatal		**velar**		**labial**	
	j̃	***w̃***	***j̃***	***w̃***	***j̃***	***w̃***
N° attested forms	71	2	53	44	56	34
Percentage	*97%*	*3%*	*55%*	*45%*	*62%*	*38%*
Total	73		97		90	

3.3. Non-homorganic glides

Not every attested form with a diphthongized nasal vowel has an offglide that is homorganic either with the vowel that diphthongizes or with the following consonant, though. In that case, for some of those attested forms, the assimilation of the color of the last vowel, through metaphony, should be considered, as exemplified in (5).

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12 For a phonetically grounded explanation on the relationship between velars and labials, cf. Ohala & Lorentz (1977).

13 Those numbers include cases where the offglide: (a) is homorganic with the following consonant *only*; (b) is homorganic with the following consonant *and* with the vowel that diphthongizes; (c) homorganic with the following consonant but is also subject to metaphony.

(5) Examples of non-homorganic offglides with possible metaphony

a.	final |U|	*lenço*	[ˈlẽsu]	[ˈlẽw̃su]	‘tissue’
		penso	[ˈpẽsu]	[ˈpẽw̃su]	‘hay’
b.	final |I|	*alpendre*	[aɫˈpẽdɾɨ]	[alˈpẽȷ̃dɾi]	‘front porch’
		alambique	[ɐlɐ̃ˈbikɨ]	[lɐ̃ȷ̃ˈbikɨ]	‘alembic’

In other attested forms, though, there is clearly neither homorganicity nor metaphony, as exemplified in (6). It is interesting to note that in those cases the offglide is always a front [ȷ̃], and that this offglide can appear even in contexts where a back offglide should be expected, as in (6c), where the vowel that diphthongizes is a back /õ/, the following consonant is a labial and the final vowel is back.

(6) Examples of non-homorganic offglides with no possible metaphony

a.	*camba*	[ˈkɐ̃bɐ]	[ˈkɐ̃ȷ̃bɐ]	‘rim’
b.	*canga*	[ˈkɐ̃gɐ]	[ˈkɐ̃ȷ̃gɐ]	‘yoke’
c.	*lombo*	[ˈlõbu]	[ˈlõȷ̃bu]	‘loin’

In some attested forms, a back offglide seems to be left unexplained since there is no possibility of metaphony, there is no homorganicity with the consonant and one wouldn’t expect to find homorganicity with the vowel because it is a low vowel /ɐ̃/ that is not realized as velar.

(7) All the attested forms of a low nasal vowel /ɐ̃/ with a back offglide

a.	*canzil*	[ˈkɑ̃w̃ziɫ]	‘kennel’	Aveiro
b.	*canzis*	[ˈkɑ̃w̃ziʃ]	‘kennels’	Aveiro
c.	*canzis*	[ˈkɑ̃w̃ziʃ]	‘kennels’	Porto
d.	*dançar*	[ˈdɑ̃w̃saɾ]	‘to dance’	Porto
e.	*dançar*	[ˈdaw̃saɾ]	‘to dance’	Viana do Castelo
f.	*feirante*	[fɐjˈɾɑ̃w̃tɨ]	‘marketer’	Porto
g.	*gansa*	[ˈgɑ̃w̃sɐ]	‘geese’	Braga
h.	*gansa*	[ˈgɑ̃w̃sɐ]	‘geese’	Braga
i.	*grande*	[ˈgɾɑ̃w̃dɨ]	‘big’	Porto
j.	*maçãzinha*	[mɐsɑ̃w̃ˈzĩɲɐ]	‘little apple’	Viana do Castelo
k.	*mantas*	[ˈmɑ̃w̃tɐz]	‘blankets’	Viana do Castelo

But it turns out that all of the attested forms where a back offglide is left unaccounted, i.e. those reproduced in (7), were produced in the north of Portugal, in the districts of Aveiro, Braga, Porto and Viana do Castelo. Knowing that in the North of Portugal the low nasal vowel evolved differently from most other varieties of EP, as instead of getting raised into [ɐ̃] it velarized to [ɑ̃] or even to [ɔ̃] (cf. Maia 1981: 77, n. 3; Sampson 1999: 204–5), it can be argued that this may be (or have been) a back vowel, which means that the back off-glide found in the forms in (7) would be homorganic.

As can be seen in Table 5, every possible coloring source taken into account (e.g. metaphony or homorganicity either with the vowel that diphthongizes or with the following consonant), the origin of all back offglides is explained, but there are still fifty attested front offglides with an undefined coloring source. Interestingly, amongst those, there are sixteen attested forms of *camba* [ˈkɐ̃j̃bɐ] ‘rim’ and twenty-six attested forms of *canga* [ˈkɐ̃j̃gɐ] ‘yoke’, two words whose diphthong is very similar to the few words in standard EP that have a lexical nasal diphthong in non-final position, i.e. *cãibra* [ˈkɐ̃j̃bɾɐ] ‘cramp’ and *zãibo* [ˈzɐ̃j̃bu] ‘lazy-eyed’.

Table 5. Front and back offglides in the corpus according to the possibility of metaphony: homorganic (with the vowel, with the consonant or both) and non-homorganic offglides

	Front offglide j̃		**Back offglide w̃**	
Possible Metaphony	***YES***	***NO***	***YES***	***NO***
Homorganic	68	257	66	32
Non-Homorganic	27	50	32	**0**
Total	402		130	

In short, the first thing that can be noticed is that front offglides are more frequent than back offglides in this corpus, [j] being found in 75,6% of the attested forms, while [w] is present in 24,4% of them. This can be *partly* explained by the fact that more than half of the vowels that diphthongize are phonological /ẽ/ (285/532)[14]. The second thing is that the rate of homorganicity with the following consonant is much higher before palatals than before labials or velars, as shown in Table 4. And finally, back offglides that are neither homorganic with the nasal vowel nor with the following consonant can only arise through metaphony (e.g. *tempo* [ˈtẽw̃pu] ‘time’), as shown in (3), while a front offglide is possible with no homorganicity nor metaphony, and even in contexts where a back offglide should be expected, as it was shown in (6c) (i.e. *lombo* [ˈlõj̃bu] ‘loin’).

4. Other processes in EP

In order to provide independent evidence for the asymmetry between the elements |I| and |U| in EP, two diachronic processes will be examined: the monophthongization of homorganic oral diphthongs and the path that led to the formation of lexical nasal diphthongs in standard EP.

4.1. Monophthongization of homorganic oral diphthongs

As exemplified in (8), there are eleven oral (surface) falling diphthongs in EP, even if it is not clear that all of them should be considered as a real diphthong[15]. EP also contains

[14] Most of them are followed by a coronal consonant (218/532).

[15] Surface diphthongs [iw], [ɛj] and [ɔj] probably have a morphological boundary in between the two vowels, as the first only appears in some verbal endings and the other two only exist in the plural forms of words ending in /-ɛl/ and /-ɔl/, with the exception of the words *herói* [iˈɾɔj] ‘hero’ and *boina* [ˈbɔjna] ‘beret’, where the diphthong can be analysed as a sequence of

raising sonority diphthongs at a surface level, but they are phonological sequences of vowels in hiatus (e.g. *hiato* [ˈjatu]~[iˈatu] 'hiatus').

(8) Oral falling diphthongs in EP

	Front offglide diphthongs				Back offglide diphthongs		
a.	aj	*paixão*	'passion'	g.	aw	*causa*	'cause'
b.	ej	*deixar*	'to leave'	h.	ew	*deuses*	'gods'
c.	ɛj	*papéis*	'papers'	i.	ɛw	*chapéu*	'hat'
d.	oj	*foice*	'scythe'	j.	ow	*couro*	'leather'
e.	ɔj	*herói*	'hero'	k.	iw	*viu*	'(he) saw'
f.	uj	*ruivo*	'red-haired'				

Amongst falling diphthongs, homorganic diphthongs /ej/ and /ow/ can have a monophthongised realization, e.g. *cheiro* [ˈʃejɾu] ~ [ˈʃeɾu] 'smell'[16], *ouro* [ˈowɾu] ~ [ˈoɾu] 'gold'[17], either in stressed or unstressed syllable, which means that they do not undergo vowel reduction and do not merge with underlying /e/ and /o/, that are respectively pronounced [ɨ] and [u] in unstressed syllable.

As reported by Teyssier (1980: 79–80), the rate of monophthongization of front and back diphthongs varies according to the region and obeys the following implication: if the front diphthong /ej/ undergoes monophthongization, so does the back diphthong /ow/, but the reverse is false, as shown by standard EP where dissimilation takes place instead (e.g. *beijo* [ˈbɐjʒu] 'kiss'). This asymmetry in monophthongization, which was also reported by Kubozono (2001) about Japanese diphthongs, is one of the processes that show that the front offglide is more suited than the back offglide to occupy a non-nucleic position[18].

4.2. Historical data: nasal diphthong formation

Portuguese (lexical) nasal diphthongs were mainly created through regressive nasalization and erasure of a nasal consonant in two contexts: when the vowel was followed by a nasal consonant in final coda (VN#) and when it was followed by Latin simplex -N- in intervocalic position (VNV). As illustrated in (9), in the latter context hiatus resolution was different according to the sonority of the vowels preceding and following the nasal consonant.

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vowels in hiatus. The actual status of these (surface) diphthongs will not interfere with the analysis presented here.

16 In some EP varieties, the diphthong /ej/ is realized as [ɐj], through the disassociation of the |I| element from the first position of the complex nucleus.

17 In some northern varieties of EP, /ow/ can also undergo dissimilation through the disassociation of the coloring element, being realized [ɐw], e.g. *cenoura* [siˈnɐwɾɐ] 'carrot'.

18 By non-nucleic position, it is meant not only a consonantal position, but also that occupied by a glide, even if the glide stands in a complex nucleus.

(9) Hiatus resolution in Galician-Portuguese (G-P) after erasure of Latin simplex -N- of V_1NV_2 sequences according to the sonority difference between the two vowels

	Sonority	G-P > EP		Examples
a.	$V_1 > V_2 \rightarrow$ VG	*-ão* >	[ɐ̃w̃]	G-P *mão* > EP [mɐ̃w̃] 'hand'
		-ãe >	[ɐ̃j̃]	G-P *pães* > EP [pɐ̃j̃ʃ] 'breads'
b.	$V_1 < V_2 \rightarrow V_1.V_2$	*-õa* >	[o.ɐ]	G-P *bõa* > EP [ˈbo.ɐ] 'good (f.)'
	(mid-vowels)	*-ẽa* >	[ej.ɐ]	G-P *vẽa* > EP [ˈvej.ɐ] 'vein'
c.	$V_1 < V_2 \rightarrow V_1.V_2$	*-ũa* >	[u.ɐ]	G-P *lũa* > EP [ˈlu.ɐ] 'moon'
	(high-vowels)	*-ĩa* >	[i.ɲɐ]	G-P *galĩa* > EP [gɐˈliɲɐ] 'chicken'
d.	$V_1 = V_2 \rightarrow$ Ṽ(Ṽ)	*-ãa* >	[ɐ̃]	G-P *lãa* > EP [lɐ̃] 'wool'
	(same vowel)	*-õo* >	[õ]	G-P *bõo* > EP [bõ] 'good (m.)'
		-ẽe >	[ẽj̃]	G-P *bẽe* > EP [bẽj̃] 'well'
e.	$V_1 = V_2 \rightarrow$?	*-õe* >	[õj̃]	G-P *leões* > EP [liˈõj̃ʃ] 'lions'
	(different vowels)	*-ẽo* >	[ej.u]	G-P *sẽo* > EP [ˈsej.u] 'your'

Following from the observation of (9e), I propose that this difference in sonority is the cause of the asymmetrical distribution and behavior of the elements |A I U| within EP nasal diphthongs. As can be seen in Table 6, in EP lexical nasal diphthongs the element |A| can only occur in the nucleus position (ɐ̃j̃, ɐ̃w̃), and |I| can occur only as an offglide (ɐ̃j̃, õj̃, ũj̃), while |U|, midway between |A| and |I|, can occur in the nucleus (ũj̃) as well as in the offglide (ɐ̃w̃).

Table 6. Distribution of |A I U| elements in the nucleus of a lexical nasal diphthong in EP

	|A|		**|U|**		**|I|**	
	Nucleus	***Offglide***	***Nucleus***	***Offglide***	***Nucleus***	***Offglide***
Does it exist?	Yes	No	Yes	Yes	No	Yes
Nasal Diphthongs	ɐ̃j̃, ɐ̃w̃	–	ũj̃	ɐ̃w̃	–	ɐ̃j̃, õj̃, ũj̃

5. Conclusions

Different kinds of data from EP were analyzed in this paper regarding the possible asymmetry of elements |I| and |U|. The data on lexical nasal vowel diphthongization showed that when a nasal vowel diphthongizes, (i) the element |I| present in the nasal vowel itself or in the following consonant will spread more easily into the offglide than the element |U|. At the same time, (ii) the back offglide will only surface through homorganicity or metaphony, knowing that (iii) a back offglide will not always emerge even if the context is propitious (e.g. *lombo* [ˈlõj̃bu] 'loin'). This observation contrasts with the fact that (iv) a front offglide can surface even when nothing would predict it, which leads me to say that [j] is the default offglide in EP. This might be more than a simple parametric choice, since cross-linguistic data on diphthongs revealed a preference for front offglides over back offglides.

The asymmetry found in this first set of EP data was confirmed by the analysis of other phenomena in the language. First, it was shown how the element |I| is more resistant to monophthongization in homorganic oral diphthongs than the element |U|, which is in accordance with the data presented by Kubozono (2001) for Japanese. Secondly, it was shown that during the historical process that led to the creation of EP lexical nasal diphthongs from etymological VNV sequences, the front vowels /i e/ did not behave the same way as the back vowels /u o/: (i) the element |I| of front vowels necessarily propagates onto a following position (e.g. G-P *vẽa* > EP [ˈvej.ɐ] 'vein', G-P *vĩo* > EP [ˈviɲu] 'wine'), while the element |U| of back vowels does not, or only exceptionally (i.e. G-P *bõa* > EP [ˈbo.ɐ] 'good (f.)', G-P *lũa* > EP [ˈlu.ɐ] 'moon'); (ii) the back mid-vowel /o/ behaves as if it were more sonorous than the front mid-vowel /e/, since the sequence *-õe* gave a nasal diphthong (e.g. G-P *leões* > EP [liˈõj̃ʃ] 'lions') while the opposite sequence *-ẽo* gave a disyllabic sequence with no nasal vowel (e.g. G-P *sẽo* > EP [ˈsej.u] 'breast').

The asymmetry between primary elements, that neither Element theory nor Government Phonology had anticipated, poses a theoretical problem: what is its formal motivation and how to express it? The different behavior of back and front vowels in VNV context leads me to propose that the element |U| is more sonorous than the element |I|, which leads to the following sonority scale: |A > U > I|. Being less sonorous, the element |I| is preferred in a non-nucleic position, which enhances the distance from the grater sonority conveyed by the nucleus.

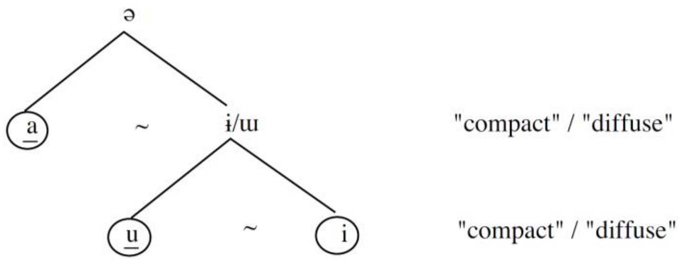
This scale can be related to Carvalho & Klein's (1996) investigation of the "markedness dissymmetry" between the cardinal vowels /a i u/, where /i/ and /u/ present mostly (but not always) a proportional relationship, at the same time as /a/ and /u/ seem to be "two 'states' of the same thing" (Carvalho & Klein 1996: 104). The authors motivate the typological evidences for the (un)markedness of vocalic systems, as well as the ill-formedness of impossible vocalic systems through "the reiteration of one single opposition, which could be labelled as 'compact' (marked) / 'diffuse' (unmarked), assuming that 'compactness' here follows from the F_2-F_1 differential […]" (Carvalho & Klein 1996: 106).

As illustrated in Figure 4, their system implies the existence of not one, but two kinds of "zero" vowels: the first has a neutral value regarding F_2-F_1 differential, and corresponds to the neutral vowel /ə/; the second is one of the outcomes of the first "compact/diffuse" split, and corresponds to a high (uncolored) vowel, i.e. /ɨ/ or /ɯ/. From the second "compact/diffuse" split, that starts from the high neutral vowel, would arise the two colored vowels /u/ and /i/. The similarities in the behavior of /u/ and /i/ derive from the fact that they occupy the same level, both being outcomes of the high vowel /ɨ/ (or /ɯ/); at the same time, their differences are justified by the fact that /u/ is compact while /i/ is diffuse. Finally, the similarities between /u/ and /a/ follow from the fact that both are compact, which distinguishes them from /i/ and /ɨ/ respectively.

Source: Carvalho & Klein (1996: 106)

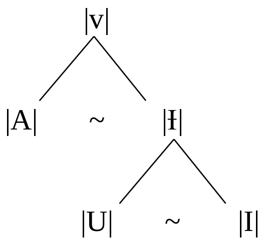
I propose to translate this into a graph containing the elements |A| (RTR), |I|

Figure 4. Vowels resulting from the reiteration of the opposition ‘compact’ (marked) / ‘diffuse’ (unmarked), where primitive vowels are circled, and the marked term of which is underlined



(palatality) and |U| (labiality), to which are added the neutral element |v| and the ATR element |Ɨ|. As presented in Figure 5, the asymmetry between elements |U| and |I| is formally motivated and is not different in kind from the contrast between elements |A| and |Ɨ|.

Figure 5. Subsymbolic hierarchy of vocalic elements



However, as it was pointed out by Harris (2006), the representational status of sonority is problematic, as it “cannot be directly read off phonological representations but has to be calculated by reference to an external look-up table – the sonority hierarchy” (Harris 2006: 1486). To motivate this sonority scale for the primary elements in a non-arbitrary way, this asymmetry should then be grounded in the internal structure of elements. Although Carvalho & Klein’s (1996) proposal represents a progress in the understanding of the asymmetric behavior of elements, and in the study of the structure of vocalic systems, it remains external to segmental structure. An alternative approach, that may solve the issue raised by Harris (2006), was proposed by the GP 2.0 theory (Pöchtrager 2015). In this framework, the element |A| is different in nature from elements |I| and |U| as it consists of structure, while the difference between |I| and |U| is expressed by the position each of them occupy in the structure representing aperture. This might be a path towards a satisfactory solution of the problem of I/U asymmetry.

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