VOWEL NASALIZATION IN BRAZILIAN PORTUGUESE: AN ARTICULATORY INVESTIGATION

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ABSTRACT

This study investigates, from an articulatory point of view, the extent to which the different nasalization processes in Brazilian Portuguese (BP) - phonemic, allophonic and coarticulatory - are the result of phonological, language specific rules or a purely phonetic transitional phenomenon between an oral vowel and a nasal consonant. The study revealed that the magnitude of the velic gestures is similar in phonemic and in allophonic nasalization, which suggests that both processes are the result of the application of phonological nasalization rules in BP. On the other hand, in coarticulatory nasalization the degree of velic opening reached during the vowel is smaller, suggesting that in this case we have a purely transitional, coarticulatory phenomenon.

1. INTRODUCTION

BP has pervasive and varied manifestations of vowel nasalization. **Phonemic** nasalization, as in *canto* (I sing) ['kã^{n}.tu], opposed to *cato* (I pick) ['ka.tu], originates from the regressive spreading of the feature [+ nasal] from a tautosyllabic nasal consonant, that has later disappeared, though leaving, in certain contexts, a residual consonantal appendix. **Allophonic** nasalization, as in *cama* (bed) ['kã.ma], occurs when there is still a nasal consonant in the onset position of the syllable that follows the nasalized vowel, from which the feature [+ nasal] spreads. However, its phonetic implementation as a nasalized vowel is the result of the application of a rule with constraints such as word stress location and the nature of the following nasal consonant. When the required conditions are not met, the degree of vocalic nasalization is, from an auditory point of view, clearly smaller, or even absent, as occurs for instance in *camada* (layer) [ka.'ma.da]). In order to distinguish this third (potential) type of nasalization, supposedly greater than that observed in oral contexts, from the allophonic nasalization, I will adopt the term **Coarticulatory** (regressive) nasalization. As a rule, allophonic nasalization occurs in stressed syllables and coarticulatory nasalization in unstressed syllables. As, however, unstressed syllables derived from allophonic nasalized stressed syllables (v.g. *c[ã]ma*) to which the diminutive suffix *-inho* was added keep their allophonic nasalization, we may have minimal pairs with the nasalized vowels in prestressed position such as *(a) c[ã]minha* (the little bed: allophonic nasalization) x *(ele) c[a]minha* (he walks: coarticulatory nasalization).

This study investigates from an articulatory point of view whether there are differences in the production of these nasalized vowels that justify the distinction proposed, and to what extent these different nasalization processes are the result of phonological, intentional language specific rules or a purely phonetic, unintended transitional phenomenon between an oral vowel and a nasal consonant. [8]

2. METHOD

A list of 112 words, embedded in the carrier sentence *É melhor dizer ... de novo* (It is better to say ... again), was read by three native speakers of the Rio de Janeiro dialect. In this *corpus*, all possible combinations of the type of nasalization, vowel quality and stress location (stressed or prestressed syllables) were included. The velic movements in the vowels were measured by means of a nasograph (see [4] for a description), a photoelectric device inserted into the subjects' nasal cavity and pharynx. The traces of velopharyngeal port opening, the nasal airflow and the acoustic waveform were recorded in FM tape and afterwards analysed with Windaq software. Three measurements were made: the mean amplitude (in mVolts) of the nasograph signal during the vowel production, which indicates the degree to which the velum lowers; the timing of velum lowering and the slope of the nasograph signal, observed in its first 50 milliseconds, which indicates the velocity of the velum movement. The starting point of the velum lowering movement was considered the point when the velocity function crosses a given noise band around zero. This noise band was defined as 20 % of the velic range, taking as minimal velic opening the average values found for the

		Degree of Veloph.Opening			Timing @ 20%			Slope @ 50 ms		
PHONEMIC		S	p	av	S	p	av	S	p	av
(ex. c[ã] ^{n} 'tava)	sp1	74.9	70.3	72.6	1.8	0.3	1.0	-3.23	-2.90	-3.06
	sp2	79.5	84.0	81.7	10.9	4.8	7.8	-3.70	-4.62	-4.16
	sp3	71.8	56.9	64.3	25.7	10.6	18.1	-1.95	-3.64	-2.79
	av.	**75.4**	**70.4**	**72.9**	**12.8**	**5.2**	**9.0**	**-3.0**	**-3.72**	**-3.34**
ALLOPHONIC		S	p	av	S	p	av	S	p	av
(ex. c[ã] 'minha)	sp1	73.3	59.9	66.6	2.1	2.5	2.3	-2.90	-2.54	-2.72
	sp2	95.8	76.7	86.2	17.0	11.8	14.4	-3.71	-4.10	-3.90
	sp3	66.0	48.1	57.0	30.0	20.9	25.4	-2.21	-2.67	-2.44
	av.	**78.4**	**61.6**	**69.9**	**16.4**	**11.7**	**14.1**	**-2.94**	**-3.10**	**-3.02**
COART.	sp1	_	56.1		_	4.1		_	-2.75	
(ex. c[a] 'minha)	sp2	_	55.1		_	24.1		_	-2.94	
	sp3	_	37.5		_	20.2		_	-1.55	
	av.	_	**49.6**		_	**16.1**		_	**-2.41**	
		S	p	av						
ORAL	sp1	3.7	3.7	3.7						
(ex. c[a] 'pina)	sp2	4.9	7.8	6.3						
	sp3	-1.5	1.5	0						
	av.	**2.4**	**4.3**	**3.3**						

Table 1. Velopharyngeal port behavior in Brazilian Portuguese vowels. Values for the degree of Velopharyngeal Opening are expressed in percentage; timing values are in milliseconds. S = stressed; p = prestressed; sp = speaker; av. = average.

oral consonant /z/ and as maximal velic opening the average values found for the nasal consonant /n/ in the carrier sentences. To allow comparisons of the magnitude of velopharyngeal port opening across subjects, the values in mVolts found were converted into percentage of the total individual range of the velopharyngeal opening/closing, calculated as the difference between a topline (the average values found, for each speaker, for the oral consonant /z/) and a baseline (the values for the nasal consonant /n/).[7]

3. RESULTS & DISCUSSION

Results show that the degree of velum opening is similar in phonemic and allophonic nasalization, with values slightly higher in phonemic (72.9 %) than in allophonic (69.9 %) nasalization. Oral vowels, on the other hand, have shown an average value of only 3.3 % (cf. Table 1 and Fig. 1).

It is also observed that, in unstressed position, the amplitude of the velic movement is smaller, confirming the claim that stressed vowels are more commonly (rather heavily) nasalized than unstressed ones [3], [6] (Fig.2).

Regressive coarticulatory nasalization, which occurs only in unstressed position, comes between (49.6 %) the allophonic nasalization and the oral vowel.

If we consider that, unlike the allophonically nasalized vowels, these coarticulatorily nasalized vowels are interpreted as oral vowels when inserted in oral contexts, as found in perceptual tests [5], we may suppose that the threshold of the perceived nasalization requires a velopharyngeal opening situated between those observed in the coarticulatory and the allophonic nasalizations. In relation to timing and slope, the same gradation may be observed between the three nasalization processes. It must be pointed out that, as to timing, the allophonic nasalization behaves much closer to the coarticulatory than to the phonemic nasalization (cf. Table 1).

Curiously, stress here shows an opposite effect to that which could be expected [3]: in unstressed syllables, whose degree of nasalization is smaller than in stressed ones, there is a kind of compensation, in the sense that nasalization starts earlier.

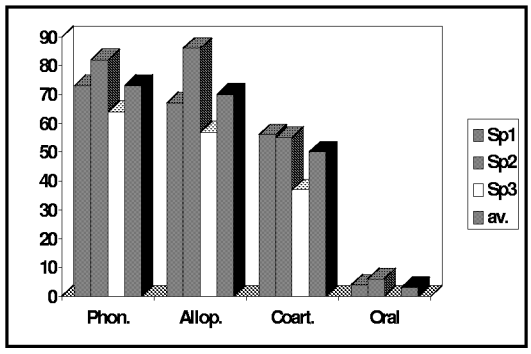

Fig. 1. Average magnitude of velopharyngeal opening, expressed in percentage, per subject, as observed in Phonemic, Allophonic, Coarticulatory nasalized vowels and in Oral vowels. Sp = speaker, av. = average.

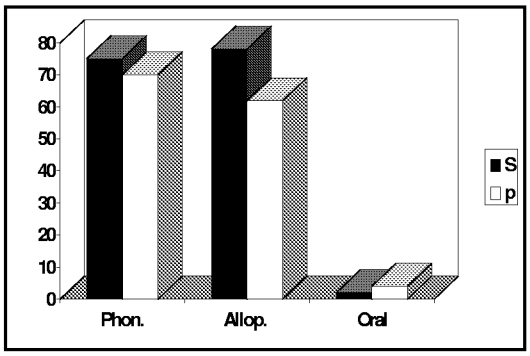

Fig. 2. Average magnitude of velopharyngeal opening, expressed in percentage, in Stressed (S) and prestressed (p) syllables in Phonemic, Allophonic nasalized vowels and in Oral vowels.

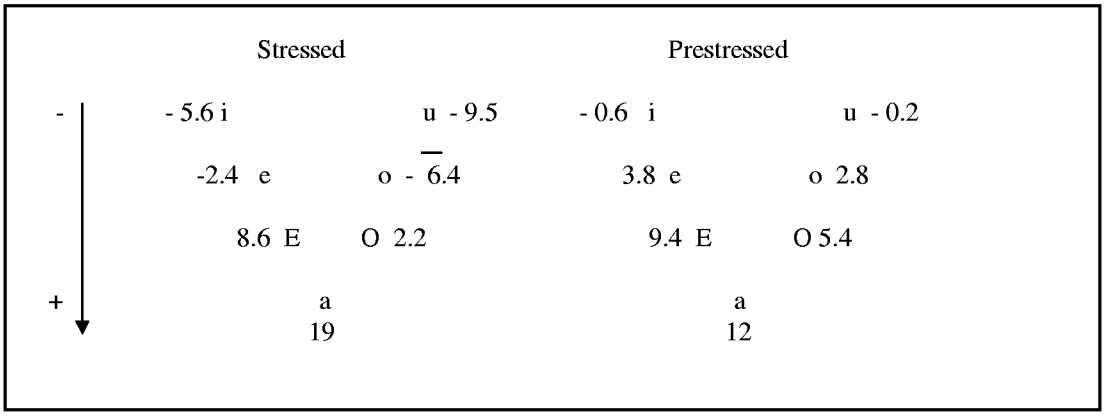

Fig. 3. Average magnitude of velopharyngeal opening, expressed in percentage, observed in oral vowels in stressed and prestressed position.

As to vowel quality, no clear, systematic relation was observed in nasalized vowels between vowel quality and velopharyngeal opening. In oral vowels, however, not only a velic lowering in the low vowel can be observed (as described for English [1], [2], [3], [4]), but also a strong correlation, in all vowels, between velum height and tongue height. As has been already suggested [3], we notice that adding stress to these vowels reinforces intrinsic velic positional differences: the lowest velum position becomes lower when stressed, the other ones become higher (Fig.3).

4. CONCLUSION

The data analysed reveals that the magnitude of the velum opening in phonemic and allophonic nasalization is superior to that observed in coarticulatory nasalization, which suggests that both processes are the result of the application of phonological nasalization rules in BP, in the sense that they are intentional, depending on language specific rules, as opposed to coarticulatory nasalization, a phonetic transitional phenomenon between an oral vowel and a nasal consonant. On the other hand, the values obtained in coarticulatory nasalization are much higher than those obtained in vowels in oral contexts, which allows it to be considered, from a phonetic point of view, as another degree of nasalization, distinct from both phonemic and allophonic nasalizations as well as from the "intrinsic" nasalization observed in oral vowels. Moreover, vowel quality in oral contexts and stress location appears as relevant factors in the degree of velopharyngeal opening. These results support the proposed distinction [8] between phonological (phonemic or allophonic) vs. phonetic (coarticulatory) nasalization processes.

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