University of Pennsylvania Working Papers in Linguistics

Volume 16
Issue 1 *Proceedings of the 33rd Annual Penn Linguistics Colloquium*

Article 8

2010

The Temporal Indeterminacy of Nasal Gestures in Karitiana

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Abstract

In Karitiana, word-medial nasals occurring between oral vowels may surface as circum-oralized, post-oralized, or completely oralized consonants. For example, the word for ‘thing’ may surface as [ki.'dnda], [ki~.'nda], or [ki.'da]. Interestingly, this surface variation of Karitiana nasals is due to the temporal indeterminacy of nasal gestures in the language, i.e. the duration of velic aperture varies significantly across tokens. This sort of temporal indeterminacy has not been documented for any language in the literature, and similar surface variation of nasal forms in other languages has been shown to result from asynchrony between velic oscillation and oral occlusion. The author provides acoustic data that illustrate clearly the temporal indeterminacy in question. These data were recently recorded and analyzed in the field, and demonstrate conclusively that velic aperture duration is far from constant in the language. This fact contravenes expectations based on the literature, and it remains to be seen if and how it will be handled by contemporary phonological models.

The Temporal Indeterminacy of Nasal Gestures in Karitiâna

Caleb Everett

1 Introduction

In this study I seek to demonstrate that the velic oscillation associated with nasals in Karitiâna is unusual typologically. Primarily, I hope to demonstrate that the duration of velic aperture in the language varies from token to token of a nasal type, even for the same lexical item produced by the same speaker. Previous research on nasals (Beddor, 2007) has demonstrated that velic aperture duration does not generally vary significantly across tokens of the same word, and that this duration is relatively constant for the nasal sounds of a given language. Furthermore, the literature on nasals suggests that the velic lowering associated with nasal consonants is expected to last at least 200 ms (Stevens, 1998) in all languages. This expectation is also not met by the Karitiâna data. In other words, two putatively universal characteristics of nasal consonants are violated in Karitiâna, as evident in the data presented below. Some of these representative data are taken from more comprehensive ongoing work on velic movement in Karitiâna (see Everett, under review).

Before delving into the relevant data on nasality in the language, it is worth considering the phonemic inventory of the language. In Table 1 I present the consonants of the language. Note that there are four nasals. The phonemic status of one of these, the post-alveolar nasal, is somewhat unclear. Landin and Landin (1973) choose to consider this form an allophone of the palatal approximant, with which it is in complementary distribution. Storto (1999) and Everett (2006) consider the post-alveolar nasal phonemic, though it does not participate in the unusual patterns described below. Everett (2008) provides a comprehensive analysis of the three plosives of the language, by presenting a series of locus-equation data for each of the stops in question.

	Bilabial	Alveolar	Alveolo-palatal	Velar	Glottal
Plosive	p	t		k	
Nasal	m	n	ɲ	ŋ	
Flap		ɾ			
Fricative		s			h
Approximant	w				

Table 1: The consonants of Karitiâna.

The vowel inventory of Karitiâna is presented in Table 2. While vowels may be contrasted via length and nasality distinctions, there are few cases in which both length and nasality are used contrastively for the same vowel. (Cf. Storto, 1999 for some examples, however.) In general, the functional load of length is relatively limited. For a comprehensive analysis of Karitiâna vowels, I refer the reader to Everett (to appear), in which normalized acoustic data for a number of speakers are presented.

	Front	Central	Back
High/Close	i		
Close-mid	e	ɨ	o
Low/Open		a	

Table 2: The oral vowels of Karitiâna.

The bilabial, alveolar, and velar nasal phonemes evident in Table 1 have a remarkable variety of surface forms, particularly when occurring between two of the oral vowels evident in Table 2. As evident in the following section, when occurring inter-orally these nasals may surface as post-oralized, circum-oralized, or completely oralized segments. While such a variety of surface forms is uncommon from a typological perspective, I will argue that the motivation for the variety of forms is more noteworthy, as it has not previously been documented in the literature on nasality. Specifically, the variety of surface forms evident in the context considered in depth below is due to the temporal indeterminacy of the velic gestures associated with the nasals in question. This temporal indeterminacy is remarkably wide-ranging, yet is still constrained in one specific way described below.

2 Relevant Production Data

2.1 Basic Distribution of Bilabial, Alveolar, and Velar Nasal Phones

In examples (1)–(4), the variety of nasal phones in question is exemplified. The word in question has one nasal phoneme, which crucially occurs between two oral vowels, the second of which is stressed. Word-level stress in Karitiâna is typically root-final, though there are some exceptions to this pattern (cf. Storto, 1999). The relevance of stress will be returned to below.

(1) [pe.ˈdndot] 'wide' (2) [pẽ.ˈndot] 'wide'
(3) [pe.ˈndot] 'wide' (4) [pe.ˈdot] 'wide'

What we see is that, in the given context, the nasal allophone may be a circum-oralized nasal, a post-oralized nasal, or a plain voiced stop. The first vowel in the word may or may not be anticipatorily nasalized. In a case such as (2), the velum lowers during the production of the preceding unstressed oral vowel, while in (3) the velum lowers synchronously with alveolar occlusion. Crucially, transcriptions (1)–(4) represent tokens produced by the same speaker, in the same social context. Examples (5)–(19) also illustrate the wide range of nasal forms evident in the relevant context. All of these examples were transcribed in the field. It is worth stressing that the variation described in these examples is not simply due to inter-speaker variation, but denotes instead intra-speaker variation. For example, tokens (5)–(7) were produced by a single Karitiâna speaker, and the same holds for (8)–(10), (11)–(13), (14)–(16), and (17)–(19). A total of eight Karitiâna speakers participated in this study.

(5) [a.ˈbmbo] 'to climb' (6) [ã.ˈmbo] 'to climb'
(7) [a.ˈbo] 'to climb'

(8) [a.ˈbmbi] 'house' (9) [ã.ˈmbi] 'house'
(10) [a.ˈbi] 'house'

(11) [se.ˈbmbok] 'wet' (12) [sẽ.ˈmbok] 'wet'
(13) [se.ˈbok] 'wet'

(14) [e.ˈgŋgɨ] 'to vomit' (15) [ẽ.ˈŋgɨ] 'to vomit'
(16) [e.ˈgɨ] 'to vomit'

(17) [ki.ˈdnda] 'thing' (18) [kĩ.ˈnda] 'thing'
(19) [ki.ˈda] 'thing'

Before discussing the variation evident in (1)–(19) in greater detail, it is worth stressing that nasals do not surface in such a wide-ranging manner in all contexts. For example, as we see in (20)–(25), nasal consonants surface as plain nasals, i.e., the velum is lowered throughout their production, when they occur adjacent to a phonemically nasal vowel. As is clear in examples (1)–(19), Karitiâna oral vowels may be *nasalized*. However, such vowels are not phonemically/contrastively *nasal*, as the vowels in (20)–(25) are.

(20)	[ˈnãm]	'rotten'	(21)	[ˈnã-]	verbal prefix
(22)	[ˈẽːm]	'dirty'	(23)	[ˈtõm.tõmã]	'guitar'
(24)	[ˈkĩ.mã]	'dry'	(25)	[mõ.ˈmẽ.mẽm]	'entrance'

In other contexts, the nasal consonants do not surface as plain nasals as in (20)–(25), but also do not surface in the seemingly capricious manner evident in (1)–(19). For instance, when nasals occur word-finally and follow a stressed oral vowel, they surface as pre-oralized nasals only, as in (26) and (27).

(26)	[ˈdʒɨgŋ]	'to stop'	(27)	[ˈɨɾɨ ˈhodn]	'thank you'

When occurring word-initially before an oral vowel, the form of the nasals depends on the place of articulation. Velar nasals tend to surface as post-oralized/prenasal type segments, as in (28)–(30), while bilabial and alveolar nasals tend to occur as plain voiced stops, as in (31)–(33). Demolin, Haude, and Storto (2006) suggest that slight nasalization always occurs in such contexts, even in tokens such as (31)–(33). Regardless, it seems clear that velar nasals tend to occur as clear post-oralized forms more frequently in such contexts, i.e., they exhibit greater prenasalization.

(28)	[ˈŋga]	'field'	(29)	[ˈŋge]	'blood'
(30)	[ˈŋgok]	'manioc'	(31)	[ˈbik]	'to sit'
(32)	[bɨ.kɨ.ˈpa]	'cockroach'	(33)	[de.wo.ˈta]	'side'

The above examples provide a general idea of the sort of variation evident in Karitiâna nasal forms. For more exhaustive lists of examples, I refer the reader to Storto (1999) and Everett (2006). The purpose of the present endeavor is not to provide a complete account of nasalization in Karitiâna. Instead, I would like to focus on the variation evident in tokens (1)–(19), and attempt to demonstrate that these and other similar forms in my data reflect a kind of nasal gesture/velic aperture that has not been documented in the linguistic literature. It is worth stressing that the current work is part of a more comprehensive study on the nasal gestures in question (Everett, under review). For the sake of space, therefore, I will focus in this work on some particularly revealing spectrographic data that highlight the most unique aspect of the nasal gestures in question, viz. their temporal indeterminacy that results in the variety of surface forms in e.g. (1)–(19).

2.2 Acoustic Data Demonstrating Temporal Indeterminacy

Based on transcription data alone, it would be difficult to make the claim that the various forms in (1)–(19) are due to the indeterminacy of velic aperture in the given words. After all, there are other ways to account for the range of word-medial forms in (1)–(19). In theory, it is possible that the nasal gesture/velic aperture associated with such forms is fairly constant, but that the alignment of such gestures with oral occlusion varies according to token. For instance, in the case of the token [pe.ˈdndot] ('wide'), it is possible that the velum lowers later than in the case of the token [pẽ.ˈndot] ('wide'). However, this does not necessarily imply that the velum is lowered for a shorter time in the case of [pe.ˈdndot], since oral occlusion may be longer in this case than in the case of [pẽ.ˈndot]. Analogous claims could be made for all of the forms in (1)–(19), and so these transcriptions alone are not capable of supporting the claim being made here, that the actual duration of nasal gesture/velic aperture varies on an intra-speaker basis. What are needed here are high-quality acoustic data, since such data can be examined for the presence or absence of the correlates of velic lowering, in order to measure the actual duration of nasal gestures in tokens such as (1)–(19).

Recently I made digital recordings of a number of tokens such as those in (1)–(19). Eight Karitiâna speakers, four males and four females, were recorded for this study. Each of these speakers produced carrier frames (cf. Ladefoged, 2003) containing words with nasal consonants occurring after an unstressed oral vowel and preceding a stressed oral vowel. Approximately thirty such tokens were analyzed for each speaker, with each of the three nasal places of articulation equally represented. A total of over 240 tokens were digitally recorded and analyzed, using Praat software (Boersma and Weenink, 2007). The tokens were recorded directly onto a Mac Powerbook laptop at a sampling rate of 44.1kHz, in a nearly soundproof environment in the city of Porto Velho.

Below I present samples of the data that have been analyzed to date. For a more comprehensive, quantitatively-oriented analysis of the results, I refer the reader to Everett (under review). For the sake of space, below I provide some particularly illustrative examples of the findings that have been made so far, as well as a table summarizing the findings.

Prior to considering the data, however, it is necessary to discuss the acoustic correlates of nasalization. While the differences between a nasal consonant and a homorganic voiced stop are clear both impressionistically and acoustically, the differences between oral and nasalized vowels are not always as obvious. Since in this study we are particularly interested in when the velum is lowered and when it is raised, the evidence of velic lowering during the production of a vowel preceding a nasal is quite relevant. Thankfully, there is a robust literature on the acoustic effects of velic oscillation on vowels. Studies such as Ohala and Ohala (1993), Beddor (1993), and Chen (1997) have noted that nasal/nasalized vowels are characterized by a more prominent lower region of the sound spectrum: for instance, there is typically a strong nasal resonant in the range of 200 Hz. Beddor (1993:173) suggests that for such vowels there is a "vowel-independent spectral correlate: the relative prominence or flatness of the low-frequency region of the vowel spectrum." Nasal/nasalized vowels are also typically characterized by wider formant bandwidths, as well as the presence of nasal antiformants.

Given the variety of spectral correlates of nasalization in vowels, there are a number of ways to try to ascertain the temporal characteristics of velic opening in acoustic data. For this study the methods described by Beddor and Onsuwan (2003:1) were employed:

> "The temporal extent of coarticulatory vowel nasalization was measured by inspecting FFT spectra in 10 ms increments throughout the course of the vowel. Offset (or onset) of carryover (anticipatory) nasalization was identified as the last (first) display with a clear low-frequency nasal formant and/or a broadening of F1 bandwidth and lowering of F1 amplitude."

In other words, in order to test when the velum was lowered during a particular token, FFT-based spectra of the token were analyzed at periodic intervals. Once the acoustic correlates of nasality surfaced, either during or after the production of the preceding unstressed vowel, this moment was judged to be the point at which the velum was lowered. The moment at which the velum was raised could also be ascertained from the FFT spectral data, by observing when the acoustic correlates associated with velic aperture disappeared.

All of the tokens recorded were examined in this manner, in order to test for patterns in the duration of velic aperture for the given context. In short, the results suggest that there is no clear pattern to the duration of velic aperture for the given environment. The duration of velic aperture was found to vary on an intra-speaker basis, from token to token of the same lexical item. In the following section I present a table summarizing the findings on duration of velic aperture. Perhaps the most effective way to elucidate the variability in question, however, is to consider a few representative tokens. Figures 1–3 contain spectrograms of the word for 'wide', which is also evident in tokens (1)–(4) above. Since these figures contain spectrograms, it is worth reiterating that the broader findings summarized in section 2.4 were based on the examination of peaks in FFT spectra, rather than the visual and more impressionistic examination of spectrograms. Nevertheless, the acoustic correlates of velic lowering are generally visible in such spectrograms, and for that reason they serve as useful illustrations of the temporal indeterminacy in question.

Figures 1–3 represent three tokens produced by a 23-year-old male. Figure 1 represents the token transcribed in (3), in which velic lowering is nearly synchronous with oral occlusion, as evidenced by the fact that the vowel preceding the nasal does not evince the spectral correlates of velo-pharyngeal coupling. Velic aperture duration is highlighted with a solid rectangle.

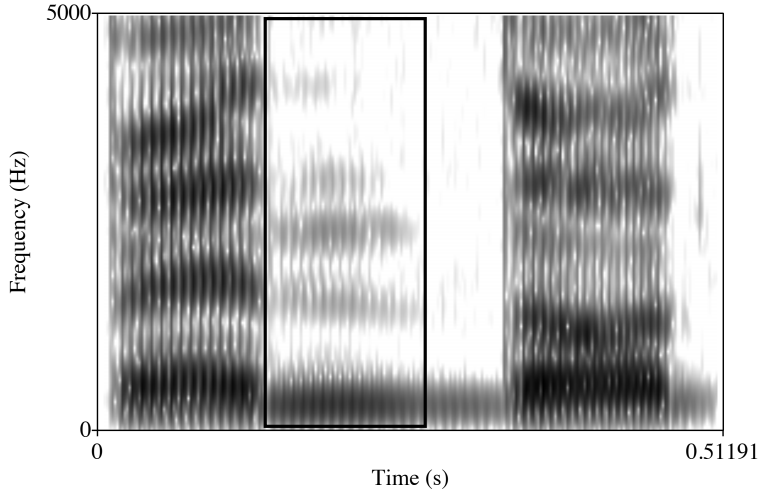

Figure 1: A rare case of synchronous velic lowering and oral occlusion.

In Figure 2, another spectrogram of the same word is presented. In this case the spectrogram represents the token in (2), in which there is anticipatory nasalization of the first vowel of the word. This nasalization is evidenced by the fact that the first and second formants of the vowel are weakened, and their bandwidths are increased, once the velum lowers. As in the case of Figure 1, the duration of velic oscillation is highlighted by a solid rectangle.

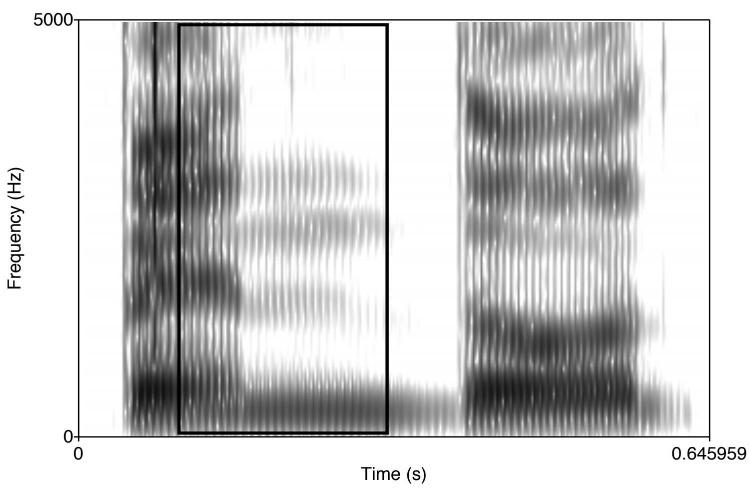

Figure 2: Anticipatory nasalization of an unstressed oral vowel.

Visual inspection of the rectangles in Figures 1 and 2 demonstrates that the length of duration of velic aperture (i.e., the width of the rectangles) varies for the two tokens. This variation is even more apparent in Figure 3, which represents the token in (1) above. In this figure, the duration of velic aperture is significantly shorter than that evident in Figures 1 and 2. To be clear, the duration of the velic oscillation varies across these three tokens, resulting in [pendot] in the case of Figure 1, [pẽndot] in the case of Figure 2, and [pedndot] in the case of Figure 3. The variation between the forms is not simply the result of asynchrony between the nasal gesture and the oral occlusion.

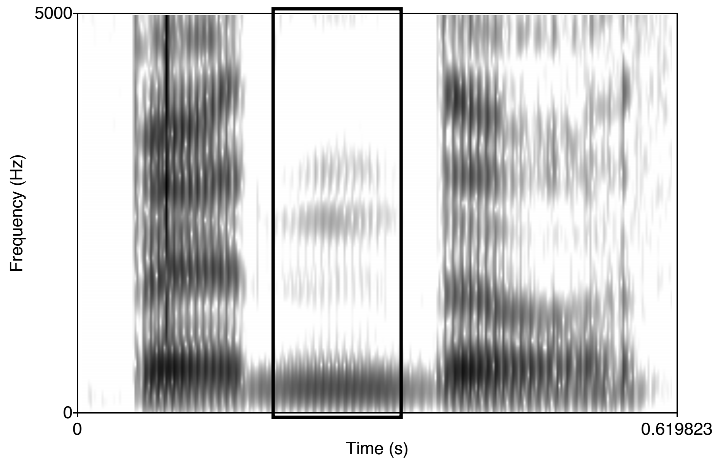

Figure 3: Circum-oralization caused by reduction of velic aperture duration.

The indeterminacy of the relevant nasal gestures is also evident in Figures 4 and 5. These figures contain bars, each of which represents a particular token of a word produced by a Karitiâna speaker. Each bar is based on a spectrogram such as those in Figures 1–3, and represents articulatory gestures (cf. Browman and Goldstein, 1986). This approach to depicting articulatory gestures is adopted from Beddor (2007). Each bar is divided up into smaller segments. The white segment represents the oral portion of the vowel preceding the nasal segment. The hatched segment represents the nasalized portion of the underlying oral vowel preceding the nasal segment. The dark segment represents the consonantal nasal resonant, while the dotted segment represents the period of voiced oral occlusion during which the velum is raised. Finally, the gray segment represents the stressed oral vowel following the nasal consonant.

Figures 4 and 5 allow us to consider the approximate duration of velic aperture for each of the four tokens represented. In each figure, the approximate duration can be found by adding the dark segment of a given bar with the hatched segment (if present), i.e., the duration of the nasal resonant plus the duration of the nasalized portion of the vowel. As we see in the figures, for the tokens represented there is a wide range of durations permissible. In some cases, e.g. the top bar in each figure, the velum is lowered for approximately 150 ms. In other cases, e.g. the bottom bar in Figure 4, the velum is lowered for less than 70 ms. In other cases, e.g. the third bar in each figure, the velum is not lowered at all. Clearly, velic oscillation is temporally indeterminate. This indeterminacy is responsible in large part for the many forms evident in (1)–(19).

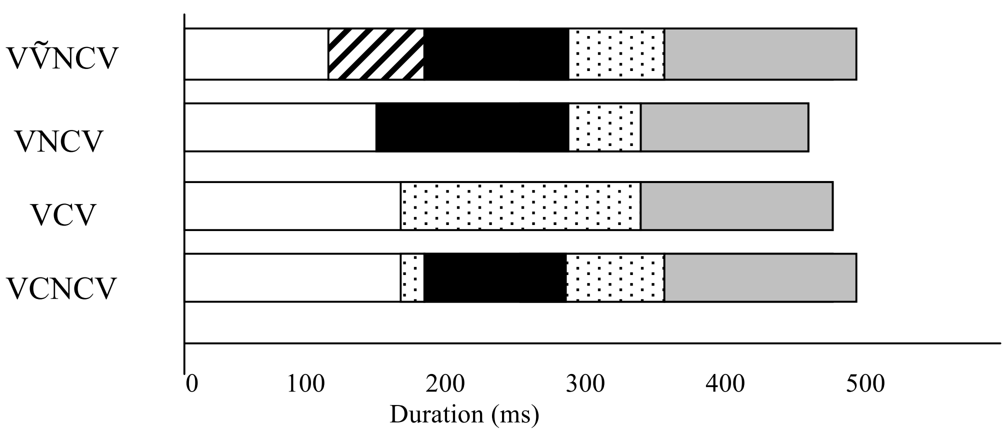

Figure 4: Four tokens of the /omo/ sequence, taken from four productions of the word /korombo/, ‘mouth’, produced by a 23-year-old female.

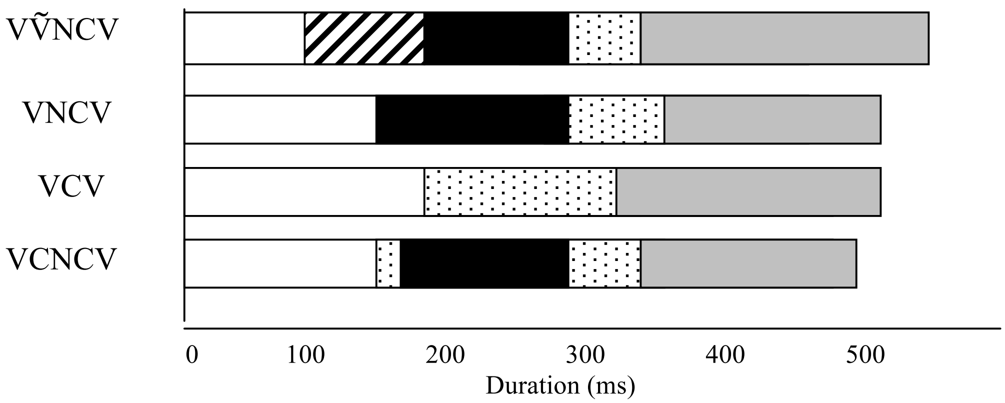

Figure 5: Four tokens of the /ina/ sequence, taken from four productions of the word /kinda/, 'thing', produced by a 22-year-old male.

Figures 1–5 provide strong evidence of the indeterminacy of nasal gestures in the language. Everett (under review) presents a review of the data on a speaker-specific level. For our current purposes, it suffices to note that the indeterminacy surfaced for all speakers in the context tested. There was no significant difference between the three places of articulation, since indeterminacy of nasal gesture characterized bilabial, alveolar, and velar nasals. Other factors such as the presence of a word-final voiceless stop, or the type of preceding vowel, were also not found to interact with the duration of the nasal gesture.

Despite the extreme amount of variation evident in the FFT-based spectra of the relevant words, there was one overriding constraint that surfaced in this study, as in previous studies on the language. Specifically, in the given context the velum must be raised prior to a stressed oral vowel. For example, in Figures 4 and 5 we see that for each of the bars there is always a dotted segment (voiced stop) prior to a gray segment (stressed oral vowel). This constraint is apparently inviolable in the language. Interestingly, tokens such as (26) and (27) suggest that stressed vowels also must be separated from *following* nasals by a segment of oralization. In other words, stressed oral vowels in Karitiâna always occur adjacent to a segment of oralization, when followed or preceded by a nasal segment. Everett (to appear b) suggests that this constraint is the result of the maintenance of the acoustic correlates of stress in the language. Specifically, stressed oral vowels in Karitiâna tend to exhibit more positive spectral tilt and greater displacement in the vowel space. Since vowel nasalization would reduce the salience of both of these correlates, it is apparently militated against by the presence of an intervening segment of oralization. I refer the reader to Everett (to appear b) for a more detailed analysis of this constraint on velic aperture, as well as a contrast of the analysis with a previous attempt (Storto, 1999) to account for the distribution of the relevant nasal forms in the language.

2.3 Summary Data

The surface forms evident in (1)–(19) are typologically remarkable in several respects. While prenasal/post-oralized segments are actually not uncommon in the world's languages (cf. Ladefoged and Maddieson, 1996), the extent of the variety of permissible nasal surface forms in the language is extremely uncommon. Another typologically remarkable facet of the distribution of phonemically nasal consonants in Karitiâna is the fact that they may surface without any nasality, as in (4), (7), (10), (13), (16), and (19). Everett (2006) suggests that the permissibility of such forms may be the result of a sound split in progress, in which nasals in such contexts are coming to be perceived and produced as voiced stops. This claim is largely unsubstantiated at present, however.

While these aspects of the distribution of nasals in the language are remarkable, however, the most remarkable characteristic of nasals in Karitiâna is perhaps less obvious, since it is not amenable to analysis based on transcribed evidence alone and only became evident upon scrutiny of acoustic data. The characteristic in question is of course the indeterminacy of nasal gestures in the language. Despite the aforementioned constraint on nasal gestures, data such as those in figures 1–5 suggest fairly convincingly that Karitiâna nasals, at least in the environment considered, cannot be characterized by constancy of nasal gesture/velic aperture duration. This lack of constancy or indeterminacy has not been attested in the literature on nasality.

As was mentioned above, the duration of velic aperture ranged significantly for each of the eight speakers, and for each of the three relevant nasal sounds. Figure 6 contains a summary of the data. The figure graphically represents the findings for all 240+ word-medial nasal tokens considered for this study. The tokens are classified according to place of articulation as well as duration of nasal gesture/velic oscillation. What we see is that nasal gestures in the given context may not occur at all, or they may occur and last as long as 230+ ms. In other cases, however, the nasal gestures may last less than 80 ms. In most cases, nasal gestures last somewhere between 81–200 ms. This range of durations is still remarkably wide, however. No pithy generalization can be made about the duration of nasal gestures in the given context, aside from the fact that the duration is never between 1–50 ms. The motivation for this restriction is apparently physiological, since the inertia of the soft palate prevents it from being raised and lowered in such a rapid manner.

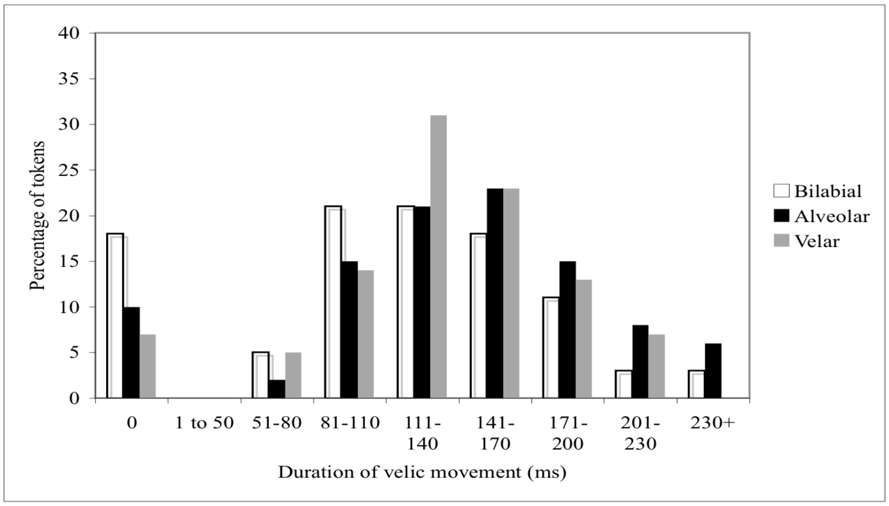

Figure 6: Velic gesture durations according to place of articulation of corresponding nasal.

The data presented above suggest that Karitiâna exploits all of the physiologically possible durations of nasal gestures in the context considered. The velum may not be lowered, or it may be lowered anywhere from 80–200+ ms. Certainly nasal gestures in the language are not characterized by any sort of constancy of velic aperture duration, contrary to any expectations based on findings in other languages.

These data call to mind a conclusion made by Shosted (2006:18), who notes that physiologists have pointed out that humans have relatively little muscle control over the velum, and as a result of this fact "it is difficult to exercise precise control over the particular moments at which nasalization will start and stop during any given utterance." Perhaps as a result of the difficulty of exercising precise motor control of the velum, asynchrony between nasal gestures/velic aperture and oral occlusion may result in a language such as English. (I am not suggesting that difficulty of exercising precise motor control is the only factor, however.) In the case of Karitiâna, difficulty in exercising precise motor control of the velum may help contribute to the temporal indeterminacy of nasal gestures in the context considered. Regardless, what is important in Karitiâna phonology is not the length of velic aperture, but whether or not the velum is raised prior to a following stressed oral vowel. In other words, raising the velum at a particular time is crucial, but lowering it at a particular time (or not lowering it at all) is apparently not so vital. As a result of this fact, inter-oral word-medial nasal gestures in the language are temporally indeterminate.

3 Discussion and Conclusion

Beddor (2007) notes that the temporal characteristics of coarticulatory vowel nasalization, such as that depicted in the top bars of Figures 4 and 5, varies according to a wide variety of factors noted in the literature. These include obstruent voicing and syllable structure, among others. Beddor suggests, however, that in the clearly documented cases of such coarticulation, the duration of velic aperture is actually fairly constant. She notes that variable vowel nasalization typically occurs when velic aperture, which is fairly constant, is not temporally aligned with the production of a vowel in a constant manner. For example, in the English words *can't* and *canned*, the amount of anticipatory nasalization varies. The vowel in the word *can't* is nasalized for a greater portion of its duration than the vowel in *canned*. Similar observations can be made for a number of other word pairs, e.g. *bent* and *bend*, in which the first word of the pair exhibits greater vowel nasalization in terms of duration. Crucially, Beddor's data suggest strongly that the duration of velic aperture does not vary significantly between words such as *can't* and *canned*, or *bent* and *bend*. The fact that the vowels in the voiceless-stop-final words are more nasalized is due to asynchrony between velic lowering and oral occlusion. In other words, in those cases in which the first vowel is more nasalized, e.g. *can't* and *bent*, the velum lowers earlier (but not for longer) than in words such as *canned* and *bend*. In such cases, then, lack of alignment between velic oscillation and oral occlusion leads to variability in the temporal extent of vowel nasalization. The duration of the actual velic gestures is relatively constant across all such words, at least in the coda environments considered by Beddor. The relative constancy of such post-vocalic nasal gestures has been established in several languages with anticipatory nasalization, specifically English, Ikalanga, Thai, and Rwanda.

The data presented above for Karitiâna are particularly interesting in the light of the data in the literature on the constancy of velic aperture duration. These data clearly demonstrate that, at least for the context examined in some depth here, nasal gestures in Karitiâna are characterized by temporal indeterminacy of velic aperture. This indeterminacy is unattested in the literature, but the empirical question of whether it is actually unattested in other languages has yet to be resolved with any degree of certainty. As I suggested above, this interesting aspect of nasality in Karitiâna would likely have been impossible to uncover without careful scrutiny of the acoustic data. For many languages with unusual patterns of nasality, there is little or no quality acoustic data available. There are many interesting patterns of nasality in the sound systems of other South American languages, for example, yet there is a paucity of quality acoustic data. Hopefully, future studies will address this issue and allow us to consider whether temporal indeterminacy of nasal gestures is actually as uncommon or unique as it appears given the current state of the literature. One language that merits further attention, for example, is Kaingang. D'Angelis (1999) presents clear aerodynamic data demonstrating the presence of nasal circum-oralization, pre-oralization, and post-oralization in inter-oral environments in the language. It is unclear, however, whether these patterns are due at all to temporal indeterminacy of nasal gestures in the language. The same could be said for a number of Tupí languages, which are well-known to exhibit interesting patterns of nasality.

Finally, the above data are noteworthy in another respect. Not only do the data demonstrate indeterminacy of velic aperture duration, but they also demonstrate that velic aperture in Karitiâna typically lasts from between 80–200 ms, at least in the context considered in some depth above. Stevens (1998:43, see also Shosted, 2006:17) predicts that the minimum duration of a complete cycle of velic opening and closing, in any language, should last from between 200–300 ms. This expectation is simply not met by the data above, since in the vast majority of cases velic oscillation lasts significantly less than 200 ms, and generally does not approach 300 ms. It should be noted, however, that many of the durations of velic oscillation that can be extrapolated from the data in Beddor (2007) are also shorter than 200 ms. I am not claiming that the data presented above are unique in representing tokens of velic movement lasting less than 200 ms. Nevertheless, such data might cause one to wonder just how short a duration of velic aperture may actually be permitted in a given language.

In conclusion, Karitiâna velic oscillation is less constant and also shorter than one might think possible given the results of previous studies of nasality. The above findings are significant to those interested in the permissible sorts of nasal patterns in language. They may also be of interest to phonologists, and may provide a challenge for algorithmic-like phonological models in which phones are characterized as discrete temporal units. More than anything, it is hoped that such findings demonstrate the continued need for the careful acoustically-oriented documentation of sound systems, particularly of those in field settings that have not previously been examined via such methodologies.

References

Beddor, Patrice. 1993. Perception of nasal vowels. *Phonetics and Phonology 5: Nasals, Nasalization, and the Velum*, ed. M.K. Huffman and R. Krakow, 171–196. San Diego, Calif.: Academic Press.

Beddor, Patrice. 2007. The phonetics and phonology of nasal gestures. Ms., Yale University.

Beddor, Patrice and Chutamanee Onsuwan. 2003. Perception of prenasalized stops. *Proceedings of the XV International Congress of Phonetic Sciences*, ed. M. J. Solé, D. Recasens, and J. Romero, 407–410. Universitat Autònoma de Barcelona.

Boersma, Paul and David Weenink. 2007. Praat: doing phonetics by computer (Version 4.6.16) [Computer program]. Retrieved November 2007.

Browman, C.P. and L. Goldstein. 1986. Towards an articulatory phonology. *Phonology Yearbook* 3:219–252.

Chen, Marilyn. 1997. Acoustic correlates of English and French nasalized vowels. *Journal of the Acoustical Society of America* 102:2360–2370.

D'Angelis, Wilmar Da Rocha. 1999. Gradient versions of pre- and circum-oralized consonants in Kaingang (Brazil*). Proceedings of the XIV International Congress of Phonetic Sciences*, ed. J. Ohala, Y. Hasegawa, M. Ohala, D. Granville, and A. Bailey. San Francisco.

Demolin, Didier, Katharina Haude, and Luciana Storto. 2006. Aerodynamic and acoustic evidence for the articulation of complex nasals. *Revue Parole* 40:235–238.

Everett, Caleb. 2006. Patterns in Karitiâna: Articulation, Perception, and Grammar. Doctoral Dissertation, Rice University, Houston, Texas.

Everett, Caleb. 2008. Locus equation analysis as a tool for linguistic fieldwork. *Language Documentation and Conservation* 2:185-211.

Everett, Caleb. To appear a. Aspects of Karitiâna vowels. *Anthropological Linguistics*.

Everett, Caleb. To appear b. Understanding the adjacency of nasal oralization and stress in Karitiana. *Chicago Linguistic Society 45*.

Everett, Caleb. Under review. Variable velic movement in Karitiâna.

Ladefoged, Peter. 2003. *Phonetic Data Analysis*. Oxford: Blackwell.

Ladefoged, Peter and Ian Maddieson. 1996. *Sounds of the World's Languages*. Oxford: Blackwell.

Landin, David and Rachel Landin. 1973. A preliminary description of the Karitiana phonological structure. *Arquivo Linguistico*. Brasilia: SIL.

Ohala, John and Manjari Ohala. Phonetics of nasal phonology. *Phonetics and Phonology 5: Nasals, Nasalization, and the Velum*, ed. M.K. Huffman and R. Krakow, 225–249. San Diego: Academic Press.

Shosted, Ryan. 2006. The Aeroacoustics of Nasalized Fricatives. Doctoral Dissertation, University of California, Berkeley.

Stevens, K.N. 1998. *Acoustic Phonetics*. Cambridge, Mass.: MIT Press.

Storto, Luciana. 1999. Aspects of a Karitiana Grammar. Doctoral Dissertation, MIT, Cambridge, Mass.

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