PRENASALIZED AND POSTORALIZED CONSONANTS: THE DIVERSE FUNCTIONS OF ENHANCEMENT

W. Leo Wetzels
Universidade Federal do Ceará and *Vrije Universiteit Amsterdam*

Andrew Nevins
University College London and *Universidade Federal do Rio de Janeiro*

We propose that contour nasals come from two principal sources. One source, articulatorily driven, comes from underlying voiced stops, as nasal venting in order to sustain voicing. The other, perceptually driven, comes from underlying nasal consonants, as shielding next to contrastively oral vowels. Although both processes are phonetically well motivated, we argue that the contoured allophones specifically arise in languages in which systemic or phonotactic restrictions allow for easy recoverability of the corresponding underlying segment. Finally, we present a few cases of contour nasals in preconsonantal contexts that seem to be neither venting nor shielding, and suggest that these arise due to place-of-articulation enhancement in clusters. We offer diagnostics for distinguishing nasal venting from shielding and present case studies from South American languages in which understanding such phenomena as enhancement involves analytical commitments to what is contrastive in the language.*

Keywords: contour nasals, nasalization, venting, shielding, enhancement, areal phenomena

1. Introduction. Partially nasal stops (such as [ᵐb][1]) often resist a unified explanation in terms of their phonetic motivation, phonological representation, and phonotactic distribution. The distinction between surface [ᵐb] and [mᵇ] in phonetic terms alone has often proved elusive, and Riehl (2008:288) casts doubt on whether these sounds can ever be cleanly isolated in phonetic terms (though she presents numerous diagnostics for unary segments vs. clusters; in what follows we deal almost exclusively with unary contour segments).

In this article, we contend that progress can be made by focusing not on the phonetic distinction between [ᵐb] and [mᵇ] but purely on the underlying distinctions these reflect: /b/ and /m/, specifically in systems that lack the contrast between these.

What is enhancement? We follow the definition from Keyser and Stevens (2006:33), in which enhancement is recruitment of a noncontrastive feature; for example: 'In a language like English where the feature [anterior] defines a contrast between /s/ and /ʃ/, speakers learn to modify the universal gesture associated with /ʃ/ by adding lip rounding in order to enhance the distinction'. Enhancement is the addition of a noncontrastive feature [F] to enhance a distinction between segments /X/ and /Y/ made otherwise only by a feature [G]. We further show that the availability of enhancement features (e.g. [±voice] among obstruents) may be evaluated not simply in terms of whether a contrast is globally absent in a language, but also in terms of whether it may be restricted to a given context C and used whenever the enhancing feature is not phonologically employed in C.[2] Crucially, therefore, any discussion of 'enhancement' presupposes a commitment to what the contrastive feature is and what the underlying segments are.

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[1] Throughout the article, we use the labial place of articulation to represent the complete series of stops, underlying or derived, that a given language possesses.

[2] Thus, while [±round] is not contrastive among English consonants, it may be among English vowels, but this is not relevant for the employment of enhancement, which is relativized to a natural class of consonants.

In this article, we argue that languages may create prenasalized, postoralized, or other partially nasal contour segments as a way of enhancing other contrasts. Specifically, we argue that SHIELDING involves partial oralization of an underlying /m/ to enhance the orality contrast in an adjacent vowel ([m^{b}a]), and that VENTING involves partial nasalization of an underlying /b/ in order to enhance the voicing contrast of the consonant itself ([^{m}ba]). Moreover, we argue that in some cases, optional postoralization may occur in order to enhance the place-of-articulation contrast inherent to the nasal consonant. In all of these cases, therefore, enhancement involves recruiting a globally or locally noncontrastive feature in order to further improve the realization of a contrastive feature. In venting, noncontrastive nasality may be imposed to improve the realization of the voicing contrast between underlying /b, p/ ([^{m}ba] vs. [pa]). In shielding, noncontrastive orality in consonants may be recruited to improve the realization of a contrast on a neighboring vowel ([m^{b}a] vs. [mã]).[3]

Prenasalization arises as 'self-directed' and articulatorily motivated enhancement, employing noncontrastive nasality in order to enhance underlying obstruent voicing, as found in Maxakalí /ba.i/ → [^{m}baˈi] 'to be good' (see Nevins & Silva 2017, figure 6). Given an analysis in which Maxakalí lacks underlying /m/ (Wetzels 2009), this prenasalization is an instance of enhancement. Unlike the word-initial prenasalized stops, instances of /b, d, ɡ/ between oral vowels in Maxakalí are fully voiced, with a closure duration 60% shorter than that of their voiceless counterparts and with f0 consistent throughout the closure, thereby showing all of the characteristics of ordinary voiced stops. Such venting processes are often distributionally restricted to utterance- or word-initial position, arguably because voicing contrasts are already more limited (if not neutralized) in the coda (see Lombardi 1995 for discussion). Examples of optional prenasalization from Nɨkak, a language without underlying /m/, are presented in §4.2 below. Moreover, when venting also applies to intervocalic voiced stops, it usually does so only in languages that lack intervocalic clusters, including /mb/.[4]

Shielding enhancement, by contrast, sacrifices the integrity of an underlying but noncontrastive nasal in order to enhance a contrastive adjacent vowel, as found in Kaingang /ma/ → [m^{b}a] 'carrying', a language in which /b/ does not exist as a phoneme. Shielding is motivated by the perceptual desideratum of enhancing the orality of a vowel in a language where vowel nasality is contrastive (and hence unpredictable), at the expense of the loss of a completely nasalized realization of a consonant such as /m/. As such, shielding will be the only source for circumoralized stops, such as those of Kaingang, discussed in §4.1 below. Shielding will typically apply more often in codas, where anticipatory nasalization of a preceding vowel would be more likely to otherwise threaten it than in the case of a following vowel (Wetzels 2008, Stanton 2018).

While shielding as a source of nasal contour segments has been previously recognized in languages with an oral-nasal contrast on vowels, why it is not more widespread has often eluded researchers. For example, Stanton's 2018 survey of shielding is entirely composed of data from South American languages, but one may ask why shielding is not even more common and found in, say, Brazilian Portuguese or French, languages with contrastive nasality on vowels, and indeed languages spoken in South America. The answer we provide here, anticipated in Hinskens et al. 1997:17 (see also

[3] Nonetheless, as we discuss below, audibly perceptible nasal venting may in fact also occur in languages that realize a triple /p, b, m/ contrast, though especially in languages with a ban on closed syllables (Riehl 2008).

[4] Thus, even in Solé's 2014 perceptual study of venting, splicing of word-initial venting from Spanish into intervocalic position led to the percept of a cluster.

Rice 1993, Botma 2004, Durvasula 2010), is that shielding as a form of enhancement PRIMARILY ARISES IN LANGUAGES WITHOUT AN UNDERLYING /m, b/ CONTRAST. The argument parallels the phenomenon found in languages without a tense/lax contrast in the mid vowels, where the allophonic realization that is chosen can be left up to context-specific optimizations. Conversely, if a language does have an /m, b/ contrast, shielding is not as easy an option.

Languages with a /p, b, m/ contrast are abundant among the indigenous languages of South America, such as Katukina-Kanamari (Dos Anjos 2011), which contrasts /p, b, m/ in the onset. In the syllable coda, neutralization of voicing and place of articulation (PoA) takes place: /p, t, k, b, d/ > [k] and /m, n, ɲ/ > [ŋ]. The language has no contrastive nasality in vowels. There are neither prenasalized voiced stops nor preoralized nasal consonants: [duːˈhãŋ] 'descend' vs. [nukanaˈna] 'peacock bass', [bak] 'be good' vs. [maˈna] 'search'. Katukina-Kanamari thus exemplifies a language that will have no shielding, as it fails to satisfy the two conditions we identify as necessary: lacking a three-way contrast among /p, b, m/ and possessing a nasal/oral vowel contrast.

The language Kanoê (Bacelar 2004), by contrast, presents a more interesting case of nonshielding, in that it does have an oral/nasal contrast on vowels after oral onsets: /ikwã/ 'horn' vs. /ikwa/ 'cocoon'. This language lacks nonsonorant voiced consonants, contrasting voiceless consonants with nasal ones: /pokuta/ 'gourd' vs. /mokuta/ 'tree, species'. As such, it should presumably satisfy the conditions for shielding: it has a nasal/oral contrast and lacks a three-way /p, b, m/ contrast. After nasal onsets, however, nasality of the following nucleus is optional in Kanoê, without clear cases of an oral/nasal contrast in this position: /tykenene/ > [tɨkenẽnẽ] ~ [tɨkenenẽ] 'butterfly'. Kanoê has mainly open syllables, allowing only falling diphthongs as complex rhymes. Nasal consonants may surface in the syllable coda as a consequence of vowel deletion. Nasalization before a (derived) nasal coda consonant is obligatory: /kani/ > [kãn] 'child', /uromu/ > [urõm] 'jaguar'. Given these facts, we can understand why Kanoê does not use shielding (e.g. *[tɨ.ke.n^{d}e.n^{d}e] or *[ka^{d}n]) to prevent leakage of nasality from nasal consonants onto contiguous oral vowels. The relevant factor that causes shielding is protection of an oral/nasal vowel contrast. But in this case, there is no oral/nasal contrast after nasal onsets and no such contrast before derived nasal codas, and shielding is therefore superfluous as an identifier of the underlying orality of vowels in this position.

Kanoê thus shows the relevance of an oral/nasal contrast on vowels, even if locally defined, for triggering shielding. Consider, moreover, the Northern Nambikwara language Negarotê (Braga 2017), where vocalic nasality is contrastive in stressed syllables only. In stressed syllables with an oral nucleus, preoralization of a nasal consonant in the coda is optional, but very frequent: [(C)V^{b}m] ~ [(C)Vm]. When preoralization does not happen, the oral vowel is still not nasalized. Stressed vowels cannot be nasalized by following nasal consonants, rendering shielding in principle unnecessary. Vowels in unstressed open syllables, however, are optionally nasalized when followed by a heterosyllabic nasal onset, while those followed by a tautosyllabic nasal coda are always nasalized. This means that nasality is not contrastive in unstressed syllables of any type in Negarotê. As expected, shielding codas are never found in unstressed syllables, confirming that shielding-based preoralization is an 'altruistic' orality enhancement of the neighboring vowel when potentially contrastive. Compare, furthermore, Mamaindê, which also belongs to the Northern Nambikwara dialect group and is different from Negarotê in a way that confirms that contrastivity is locally defined for the sake of predicting the occurrence of shielding consonants. Nasality in Mamaindê is contrastive in both stressed and unstressed syllables alike (Eberhard 2009:97), and preoralized shielding consequently applies obligatorily not only in stressed but also in unstressed syllables (e.g. [ˈʔaiː.heᵍŋ.soʔ] 'to always go'; Eberhard 2009:233).

On this view, enhancement is crucially linked to the contrasts found within a language, at times contextually. Our overarching aim in this article is thus to identify a set of conditions that allow for the creation of contour nasals as a way of recruiting noncontrastive features for distinct enhancing purposes: to enhance voicing contrasts in stops, or to enhance orality contrasts in vowels. In addition, we propose that some instances of contour nasals may arise in order to enhance PoA contrasts in nasals. Crucially, however, enhancement depends on an analytic commitment to the set of contrastive segments within a language. We therefore present case studies that can show how one may decide whether a given nasal contour is [ᵐb] or [mᵇ] when they cannot be distinguished by phonetics alone, based on what the underlying contrast is and what contrast is being served in the case of enhancement.[5]

The structure of the article is as follows. We first present an overview of shielding (§2), a phenomenon that creates nasal contour segments in languages that contrast oral/nasal vowels in order to protect this contrast, as observed in Bartholomew 1960, Rivierre 1973, Hyman 1975, Herbert 1986, Michaud et al. 2012, Haudricourt 2017 [1970], and Stanton 2018. We then present an overview of venting (§3), a phenomenon that creates nasal contour segments as a kind of hypervoicing in order to achieve aerodynamic phonation in voiced stops, as observed in Iverson & Salmons 1996 and Piñeros 2003. Both phenomena are exemplified with respect to South American languages. While §3 concludes with a set of diagnostics that can be used to distinguish shielding vs. venting, we contend that viewing these phenomena within the theory of enhancement necessarily involves understanding what the underlying contrasts are within a given language. To this end, §4 is composed of three case studies from South American languages.

The first case, Kaingang (§4.1), a celebrated instance of contour-segment creation, shows the relevance of syllable structure in the distribution of shielding phenomena. It further allows for a comparison within the Macro-Jê language family, in which underlying two-way contrasts between /m/ and /p/, with nasal contour allophones, still typical of Kaingang, may come to be reinterpreted as underlying two-way contrasts between /b/ and /p/, with nasal contours as venting allophones, such as in Maxakalí. The second case, Nɨkak (§4.2), demonstrates a complex set of phenomena acting on underlying voiced stops to produce a range of contour segments. We demonstrate, based on interspeaker variation, that the underlying source of onset contour segments is voiced /b/, and that variation arises between [b] and [ᵐb] due to venting. The third case, Wari' (§4.3), involves contour-segment creation in a language with no nasal vowels and therefore cannot be motivated by shielding. Both in Wari' and in Kaingang, this specific contour segment arises especially in preconsonantal contexts. We thus suggest, based on a comparison with languages of Australia, that the variation that arises between [m] and [mᵇ] may be due to enhancement of PoA cues, as the PoA is clearer in the transition from oral stops to sonorants than from nasal stops to sonorants (Ohala & Ohala 1993, Jun 1995, Boersma 1998).

[5] While the sequencing of features as [+nasal][−nasal] cannot distinguish [ᵐb] vs. [mᵇ], the representational vocabulary afforded in Inkelas and Shih's (2017) Q THEORY, in which segments are subdivided into quantized subsegmental portions, is potentially a formal means to express the difference between prenasalization and postoralization as C(m m b) vs. C(m b b).

We conclude in §5 with a summary of our most important findings and a discussion of areas for future research, including the presence of shielding languages where a three-way contrast is present but clusters are not, and the need for an increased understanding of the role of areal factors in providing the seeds for allophonic variation that may be recruited in enhancement.

2. Shielding. The complementary distribution of [mã] vs. [m^{b}a] has been observed by many scholars as a way of achieving ‘perceptual reinforcement of the orality of a neighboring vowel’ (Hyman 1975:256, 259). The idea is that, in order to prevent the potential contamination of an oral vowel by an adjacent nasal consonant, ‘[s]hielding, or raising of the velum prior to the onset of the oral vowel, prevents coarticulatory nasalization from occurring’ (Stanton 2018:40). Naturally, this potential contamination of an oral vowel by a nasal consonant could occur in any direction, and hence protection of a [−nasal] vowel by sacrificing part of the nasality of a consonant may result in postoralization [m^{b}a], preoralization [a^{b}m], or indeed circumoralization [a^{b}m^{b}a].

The origins of this way of understanding postoralization can be found in work such as Bartholomew 1960 and Rivierre 1973. Haudricourt (2017 [1970]), focusing on the development of prenasalized stops in the Unya dialect of New Caledonia studied in Rivierre’s work, argues that ‘nasal consonants that used to be followed by an oral vowel became prenasalized stops in the Unia dialect’ (p. 2). In fact, Haudricourt seems to contend that the resulting [mb] sounds were phonemic: ‘The distinctive feature which used to be carried by the vowel (oral vowel vs nasal) was transferred onto the second half of the preceding consonant’ (p. 2). However, as data on free variation within our case studies reveals, shielding phenomena often result in [m^{b}], [^{b}m], or [^{b}m^{b}] in variation with [m] (see D’Angelis 1999 for a phonetic study of Kaingang), in a manner that suggests that these are all allophones of an underlying phonemic nasal /m/.

Herbert (1986:201) discusses the Unya case as follows: ‘perceptual factors, viz. the need to preserve a distinction between oral and nasal vowels, may lead to a process whereby nasal consonants become prenasalized stops before oral vowels’. We agree with the spirit of Herbert’s interpretation in considering the shift from nasals to contour segments to be driven by the following vowel, but one of our central goals is to replace the term ‘prenasalized stops’ here with postoralized nasals, per our insistence that shielding specifically involves sacrificing the latter portion of an underlying nasal consonant before an oral vowel.

Similarly, Haudricourt cites Bartholomew’s work on the San Gregorio dialect of Otomi, concluding that ‘[n]asal consonants followed by an oral vowel have been preserved in San Felipe, but have become prenasalized stops in San Gregorio’ (2017 [1970]:3). Again, we might agree entirely with Haudricourt’s description, save for the fact that it became a postoralized nasal, and that shielding before oral vowels specifically involves allophones to be described as [m^{b}], and not [^{m}b].

As the discussion above shows, shielding has enjoyed a long and important tradition in phonological theory, with particular emphasis often in dialect comparison and diachronic developments. However, as evident in the two studies reviewed above, scholars have continued to call the resulting nasal contour segments ‘prenasalized stops’ (e.g. [^{m}b]) even when we would contend that their underlying representation (and thus their allophonic development) is one of a nasal that becomes postoralized (to [m^{b}]). In fact, as noted above, the process of shielding can lead to a wide range of nasal contour segments—not just postoralized nasals but preoralized, or even circumoralized nasals (as have been well known in the literature since Anderson’s 1976 discussion of Kaingang).

Thus, in the Tupi stock, on which there are numerous discussions of the status of 'prenasalized stops', the partially nasalized stops are underlyingly nasal (e.g. postoralized) within some languages in the family (though in others, reanalysis may have happened, as we discuss below for Kaiowá Guaraní). For example, Navarro's 2006 grammar on Old Tupi calls [n^{d}] 'an allophone of /n/' (p. 15) and says 'when a syllable with /m/ or /n/ is followed by a tonic or pretonic syllable without a nasal phoneme, /m/ and /n/ may change into [m^{b}] and [n^{d}], respectively' (p. 16). More broadly within the Tupi stock, consider Munduruku (Picanço 2005:75), where nasal consonants are 'partially oralized syllable-finally following an oral vowel'.

(1) Shielding after oral vowels creates preoralized nasals in Munduruku

/t-írem/	[tírɛ̀^{b}m]	's/he is wet'
/i-kó-n/	[ìkó^{d}n]	'to dig something'
/i-beŋ-beŋ/	[ìbɛ̀^{g}ŋbɛ̀^{g}ŋ]	's/he is full'

Still within Tupi, in Karo, pre-denasalized stops occur 'word-finally after an oral vowel' (Gabas 1989:10–12).

(2) Shielding after oral vowels creates preoralized nasals in Karo

[koˈrɛ^{b}m]	'also'
[ˈkɛ^{d}n]	'to sleep'
[ˈm^{b}ɔ^{g}ŋ]	'to hold'

The examples in 1–2 illustrate that shielding can yield cases of preoralized nasals.[6] What is crucial to understanding the distribution of these contour nasals as a case of enhancement, therefore, is that they necessarily involve underlying nasal segments that occur adjacent to oral vowels in a language with nasal/oral vowel contrasts. The resulting contour segment is thus a perceptually driven phenomenon, and one found widespread throughout South American languages, as recently catalogued in Stanton's 2018 data survey. Stanton's work demonstrates the pervasiveness of shielding and its relation to vowel nasality. The existence of shielding throughout South American languages is widespread in large part, we would contend, because of the widespread existence of oral/nasal contrasts on vowels, and the simultaneous lack of a three-way contrast between /p, b, m/ on consonants. Shielding may also arise in a specific syllabic position where a three-way contrast is suspended. For example, Durvasula (2010) highlights the fact that in Jambi Malay, a laryngeal contrast is found in onsets but not coda positions and preoralizing shielding arises in codas only, and concludes that partially nasalized stops 'are conditioned by the nature of the laryngeal contrast in respective syllabic positions' (p. 106).

Nonetheless, although shielding is a very important aspect of enhancement, we contend that it does not exhaustively explain the distribution of contour segments in South American languages. Instead, in many cases, such segments arise not from the partial oralization of an underlying /m/, but instead from aerodynamic pressures inherent to the successful production of an underlying /b/, to which we now turn.

3. NASAL VENTING. A variety of articulatory mechanisms are often recruited in order to enhance stop voicing. This is because, in order to maintain the airflow through the glottis that is necessary for the vibration of the vocal cords in the production of voiced stops, a difference in air pressure (from high to low) is required between the sub- and supra-

[6] In fact, there is no reason that the oralized portion need remain voiced, if its function is to isolate the preceding vowel from nasality. Indeed, Durvasula (2010:Ch. 3) reports that the voicing in preoralized nasals in Jambi Malay is variable and occasionally voiceless.

glottal areas (Ohala 1983, Westbury & Keating 1986, Piñeros 2003). In the production of obstruents, air pressure quickly builds up in the supraglottal area behind the closure. Without any enhancing gestures being made, vocal-fold vibration cannot be maintained during the complete closure duration of stops. There are several ways in which the equalization of subglottal and supraglottal air pressure can be delayed, such as the laxing of the vocal-tract walls, allowing greater passive enlargement of the supraglottal cavity (Westbury 1983). Similarly, lowering the velum during the closure interval prevents pressure build-up in the vocal tract and allows continuous voicing, which may lead to the production of a plain nasal consonant, unless the velum is raised again before the consonant is released, in which case the resultant consonant has a nasal and an oral phase.

The necessity for secondary gestures to enhance the [±voice] feature is greatest for dorsal stops, for which the area between the glottis and the point of constriction is smallest, while it is less urgent for palatal and alveolar stops and least urgent for labial stops. This may explain why in Chalcatongo Mixtec prenasalization occurs optionally before labials in word-initial position and obligatorily before alveolars and velars. The following examples are from Iverson & Salmons 1996:166–67.[7]

(3) Venting of voiced stops creates prenasalized stops in Chalcatongo Mixtec

[(m)bàʔà]	‘good’
[(m)báʔù]	‘coyote’
[(m)bíʔʒa]	‘nopal’
[ndaʔa]	‘hand’
[ndákɨ]	‘stiff’
[ciŋgi]	‘to curl’
[kwaŋgo]	‘to twist’

Iverson and Salmons’s work points to prenasalization as a kind of ‘hypervoicing: a low-level phonetic phenomenon serving to help maintain a distinction that is otherwise difficult to produce’ (1996:172). The PoA hierarchy, where velar voiced stops are simply not found root-initially, where prenasalization is obligatory before coronal voiced stops, and where prenasalization is optional before labial voiced stops, confirms the aerodynamic character of this process, whereby lower supralaryngeal volume is directly related to the greater difficulty of sustaining voicing (and thereby the need to recruit prenasalization as venting).[8]

Similarly, Piñeros (2003:1189) observes for the Palenquero prenasalization of Spanish loans (limited to word-initial position) that ‘[t]he dorsal voiced stop undergoes the process more often than the coronal voiced stop, which in turn prenasalizes slightly more often than the labial voiced stop’, citing examples such as 4.

(4) Venting of voiced stops creates prenasalized stops in Palenquero

Spanish		Palenquero	
bolsa	>	[ᵐbó.sa]	‘bag’
duro	>	[ⁿ̪d̪ú.lo]	‘hard’
gusano	>	[ᵑgu.sá.no]	‘worm’

Venting is also found in the Macro-Jê language Maxakalí, which features optional prenasalization of initial voiced stops. Although some analyses posit that Maxakalí has un-

[7] Voiced dorsal stops do not occur word-initially in Chalcatongo and are very rare medially (Iverson & Salmons 1996:167).

[8] Other languages of the (eastern) branch of the Otomanguean phylum, to which the Mixtec languages belong, show shielding contours, such as the Amuzgo language, studied in Do Bui 2018.

derlying nasal consonants (e.g. Gudschinsky et al. 1970), plain voiced stops are found intervocalically. Prenasalization is found only optionally in word-initial position (e.g. [$^{(n)}$daˈɪj] ‘clay pot’), and Portuguese words with initial voiced stops are also optionally produced with prenasalization, for example, *garrafa* ‘bottle’ > [$^{(ŋ)}$gahaw] (Nevins & Silva 2017). Word-internal (i.e. intervocalic) prenasalization does not occur. While Maxakalí has nasal harmony transferred from vowels to consonants (Wetzels 2009), the fact that the realization of the initial consonant in this ENTIRELY oral loanword varies between [^{ŋ}g] and [g] is indicative of an underlying oral voiced stop, whose variable pronunciation with prenasalization in word-initial position is a result of the availability of this allophonic nasal contour as a way of enhancing voicing in the absence of a three-way contrast. In short, when within a given position the observed inter- or intraspeaker variation is between [^{ŋ}g] and [g], it is a case of venting, whereas when it is between [ŋ^{g}] and [ŋ], it is a case of shielding.

Venting can also be clearly diagnosed when prenasalized stops arise in languages with morpheme-level nasal harmony in morphemes or words that otherwise are entirely oral. For example, consider Southern Barasano, which has morpheme-level harmony creating all-nasal (5a) or all-oral words (5b). Interestingly, as Flynn (2012:160–61, citing Pulleyblank 1998:97) points out (see also Gomez-Imbert 1997), the all-oral words in 5c show optional prenasalization. There is clearly no shielding source at work here, since the voiced stops are nonnasal. Their prenasalized character is not due to the presence of a contrastive nasal feature in the lexical representation; if there were one, it would spread in harmony. Instead, the presence of prenasalization in such cases is the result of a venting phenomenon found for voiced obstruents in onset position.

(5) Distribution of nasals, voiced stops, and prenasalized stops in Southern Barasano

a. Nasal harmony words

[mãnõ]	‘none’
[mĩnĩ]	‘bird’
[mãh̃ ãŋĩ]	‘comer’
[ŋãmõř̃õnĩ]	‘ear’
[ẽõnõ]	‘mirror’

b. Oral harmony words

[juka]	‘vulture’
[wati]	‘going?’
[wesika]	‘above’
[hikoro]	‘tail’

c. Oral harmony words with prenasalized stops

[^{n}diro]	‘fly’
[wa^{m}ba]	‘come!’
[^{m}ba^{ŋ}go]	‘eater’
[ho^{ŋ}goro]	‘butterfly’
[ta^{m}boti]	‘grass’

As there is no shielding-based motivation for the contour nasals in 5c, we propose instead that the prenasal portion that emerges on the voiced stops is a way of enhancing the voicing contrast in the class of oral stops. Importantly, it is the underlying class contrast that matters; as Flemming (2017) points out, languages like Tümpisa Shoshone (Uto-Aztecan) and the Australian aboriginal Bardi have only voiceless stops, with allophonic intervocalic voicing. Crucially, intervocalic prenasalization does not arise for such cases, because there is no underlying /p–b/ contrast to enhance.

The pattern shown above for Barasano is relevant for an understanding of languages of the Tupi-Guaraní family, such as Kaiowá (Cardoso 2009). Prenasalized stops are found in two environments in Kaiowá: word-initially (6b), and intervocalically as the result of adjacent-triggered nasal harmony (6d). We treat both of these as coming from underlying voiced stops as in 6a—noting that this would potentially constitute a reanalysis of the original Tupi pattern as described above for Old Tupi, Karo, and Mundurukú. Crucially, these word-initial prenasalized stops and intervocalic cases differ in their realizations: as Cardoso (2009:67) states, word-initial instances of [^{m}b, ^{n}d] before oral vowels—by hypothesis, venting—are falling into disuse among younger speakers.

(6) Voiced stops, prenasalized stops, nasals, and nasal harmony in Kaiowá
  a. [surubi] ‘catfish’
  b. [$^{(m)}$bopiri] ‘bat’
  c. [kunũmĩ] ‘boy’
  d. [mã^{n}dɨʤu] ‘cotton’

By contrast, the intervocalic cases that arise from the realization of nasal harmony in [nasal] _ [oral] spans (e.g. 6d above, and [ĩtĩ$^{\text{ŋ}}$gwara] ‘nostril’ from Cardoso 2009:57) show no such variation. Since our focus in this article is on instances of contour nasals that arise from enhancement, we do not analyze any further the latter cases, which are related to the local realization of nasal harmony.[9]

Summarizing thus far, venting, as an articulatorily motivated process, should demonstrate patterning that is distinct from shielding, as listed in the claims below.

(7) Consequences of analyzing prenasalization as hypervoicing
  a. Prenasalized voiceless consonants cannot emerge as the result of venting.
  b. Prenasalized fricatives, including voiced ones, cannot emerge as the result of venting.
  c. When venting is conditioned by place of articulation, we expect prenasalized velars > prenasalized palatals > prenasalized coronals > prenasalized labials (where ‘>’ means ‘more often than’, with obligatory application as the extreme case).
  d. Venting will be more prominent in prosodic domain-initial position than intervocalically, given that cues for the voiced/voiceless distinction are weaker in the former than the latter (Steriade 1997:9).

[9] Interestingly, some Guaraní varieties have fully transparent voiceless stops in nasal harmony (e.g. Paraguayan Guaraní; Walker 1999), suggesting an autosegmental representation that may incur nasal realization on all segments besides voiceless ones, including rhotics, with prenasalization as the realization of stops in [nasal] _ [oral] spans. The literature on the representation of prenasalized stops in languages of the Guaraní family is vast, with some authors assuming underlying voiced stops, and others, underlying nasals or even underlying prenasalized stops. As our focus is on enhancement processes, we restrict our attention to the variability in word-initial venting, for which we assume underlying voiced stops, especially given the optionality documented by Cardoso (2009). Looking at the word-internal distribution of prenasalized stops nonetheless shows a startling degree of microvariation within the family and morphological conditioning of prenasalization. Our conclusion that prenasalized stops may arise due to local conditioning of /b/ in [nasal] _ [oral] environments is based on varieties such as Kaiowá (as described in the text) and Aché (Roessler (2008:46), who assumes underlying /b/ plus local conditioning of prenasalization); such a process can even sometimes be found to affect underlying VOICELESS stops, for example, /ava + k^{w}e/ > [avaˈk^{w}e] ‘man + PL’ vs. /kũɲã + k^{w}e/ > [kũɲãˈ$^{\text{ŋ}}$g^{w}e] ‘woman + PL’ in Mbyá Guaraní (Thomas 2014:85) and Nhandeva Guaraní (Costa 2007:97). Future work on microcomparison of the factors governing word-internal distribution of prenasalized stops from voiceless sources, and of the degree of postnasal voicing (Walker 1999:86, Hayes & Stivers 2000), could be very helpful in determining whether distinct representations govern this variation.

The properties above are necessary consequences of venting being a strategy for hypervoicing obstruents. Voiceless obstruents (7a) do not possess the aerodynamic conflict of voiced stops, which require pressure differential in the supralaryngeal cavity to sustain voicing. Voiced fricatives (7b), while they might benefit from venting to sustain voicing, would suffer a decrease in pressure behind the oral constriction which would then reduce the airflow necessary to produce turbulence at the constriction site, and therefore prenasalized fricatives, often avoided where otherwise expected (Padgett 1994), cannot be the output of enhancement. Finally, the need for this kind of venting is inversely proportional to the supralaryngeal volume, which derives the place hierarchy (7c). This discussion, in turn, allows us to develop a set of clear phonological indicators of whether a given nasal contour is the result of shielding or venting. Finding a nasal contour in a language without an oral/nasal contrast on the vowels rules out shielding. Finding a postoralized or circumoralized nasal consonant rules out venting. Syllable structure is relevant as well: coarticulatory nasalization that would threaten the orality contrast in a vowel is more likely in anticipatory than perseveratory contexts (Kawasaki 1986; Cohn 1990:147: 'it may well be the case that anticipatory nasalization is perceptually more salient than carryover nasalization').[10] In fact, Kawasaki (1986:95) argues that vowels are even more nasalized before devoiced nasal consonants, and more generally that the weaker the nasality is within a consonant, the stronger the perception of nasality of an adjacent vowel. In this connection, it is interesting to consider the fact that in a wide range of South American languages, coda nasals are unreleased (see e.g. Singerman 2016). Assuming that unreleased nasals in coda position have a weaker percept of nasality and Kawasaki's observation that adjacent vowel nasalization is even stronger next to weak nasals, it becomes all the more imperative to produce preoralized shielding in a coda.

(8) Distinguishing shielding vs. venting
  a. /m/ undergoing shielding: only when there is a nasal/oral vowel contrast
  b. /m/ undergoing shielding: can yield preoralization, postoralization, circumoralization
  c. /b/ undergoing venting: found only in the onset, often limited to prosodic domain-initial position, may vary depending on place of articulation
  d. /m/ undergoing shielding in the onset implies shielding in the coda
  e. /m/ undergoing two-sided shielding (circumoralization) implies shielding in the coda and in the onset

Shielding is inherently related to oral/nasal vowel contrasts and can thereby yield partial oralization on either or both sides of the nasal consonant. Venting, by contrast, as enhancement of voicing, is often limited to domain-initial position (as opposed to intervocalically) precisely because voicing contrasts are more weakly cued in the former (see Steriade 1997), and it is limited by the kinds of aerodynamic factors that require increased voicing enhancement discussed above for Chalcatongo Mixtec.

While shielding languages always contrast oral and nasal vowels and typically do not contrast /b, m/, nasal venting shows a broader distribution, since it is found as a strategy for voice enhancement in /p, b, m/ languages, such as in the Mixtec languages Chalca-

[10] Jeong (2012) provides a discussion of crosslinguistic differences in the direction of nasal coarticulation on vowels, ultimately concluding through an AXB perception experiment that anticipatory coarticulation is more easily perceived than carryover coarticulation. Baraúna and Picanço (2017) mention two languages, Anambé and Asuriní, that have shielding in onsets but not in codas. However, Anambé lacks coda nasals altogether, and Asuriní has 'poucos casos' ('few cases') of nasals in codas (p. 152).

tongo or Jicaltepec (Bradley 1970), with contrastive nasal vowels, and other Mixtec languages without such a contrast, like Peñoles (Daly 1973). Furthermore, in Riehl's (2008) study of Oceanic languages, prenasalization of voiced stops is common in /p, b, m/ languages. However, as Riehl observes, Oceanic languages that show prenasalization typically have a CV syllable structure, not allowing consonant clusters, a characteristic they share with the aforementioned Mixtec languages.[11]

Since prenasalization is part of a larger set of enhancement strategies for stop voicing, one would not expect it to be limited to languages without contrastive /m/. Indeed, velum leakage was identified as a 'voice-initiating' gesture in Spanish by Solé and Sprouse (2011), and in French by Solé (2018). These authors' instrumental studies of Spanish and French, alongside Mahecha's analysis of Nɨkak (see §4.2 below), suggest that properties of prenasalization tend to be similar across languages in showing variation among speakers for degree and duration of velum leakage. As a voice-enhancing strategy, prenasalization is used more frequently utterance-initially than intervocalically, and more often in unstressed than in stressed syllables. It is striking nevertheless that perceptually salient nasal leakage is more commonly found in languages that have either no /b, m/ contrast, or no medial clusters, or neither of these properties. For many South-American languages, including Maxakalí, Nɨkak, Puinave, and the Mixtec languages, utterance-initial prenasalization, although variable, is easily detectable by ear,[12] and, especially in languages in which intervocalic voiced stops are not spirantized such as Southern Barasano, clearly noticeable nasal venting may also occur intervocalically. Contrariwise, in French and Spanish the prenasalization of voiced stops, which is restricted to utterance-initial position, is hardly audible, if at all.[13] We therefore speculate that the lack of a /b, m/ contrast, as well as the absence of intervocalic clusters, facilitates the recoverability of the underlying monosegmental source of prenasalized voiced stops in utterance-initial and intervocalic positions, and therefore allows more extreme degrees of nasal leakage than in languages without these phonemic or phonotactic characteristics.

Summarizing more broadly, in many cases where there are nasal contours, given the inconclusiveness of the phonetic distinction between postoralized nasals and prenasalized stops crosslinguistically and a range of interacting phonological processes in the language, detailed analytic discussions of the phonology of the language are needed in order to decide whether the underlying contrast is one of /p, b/ or /p, m/. To be clear, therefore, our claim is not that shielding explanations for pre- or postoralization are incorrect, but rather that they do not exhaust the entire panorama of where contour nasals come from. In languages with no underlying nasal consonants, contour nasals must come from articulatorily driven venting of voiced stops. Crucially, however, to decide what the underlying inventory is requires detailed investigation of patterns throughout the language. We therefore proceed to exemplify three case studies, where interindividual variation, intraindividual variation, nasal harmony, and analytic decisions about syllable structure interact with diagnosing and understanding enhancement effects.

4. Case studies. In what follows, we demonstrate how this view of enhancement depends on understanding the representation of contrast (and hence what the underlying

[11] The Mixtec languages mentioned above do allow for a limited set of complex onsets, but have no codas, except for the glottal stop.

[12] As Monica Macaulay (p.c.) points out, audible salience of prenasalization is also found in Chalcatongo Mixtec.

[13] We thank Maria-Josep Solé (p.c.) for confirming the qualitative difference in audible perceptibility of prenasalization in the South American cases mentioned in the text vs. those that consistently require instrumental confirmation, such as French and Spanish.

system is) within the language, and we present case studies where evidence needs to be analytically considered to show what the relevant contrasts are.

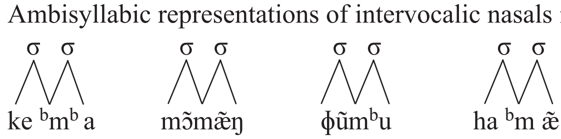
4.1. Kaingang: shielding by /m/ within tautosyllabic contexts. The Kaingang phonemic system, well known in the literature since Anderson 1976, distinguishes a series of voiceless and nasal consonants, the latter represented by a set of allophones containing the plain nasal [m], preoralized [^{b}m], postoralized [m^{b}], and circumoralized [^{b}m^{b}], which we refer to as the /m/ class (see Storto 1999 for a similar distribution in the Tupi language Karitiana).[14]

(9) Allophones of underlying nasals in Kaingang

a.	# _ Ṽ	[m]	[mãn]	'hold'
b.	Ṽ _ #	[m]	[ŋãm]	'break'
c.	# _ V	[m^{b}]	[m^{b}a]	'carrying'
d.	V _ #	[^{b}m]	[kɨ^{b}m]	'cut'
e.	Ṽ _ Ṽ	[m]	[mɔ̃mæ̃ŋ]	'fear'
f.	V _ V	[^{b}m^{b}]	[ke^{b}m^{b}a]	'try out'
g.	Ṽ _ V	[m^{b}]	[kẽm^{b}e]	'tobacco'
h.	V _ Ṽ	[^{b}m]	[ha^{b}mã]	'listen'

Kaingang has an oral/nasal contrast on vowels. Plain nasal consonants emerge in nasal syllables. The allophones of the /m/ class always surface as contour segments when tautosyllabic with an oral vowel, as argued in Wetzels 2010. However, given the circumoralized nasals, for this generalization to hold, it must be the case that intervocalic nasal consonants are ambisyllabic geminates (and indeed, in the tokens we have recorded, they are up to twice as long as word-initial nasals).

(10) Ambisyllabic representations of intervocalic nasals in Kaingang



The plausibility of the syllable divisions proposed above is confirmed by (i) the fact that the preoralized variants of the nasal consonants are typical coda variants, (ii) circumoralized variants occur exclusively in languages with preoralized variants in the coda,[15] and (iii) [bm] does not exist in South American indigenous languages as an alternant of /m/ word-initially or syllable-initially before oral vowels. Wiesemann (1964: 311), discussing length in Kaingang, states that 'stressed-syllables are long, unless followed by the [bm] or [bmb] allophones of nasal consonants'; on an interpretation of open-syllable lengthening this would confirm that preoralized nasals involve a coda syllabification, in addition to an onset to the following syllable.

We note that for some realizations of [bmb] sequences, D'Angelis (1999) reports that the preoralization phase is shorter and more variable than the postoralization phase. This

[14] Unless otherwise noted, all of the Kaingang examples provided below were recorded with Dr. Márcia Nascimento Kaingang, a native speaker from Nonoai, Brazil. Sound files for all tokens discussed in this section are available as supplementary material accompanying this article (available online at http://muse.jhu.edu/resolve/55).

[15] Harakmbut (Van linden 2019) is an unclassified Peruvian Amazonian language that has shielding variants [m^{b}] and [^{b}m] of /m/, but not [^{b}m^{b}]. Morpheme-finally, however, only /n/ is possible, and there are also suffixes starting with /n/. As a result, for /n/ the /n + n/ geminate sequence comes out [dnd], always across morpheme boundaries, combining a coda plus an onset; for example, /ˈwa-min-na/ 'NMLZ-tall-FOC' is realized as [ˈwam^{b}i^{d}n^{d}a] (Van linden, p.c.), in a manner parallel to the ambisyllabicity proposed for Kaingang circumoralization.

would be expected, however, if ambisyllabicity is occasionally optional, and an intervocalic nasal will always be syllabified as an onset, given the ONSET MAXIMIZATION PRINCIPLE (Îto 1986). If this intervocalic nasal is optionally geminated, creating a coda for the preceding syllable as well, the tautosyllabic condition will then incur preoralization. This particular analytic issue does not even arise in the tokens we have recorded (e.g. [ke^{b}m^{b}a]), where the preoralized portion is of equal duration to the postoralized portion.

Kaingang is clearly a case of shielding, as the prenasalization of voiced consonants in nasal venting languages is often optional and often restricted to word-initial position, or its variable nature is influenced by the stressed/unstressed distinction and possibly sensitive to the PoA hierarchy. The occurrence of medio-nasalized consonants is unheard of in nasal venting languages. As is typical for languages lacking the /b, m/ contrast, analysts diverge regarding the question of the feature definition of the underlying consonant system. Since only nasal targets develop shielding variants, we propose the underlying consonant system in Table 1.

	LABIAL	CORONAL		DORSAL	GLOTTAL
		[+ANT]	[−ANT]		
VOICELESS	p	t		k	ʔ
NASAL	m	n	ɲ	ŋ	
CONTINUANT	ɸ		ʃ		h
RHOTIC		ɾ			

TABLE 1. Proposed underlying consonant inventory of Kaingang.

As observed above, plain nonsonorant voiced consonants do not occur in Kaingang. In fact, the word *padre* from Spanish is adapted as [pa$^{(d)}$n^{d}eɾ]—with no possible realization of plain [d] intervocalically, and with restructuring to avoid the [dɾ] cluster. Further evidence for shielding as the motive for partial oralization comes from coda consonants that cannot be syllabified as an onset, as in the following words.

(11) Preoralized nasals in Kaingang coda position[16]

a.	[ka^{g}ŋ.je]	*[ka^{g}ŋ^{g}je]	'tie'
b.	[mə̃n.jɔ.ka]	*[mə̃n^{d}jɔ.ka]	'manioc' (cf. Port. *mandioca*)
c.	[jɔ^{g}ŋ.jɔ]	*[jɔ^{g}ŋ^{g}jɔ]	'parrot'
d.	[pãŋ.ja]	*[pãŋ^{g}ja]	'right'

In Kaingang, only /ɾ/ can be the second consonant of a complex onset, and it can combine only with /m, p, ŋ, k/ by virtue of the phonotactic constraint $*_{\sigma}[C_{[+cor]}\ C_{[+cor]}$, which prohibits the combination of coronal consonants. The words above show that the mere adjacency of an oral sound is not a sufficient condition for the emergence of an oral phase on the right side of the nasal consonant. Thus, the sequence /NjV/ does not cause postoralization, because it necessarily triggers a heterosyllabic division. Shielding occurs only with tautosyllabic oral vowels. In a sequence like [nĩŋ^{g}ɾu] (< /nĩŋɾu/) the /ŋɾ/ cluster is tautosyllabic with the oral vowel of the second syllable, whereas in a word like [jɔ^{g}ŋ.jɔ] (< /jɔŋ.jɔ/), /ŋ/ is fully contained as a coda in the first syllable.

The relevance of syllable structure is equally visible in words that contain an intervocalic [coronal] + /ɾ/ sequence. Compare the words with intervocalic coronal clusters in 12a–b with those containing intervocalic [dorsal] + /ɾ/ clusters in 12c–d.

[16] Of all the vowels within Kaingang, the realization of the nasal vowel /ã/ varies regionally and dialectally (and even related to idiolectal factors such as one's clan and pragmatic 'diminutive/augmentative' usage) between [ə̃, ã, æ̃]; see D'Angelis 2007.

(12) Lack of postoralization in Kaingang [coronal] + /ɾ/ clusters

a.	/kikaɲɾɔ/	[kikaʲɲᵊɾɔ]	*[kikaʲɲʲɾɔ]	'know'
b.	/ĩnɾa/	[ĩnᵊɾa]	*[ĩnᵈɾa]	'to the house'
c.	/ŋɾiŋɾen/	[ŋᵍɾiᵍŋᵍɾeᵈn]	*[ŋᵍɾiᵍŋɾeᵈn]	'dance'
d.	/nĩŋɾu/	[nĩŋᵍɾu]	*[nĩŋɾu]	'claw'

Coronal stops are not allowed to combine with /ɾ/ to make a well-formed word-initial onset in Kaingang. When [coronal] + /ɾ/ clusters occur intervocalically as in 12a–b, we expect these to straddle syllables. As syllable structure is indeed relevant for the distribution of the different allophones of the nasal consonants, an oral vowel following an {n, ɲ} + /ɾ/ sequence does not trigger the emergence of a postoralized nasal stop. By contrast, the dorsal nasals in 12c–d are ambisyllabic, with consistent postoralization (and accordingly preoralization, depending on whether the preceding vowel is oral or nasal).

Independent evidence for the fact that /ɾ/ is not part of a complex onset in 12a–b comes from the specific phonetic properties of /ɾ/. Kindell (1972:203, n. 4) states: 'A transitional vocoid of central quality occurs preceding the phoneme /r/ when the /r/ occurs syllable initial following /n/ or /ñ/, or word initial'.[17] This vocoid is excrescent, oral, and not tautosyllabic with the preceding nasal. It is thereby exempt from the need for shielding before it. According to Kindell, a prevocalized [ᵊɾ] opens the syllable after a coronal nasal consonant, which means that [coronal] + /ɾ/ clusters are heterosyllabic. An equivalent way of stating the distribution of the [ᵊɾ] allophone is to say that it occurs syllable-initially, except when preceded by a word-internal vowel. Again, therefore, when the tautosyllabicity condition is not met, the nasal consonant remains unaffected. Kindell's impressionistic detection of the different degrees of preoralization in /Cɾ/ clusters is confirmed by the acoustic images below, where heterosyllabic /n.ɾ/ [n.ᵊɾ] and tautosyllabic /mɾ/ [mbɾ] are compared. As the spectrograms show, there is slight preoralization of tautosyllabic /ɾ/ in [mbɾo] (Figure 1), while the prevowel of syllable-initial /ɾ/ in [ĩnᵊɾa] is twice as long (Figure 2).

In Kaingang, oralization of nasal consonants is determined by syllable structure, with intervocalic nasals, the only consonants in Kaingang allowed to appear in both onset and coda position, functioning as ambisyllabic geminates. Kaingang oralization of nasal consonants, which is systematic and largely obligatory, never leads to full oralization. The oralization of partially oralized nasals is therefore interpreted as enhancement of underlying nasal consonants that sacrifice part of their identity, still noncontrastively, in order to preserve the contrast present in a neighboring vowel between [±nasal] vowels. In §4.3 below, we briefly return to the question of nasal contours inside Kaingang onset clusters, for which a shielding explanation is less obviously available (as the following rhotic is not contrastively [±nasal]). In §5 we consider the historical evolution of the consonant system of Maxakalí, which belongs to the same linguistic stock as Kaingang, but where plain voiced stops contrast with voiceless stops in the onset of oral syllables, with optional prenasalization restricted to word-initial voiced stops; Maxakalí therefore represents a case of venting, not shielding.

4.2. NɨKAK: VENTING OF /b/ AND SHIELDING BY [m]. We turn to a case study that again illustrates the relevance of syllable structure. Nɨkak, a language that is part of the Nɨkak-Kakua language family, is spoken in the Amazon region of the department of Guaviare, Colombia. Mahecha (2019) proposes the consonant system in Table 2, with a two-way underlying distinction between voiceless and voiced stops.

[17] We reproduce this use of the typescript /r/ in the quotation, although the Kaingang rhotic is a tap.

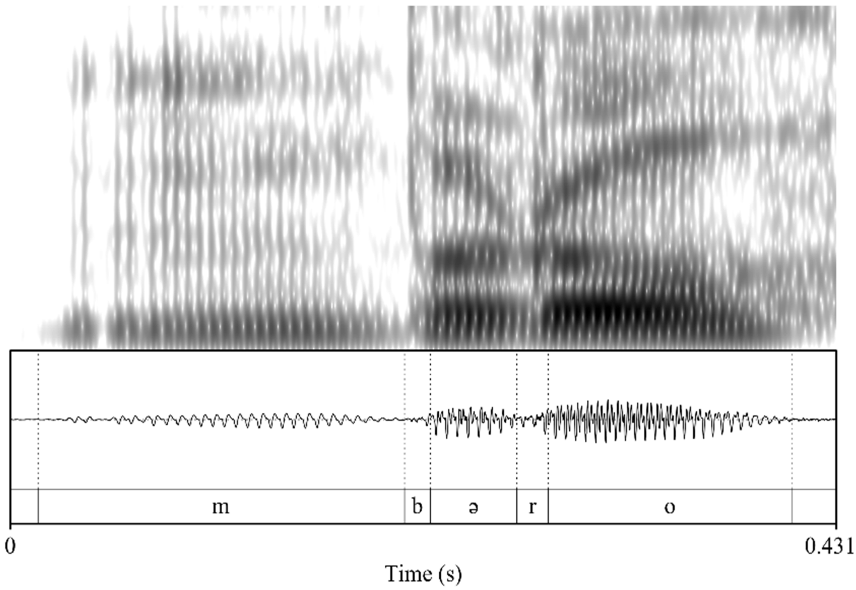


FIGURE 1. Kaingang /mɾo/ [mbɾo] 'float' with a prevocalization duration of 45.2 ms.

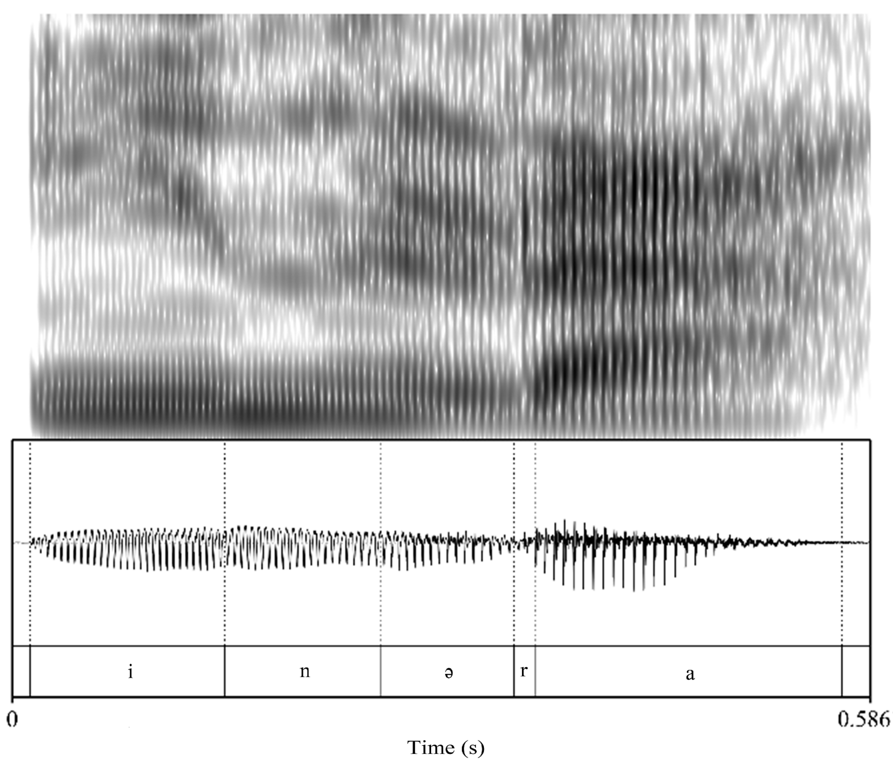


FIGURE 2. Kaingang /ĩnɾa/ [ĩnᵊɾa] 'to the house' with a prevocalization duration of 91.2 ms.

Nonglottalized voiced consonants have plain nasal, plain voiced, and pre- and post-nasalized allophones, except for /g/, which is not allowed word-initially and therefore

LABIAL	CORONAL		DORSAL	LARYNGEAL
	[+ANT]	[−ANT]		
p	t	c	k	ʔ, h
b	d	ɟ	g	
bˀ	dˀ		gˀ	
w	ɹ			
wˀ				

TABLE 2. Proposed consonant inventory of Nɨkak (Mahecha 2019).

lacks the prenasalized allophone [$^{\text{ŋ}}$g], and /ɟ/, which is vocalized in the syllable coda and therefore has no preoralized exponent [$^{\text{ɟ}}$ɲ]. Nɨkak is a tone language, with morpheme-level nasal harmony, except for the voiceless stops, which may occur in either morpheme type.

We show the distribution of nasal vs. oral consonants in the examples below, where morpheme-final ~ marks morpheme-level nasality,[18] a tilde under a vowel marks creaky voice, an acute accent marks high tone, and a circumflex ˆ marks a falling tone. The underlying forms shown presuppose a /p, b/ contrast, where autosegmental nasal harmony (arguably determined by a specification on vowels within a word) turns all voiced elements into their [+nasal] counterpart. All examples come from Mahecha's 2019 dissertation.

(13) Distribution of nasal, oral, prenasalized, and preoralized allophones in Nɨkak

a. [m, n, ɲ, ŋ]: in nasal morphemes

/bêb~/	[mɛ̃̂m]	'you (2nd person singular pronoun)'
/kadaʔ~/	[kãnãʔ]	'corn'
/ɟɨ́ʔ~/	[ɲɨ̰̃̂ˑʔ˺]	'swamp'
/tágap~/	[tã́ŋãp˺]	'caterpillar (species of)'

b. [b, d, ɟ, g]: intervocalic in oral morphemes

/pɨbɨp/	[pɨbɨp˺]	'owl (species of)'
/téde/	[téde]	'beetle (species of)'
/puɟú/	[puɟú]	'cotton'
/tigiʔ/	[tigḭʔ˺]	'ant'

c. [$^{\text{(m)}}$b, $^{\text{(n)}}$d, $^{\text{(ɲ)}}$ɟ]: word-initially in oral morphemes

/bɨ́ɹɨp/	[$^{\text{(m)}}$bɨ́ɹɨp]	'basket'
/diwi/	[$^{\text{(n)}}$diwi]	'snake'
/ɟibiʔ/	[$^{\text{(ɲ)}}$ɟibiʔ]	'mosquito'
*/g…/	*[$^{\text{(ŋ)}}$g…]	

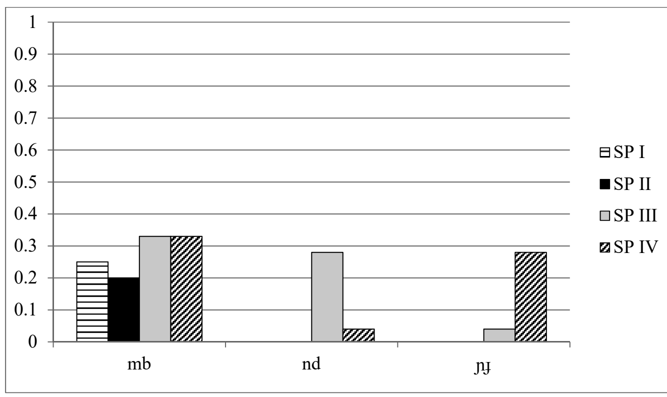
d. [$^{\text{b}}$m, $^{\text{d}}$n, $^{\text{g}}$ŋ]: word-finally in oral morphemes

/hib/	[hi$^{\text{b}}$m]	'walk'
/ɟad/	[ɟa$^{\text{d}}$n]	'spouse'
	*[$^{\text{ɟ}}$ɲ]	
/híg/	[hí$^{\text{g}}$ŋ]	'tie up'

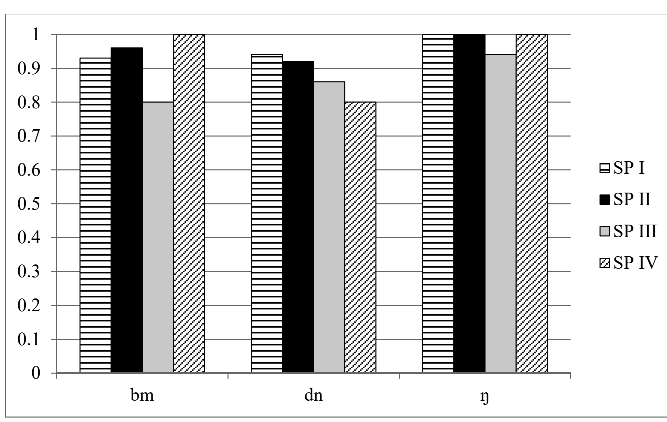
Glottalized nasal consonants, which are overall rare, have a limited distribution. They do not occur in the onset of oral syllables. They do appear as glottalized nasal consonants in nasal syllables and, only for /bˀ/ and /gˀ/, in the coda of oral syllables, where they may realize a shielding variant [$^{\text{b}}$mˀ, $^{\text{g}}$ŋˀ]: /ɟábˀ/ [ɟá$^{\text{b}}$mˀ] 'deny'; /cígˀ/ [cî$^{\text{g}}$ŋˀ] 'rat'.

[18] Nasal harmony is indeed morpheme-bound, as an oral morpheme sandwiched between two nasal morphemes remains oral: [mĩ=ˈbéh-nɛ̰̃́ʔ] (3SG.F=go-DUR) 'she is going'.

The frequency of use of partially nasalized consonants in oral morphemes varies widely among speakers, as well as by PoA. Figure 3 summarizes the measurements performed by Mahecha for four Nɨkak speakers (two male, two female; speakers I–IV), who pronounced twelve different words, six of which contained the voiced consonants licensed in the word-initial onset (two for each of three possible PoAs) and six of which presented the subset allowed in the syllable coda (two for each of three possible PoAs). Words were recorded in isolation, and durations of nasal and oral portions were then measured in Praat (Boersma & Weenink 2017). Figure 3 shows the average length of the initial phase as a proportion of the total length of the consonant in both contexts.



a. Proportion of nasal portion in onset for Nɨkak: speakers I–IV.



b. Proportion of nasal portion in coda for Nɨkak: speakers I–IV.

FIGURE 3. Preoralized and prenasalized phases across four Nɨkak speakers.

In terms of the patterns across speakers, speakers I and II pronounce plain voiced stops [d, ɟ] in the onset and realize a very short oral phase for the labial and coronal PoA in the coda, where the velar PoA appears as a plain nasal [ŋ]. Speaker IV pronounces plain nasal [m] and [ŋ] in the coda. Only speaker III realizes contour variants for all eligible consonants in the onset and in the coda, with the initial phase being very short for the palatal consonant in the onset and for the velar consonant in the coda. In terms of patterns across PoAs, labials show the greatest degree of prenasalization, whereas all PoAs show similar degrees of shielding in the coda (with velars the least amount of preoralization, perhaps because of the increased aerodynamic difficulty in producing coda [ɡ]).

The acoustic image of an utterance-initial voiced stop of the word /dab/ [ⁿdam] 'unripe' provided in Figure 4 shows perceptually salient prenasalization.

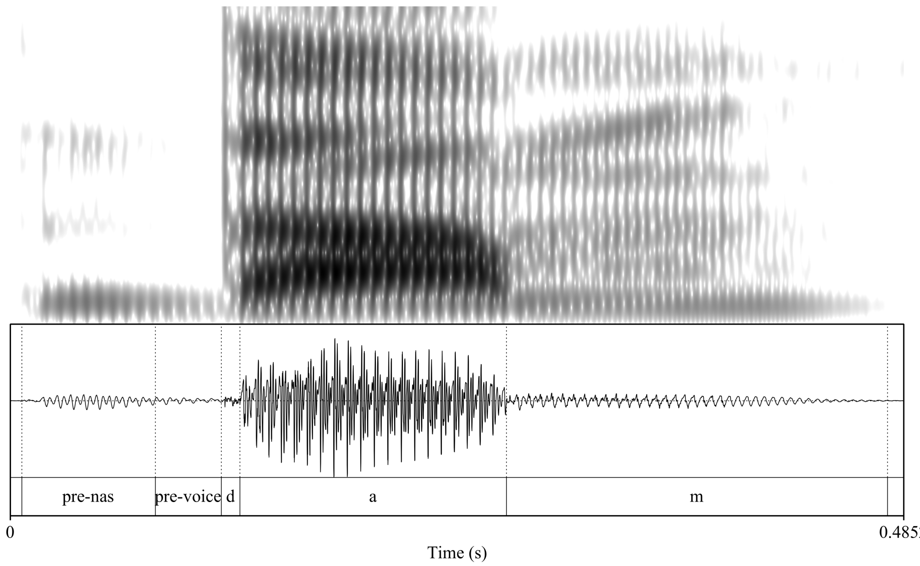


FIGURE 4. Nɨkak /dab/ [ⁿdam] 'unripe'.

Summarizing, in Nɨkak, the NASAL CONTOUR SEGMENTS IN ONSETS ALTERNATE WITH PLAIN VOICED STOPS. In word-internal onsets between oral vowels, only nonsonorant voiced stops are realized, instead of nasal consonants. By contrast, in the CODA of oral syllables, PREORALIZED CONSONANTS ALTERNATE WITH NASALS (and not voiced stops). This suggests that, in oral morphemes, the underlying series of voiced stops realize two main variants at the output of the lexical phonology of Nɨkak: plain voiced stops in the syllable onset and plain nasal consonants in the coda. The onset [b] and coda [m], both deriving from underlying /b/, can nonetheless undergo venting and shielding, respectively, though venting again occurs only in word-initial position. What is variable in the onset is nasality, and what is variable in the coda is orality. Since nasality is marked at the morpheme level, all nasalizable segments in nasal morphemes surface automatically as nasal. Phonetic implementation will subsequently act upon nonsonorant voiced onset consonants and on nasal coda consonants in oral syllables, creating optional contour segments, motivated by voicing enhancement for the voiced onsets and by shielding for nasal codas. We follow the proposal by Mahecha for the lexical feature definition of the Nɨkak consonants in Figure 5, with a supplementary nasalization rule accounting for the complementary distribution of nonsonorant and nasal voiced consonants in oral morphemes, represented as the dotted arrow.[19]

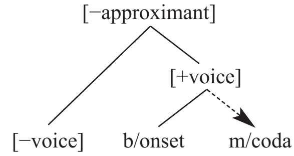


FIGURE 5. Distribution of oral and nasal stops in Nɨkak oral morphemes.

[19] Pessoa's (2012) analysis of the distribution of contour segments in Krenak is similar in positing underlying /b/, with venting in onsets and shielding of derived [m].

It is important to observe that the nasalization of the lexical nonsonorant voiced consonants in the coda in Nɨkak is not a case of neutralization of an underlying contrast (since, as we argue below, the underlying contrast is /p, b/ and not /p, b, m/). As pointed out by Steriade (2008), neutralization of voiced stops in the coda is rarely achieved by nasalization (although see Merrill 2015 for an intriguing example of nasalization of voiced stops in the Senegalese language Noon).[20] Instead, in Nɨkak we are witnessing a contextual preference for high-sonorant consonants in the weak prosodic position of the coda.[21] Interestingly enough, although this polarization of the contrast in codas to [p ~ m] threatens the PoA distinctions among the resulting nasal consonants (as nasal consonants have weaker place cues than their corresponding voiced stop counterparts; Ohala & Ohala 1993, Jun 1995, Boersma 1998), the shielding process in Kaingang (shown in 9d) reestablishes a preoral phase, in which place cues can be recovered.[22] As Table 1 shows, these [^{b}m] segments are alternants of a target [m].

Nɨkak highlights the importance of taking interspeaker variation into account. While speakers vary in their realizations of contour segments in ways that looking at each of them individually might not reveal, we see that all speakers produce relatively small amounts of nasalization in the onset [^{m}b/b] and large amounts in the coda [^{b}m/m]. Specifically, the fact that, given this variation, onset [^{m}b] alternates with a canonical target [b] while coda [^{b}m] alternates with a canonical target [m] suggests that the onset contour nasal is the result of venting, while the coda contour nasal is the result of shielding. Given the fact that there is no underlying contrast for /b, m/ in this nasal harmony language, but that nonetheless voiced stop codas are realized as [m], we have posited a coda nasalization process in the lexical phonology, which can subsequently undergo shielding enhancement for the sake of preceding oral vowels. Since these nasals are unreleased, the variable creation of a noncontrastive preoralization phase may be additionally recruited for the added benefit of providing a secondary PoA cue.

The claim that we are dealing with syllable-initial voiced consonants in Nɨkak is furthermore corroborated by their acoustic characteristics. If the prenasalization of voiced consonants in this language is correctly analyzed as hypervoicing, we expect that when prenasalization is not present, these consonants will show the characteristics of voiced

[20] In a study on coda nasalization in Tupari, where voiced, voiceless, and nasal consonants are all realized as nasal consonants after nasal nuclei, Singerman (2016) argues that this merger is favored by the nonreleased character of coda obstruents, based on a formalization in terms of Steriade's (1993) APERTURE THEORY. Similarly, Clements and Osu (2002) demonstrate that the nonexplosive voiced stops of Ikwere nasalize as opposed to the explosive ones. Although Nɨkak, like many indigenous languages of South America, has unreleased coda obstruents, its coda nasalization affects only the lexical voiced consonants, turning the /p, b/ contrast into a [p, m] contrast at the output of the lexical phonology. Further research must show to what extent nonreleased consonants more easily shift to nasal consonants than released consonants, even after oral nuclei.

[21] The Pomo language Kashaya shows a similar complementary distribution between onset [b] and coda [m]; see Oswalt 1961 and Buckley 1994 for discussion of alternatives arising from a common underlying source. Two additional South American languages showing the same distribution of nonsonorant voiced and nasals consonants are briefly discussed below.

[22] The distribution of Nɨkak allophones as [b] in the onset and [m] in the coda can partially be understood as an avoidance of [m] in the onset for reasons of better PoA cueing by oral consonants (see also our discussion in §4.3 below) and an avoidance of [b] in the coda given the general dispreference for coda voiced obstruents, but this complementary distribution is complicated by resyllabification. Resyllabified coda nasals that were preoralized become fully nasal onsets before the vowel-initial nominalizing suffix, and in turn nasalize the following vowel, for example, /bɨ̂d/ > [^{m}bɨ̂^{d}n] 'disappear', [^{m}bɨ̂.nãt̚] 'disappearance' (Mahecha 2019). This retention of the nasal allophone in resyllabification is reminiscent of the retention of dark-[ɫ] allophony in English *feely* (Boersma & Hayes 2001) and can be understood along similar lines as a correspondence effect, though one where tautosyllabic shielding of the preceding vowel is no longer needed.

consonants as in true voicing languages. As it turns out, utterance-initial voiced stops of Nɨkak produce a significant and persistent amount of prevoicing, typical for voiced consonants in languages with a voiced/voiceless contrast, such as Brazilian Portuguese or Dutch. This is shown in Figure 6 below for the token [bebehat] 'wet.NMLZ', which clearly displays voicing bars during the closure phases of both instances of [b]. This shows that the vocal folds begin vibrating before release, indicative of prevoicing or negative voice onset time. In summary, onsets in Nɨkak alternate optionally between a prevoiced [b] and a vented [ᵐb].

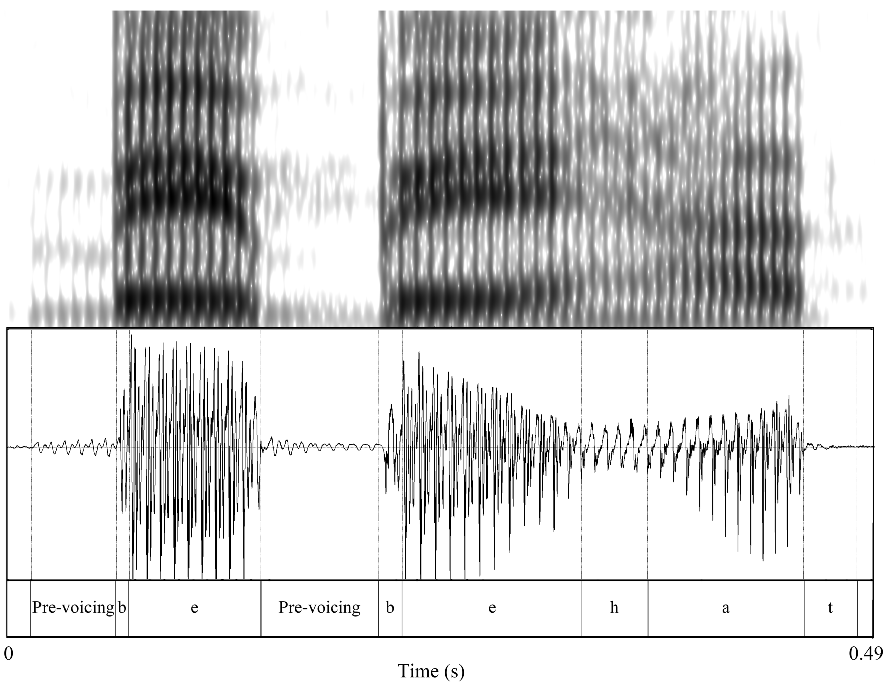


Figure 6. /bebehat/ [bebehat˺] prevoicing in Nɨkak voiced stops.

Within the coda, however, there is nasalization of underlying /b/. This turns out to be a fairly widespread process for voiced coda consonants found in South American /p, b/ languages (and indeed, a strategy for avoidance of voiced obstruent codas that makes use of an available allophone). For example, there is a broad consensus among specialists of the Chibchan language family that nasality was not contrastive for consonants in the proto-language (Constenla Umaña 1981). The absence of contrastive nasal consonants can still be seen in some of the present-day languages, one of which is Bribri, studied in Chevrier 2017, where it is also shown that different dialects of this language represent different stages in the process of voiced stop nasalization.[23] While in the Coroma dialect this process is obligatory after oral and nasal nuclei at the lexical level, in the Amubre dialect there is obligatory nasalization of voiced stops only utterance-finally; it is still optional elsewhere, as exemplified below (examples from Chevrier 2017:272–75).

[23] The Bribri people live in the cantons of Talamanca and Buenos Aires in the state of Costa Rica. Three dialects are distinguished for Bribri: Salitre, Coroma, and Amubre (Chevrier 2017:29–30).

(14) Obligatory across-the-board coda nasalization in Coroma

a.	[wîm]	'man' (in isolation/utterance-final)
b.	[wîm ˈagbɽɛ]	'the man has stolen' (between words)
c.	[ˈkɽɛ̃m-ɽa]	'catfish-diminutive' (before suffix)
d.	[jam]	'palm tree (species of)'
e.	[dʒɛ kĩ ˈjam=ɪ kjanɛ̃]	'I only want palm trees' (before clitic)

(15) Obligatory utterance-final coda nasalization in Amubre

a.	[wí**m**]	'howler monkey' (in isolation/utterance-final)
b.	[ˈsɛˌwɪna kɽɔ**m~b**ˌsu]	'that looks like a sapote' (between words)
c.	[ˈwî**b**-ɽa]	'man-diminutive' (before suffix)
d.	[suɽi**m**-ɽa]	'inga-diminutive (species of)' (before suffix)
e.	[baˈkɔ̃**m**]	'cannonball *couroupita nicaraguensis*' (in isolation/utterance-final)
f.	[dʒɛ kĩ bəˈkɔ̃**b=**ɪ kjanã]	'I only want cannonballs' (before clitic)
g.	[dʒɛ kĩ wî**m**=ɪ ˈkjanã]	'I only want men' (before clitic)

Furthermore, if, as we claim for Nɨkak, nasal venting in onsets may cooccur with shielding in codas, we expect to find languages phonotactically similar to Nɨkak that have venting without shielding. One such language is Puinave, which uses nasality as a distinctive feature for vowels.[24] Similar to Nɨkak, Puinave has a general ban on voiced codas (Girón 2008). In syllable onsets, /p, b/ contrast before oral vowels, while /p, m/ occur before nasal vowels (16a). In the syllable coda, /p, m/ contrast after oral and nasal vowels (16b).

(16) Distinctive nasality in Puinave

a.	[⁽ⁿ⁾debɤ̀m]	'pig'	b.	[⁽ᵐ⁾bóp]	'arrow'
	[tɤ́ʔ]	'banana'		[atə̃́p]	'I have a fever'
	[pə̃́t]	'axe handle'		[⁽ⁿ⁾debɤ̀m]	'pig'
	[mə̃́t]	'rat'		[atə̃̀m]	'my name'

In Puinave, voiced stops show optional prenasalization only word-initially. Unlike Nɨkak, however, nasal consonants are not preoralized in the coda in Puinave, as there is no shielding rule in the language. Plain nasal consonants occur that moreover do not extend their nasality to the previous vowel, as explicitly observed by Girón (2008:78). The existence of this language type supports the claim that shielding in onset consonants cannot occur independently of shielding in coda consonants.

Voiced stops and nasal consonants are in complementary distribution in Nɨkak at the output of what might be called the lexical phonology, before enhancement steps in. Plain nonsonorant voiced stops contrast with voiceless stops in the onset of oral syllables and show optional prenasalization as a venting strategy, while preoralized nasal consonants (as a shielding strategy) alternate with plain nasal consonants in the syllable coda. We conclude that Nɨkak is a /p, b/ language that combines nasal venting in the syllable onset with shielding in the syllable coda, though the two are independent and orthogonal enhancement strategies.

4.3. Contour segments from neither venting nor shielding: PoA enhancement? We have provided discussion above of the complementary roles of venting and shielding as responsible for the creation of nasal contour segments from /b/ and /m/, respectively. However, there are cases of /p, m/ languages without contrastive nasality on

[24] Puinave, an indigenous language of Colombia, is a tone language (Girón & Wetzels 2006). In the examples, grave accent represents low tone, while acute accent represents high tone.

vowels that have contour segments for which neither shielding nor venting can clearly be used as the motive for their mainly unsystematic occurrence.

None of the languages of the Txapakura family (spoken in the Guaporé valley in Brazil) contrast nasality and orality for vowels, and all of the languages lack the opposition between nonsonorant voiced and nasal consonants. However, some of the well-documented Txapakura languages within the Wari' dialect group have partially nasal consonants. Oro Nao', of the Southern subgroup, has what seems to be a random distribution of [mᵇ ~ m] allophony. According to Everett and Kern (1997:407), 'nasalization of vowels only occurs on surface diphthongs. In fact, there are only a few diphthongs which are not nasalized'. Therefore, the conclusion is that there is no contrastive nasality, not even in diphthongs. Oro Nao' has a /p, m/ contrast with glottalized nasals as well, but no voiced stops. The contrast between plain and glottalized nasal consonants is neutralized word-initially in favor of the plain series. According to Everett and Kern, the contours [mᵇ, nᵈ] fluctuate with [m, n] syllable-initially 'more frequently before [a] and less frequently before the other vowels. [There is] a greater tendency toward this fluctuation in stressed syllables' (1997:400–401). We note that neither of these tendencies is compatible with a shielding explanation, as high-sonority and stressed vowels have the least peril of perceptual contamination (see Stanton 2018:§3.4 for explanation of why shielding is more likely in unstressed syllables and adjacent to low-sonority vowels, as both of these environments provide weaker cues for oral/nasal contrasts and thus require additional enhancement).

(17) Optional postoralization in Oro Nao'

a.	[ˈmõⁱnˀna]	or	[ˈmᵇõⁱnˀna]	'it is full'
b.	[ˈtõⁱname]	or	[ˈtõⁱnamᵇe]	'the birds flew'
c.	[noˈwi]	or	[nᵈoˈwi]	'electric eel'
d.	[wiˈna]	or	[wiˈnᵈa]	'my head'

The absence of a contrast on vowels rules out an explanation based on shielding. This conclusion is corroborated by the fact that the contour stops may occur in the onset of syllables that contain a nasal diphthong, such as 17a. Moreover, if the syllable-initial contour stop were to be explained by shielding, we would expect preoralized nasals [ᵈn, ᵇm] to occur in the syllable coda. Conversely, the fact that the existing contour segments alternate with plain nasal segments and that otherwise plain nonsonorant voiced stops do not alternate with [mᵇ, m] makes nasal venting a less obvious explanation for the contour stops in this language.

According to Apontes (2015), nasality is not contrastive in the related language Oro Waram.[25] Similar to Oro Nao', diphthongs can be optionally nasalized in Oro Waram. In all cases, these sounds can be shown unmistakably to be derived synchronically through optional vocalization of a palatal nasal consonant in the syllable onset or coda: /ɔɲ/ > [ɔ̃ɲ ~ ɔ̃ĩɲ ~ ɔ̃ĩ] 'plant'; /ɲew/ > [jẽw] 'grandfather' (Apontes 2015:53). As in Oro Nao', contour segments, which are overall rare and more frequently used by the elderly than by the youngsters, vary freely with plain nasal consonants. Judging by the phonetic transcriptions provided by Apontes, the frequency of postoralization of onset nasals follows the scale [mᵇ] > [nᵈ] > [ɲᵈʒ], where '>' means 'more frequent than', and the latter

[25] Silva (2003:30–35) presents a study of Portuguese loanwords into Northern Wari' Oro Mon, whereby Portuguese /b/-initial loans like *batata* are adapted either as fully nasal [maˈtat̚] or as postoralized [mᵇaˈtat̚], broadly supporting an analysis of no underlying voiced stops.

is the postoralized allophone of the palatal nasal: /me/ > [me] ~ [m^{b}e] ‘bird’; /naɾaˈwo/ > [naɾaˈwo] ~ [n^{d}aɾaˈwo] ~ [dɾaˈwo] ‘fire ant’; /ɲew/ > [ɲ^{dʒ}ew] ‘grandfather’.[26]

Although plain oral voiced consonants are part of the allophonic range of labial and dental nasals, their appearance is obligatory in derived complex onsets, as in the word /naɾaˈwo/ > [dɾaˈwo] ‘fire ant’. How can this be understood? This is neither shielding nor venting, and it is interesting to consider the following passage from Herbert (1986:214):

> We have claimed … that the motivation for the development of complex nasal consonants in many cases was perceptually motivated to protect the nasality/orality of vowels. It might be claimed for individual languages that the motivation is actually articulatory, i.e. a simple non-coordination of the velum with the movements of the other articulators. Upon a closer examination, it becomes clear that the opposite is the case, i.e., these processes are designed to prevent noncoordination which would result in the neutralization of an obviously valued V/Ṽ distinction. The reason *we do not find such cases in languages without distinctive nasality in vowels* is simply because it is irrelevant and therefore the language takes no measures to prevent it. (italics ours)

Of course, we DO find such cases, as just noted for Wari’. Indeed, what Herbert calls ‘simple non-coordination’ could very well be the initial cause for the emergence of allophonic contours. Suppose that the PoA contrast of nasal consonants is enhanced by partial oralization—then there is a THIRD enhancement motive for their appearance in this language type. The availability of orality as an enhancement feature for nasal consonant PLACE in languages that lack nonsonorant voiced stops could explain its systematic absence in languages that contrast voiced and nasal consonants. In fact, an entirely parallel typological phenomenon may be found in what Butcher (1999) argues for PRESTOPPING, a phenomenon that creates [^{b}m] from underlying segments such as /m/ (see also Keyser & Stevens 2006:50). Prestopping is widely found in Australian languages (see Hercus 1972, Evans 1995) as a way to enhance PoA in nasals, perhaps all the more important given the density of place contrasts in such languages.[27]

Additional support for PoA enhancement as a motivation for partial oralization comes from its occurrence in Kaingang complex onsets. We have established that Kaingang is a shielding language. This raises the question of why partially nasal consonants also show up inside the complex onsets /mɾ, ŋɾ/ of oral syllables. Compare the words in 18.

(18) Postoralization within Kaingang complex onsets

a.	/mɾ̃æ̃jæ̃/	[mɾ̃æ̃jæ̃]	‘ashes’
b.	/kãŋɾ̃ãñ/	[kãŋɾ̃ãñ]	‘rub’
c.	/mɾo/	[m^{b}ɾo]	‘float’
d.	/nĩŋɾu/	[nĩŋ^{g}ɾu]	‘claw’

The nonemergence of an oral phase in /mɾ, ŋɾ/ in nasal syllables such as 18a,b is explained by nasality spreading, which also applies to /ɾ/ and /j, w/ in Kaingang; nasalization is a property of the entire syllable in the language (with its concomitant importance of syllable divisions). What is most intriguing, however, is the presence of the intrusive consonants such as [b] in 18c,d—highly reminiscent of the diachronic change from *al*

[26] In the syllable coda, only preoralized realizations of the labial nasal consonant are transcribed with frequency: /nem/ > [nɛm] ~ [ne^{b}m] ‘brother-in-law’. Importantly, when preoralization of the coda consonant does not occur, the preceding nucleus is still not nasalized. In other words, there is no need for shielding.

[27] Of perhaps even greater interest is the parallel noted between the postoralization found in Wari’ here, even in the absence of an oral/nasal vowel contrast, and the similar existence of ‘post-stopped’ nasals in Northern Min dialects studied by Chan (1987), where ‘nasals may be accompanied by plosive release even in dialects without an oral-nasal vowel contrast’ (p. 94). Chan notes that ‘bilabial nasals have the greatest tendency to be produced by plosive release’ (p. 100), paralleling the observations made above for Wari’. We contend that, despite Chan’s assertion that ‘[s]ynchronically, there are no reasons for the post-stopping of the nasals in these dialects’ (p. 94), in fact it may be a PoA enhancement, just as in Wari’.

hamra > *alhambra* from Arabic to Spanish in Ohala 1997. The emergence of a postoralized [b] among /mɾ/ clusters is not easily accounted for by a shielding explanation, as there is no underlying contrast between nasal and nonnasal /ɾ/. It is possible, of course, to conceive of a domino-effect enhancement: the postoralized [mᵇ] protects the [ɾ] from nasalization, which would otherwise threaten the following nucleus in turn with contaminating nasalization. However, long-distance enhancement of this sort has not been, to our knowledge, proposed, and despite the extensive discussion of avoiding contaminatory nasalization in Herbert 1986 and Stanton 2018, the emergence of contour nasals before [ɾ] has not been proposed as an instance of shielding. We instead suggest that the rule of postoralization with tautosyllabic oral vowels is grammaticalized in Kaingang, regardless of whether this vowel is adjacent, but that the emergence of a postoralized [b] has the salutary enhancing function of PoA ENHANCEMENT OF THE NASAL ITSELF, which would be threatened before a rhotic.[28]

The hypothesis, therefore, is that the emergence of postoralization in /mɾ/ clusters is not shielding per se, but PoA enhancement to improve the relative perceptibility of the weaker [mɾ] vs. [nɾ] contrast compared to the more perceptible [(m)bɾ] vs. [(n)dɾ] contrast as cued by the prerhotic voiced stops, where the prerhotic environment provides good place contrasts for preceding stops (Flemming 2007). This directly parallels PoA enhancement in Wari', where postoralization is optional for nasals, but a fully oral allophone becomes obligatory with vowel deletion: [naɾaˈwo] ~ [nᵈaɾaˈwo] ~ [dɾaˈwo] 'fire ant'. The obligatory oralization of the derived [nɾ] cluster in a language with no shielding contrast at stake is again reflective of a PoA-based motivation, where the lack of contrast between /n ~ d/ allows choice of the latter in prerhotic contexts where nasal place identification requires further enhancement. Further support for nasal + rhotic clusters triggering PoA enhancement with intrusive stops may come from Pech, a Chibchan language in which /nɾ/ sequences have an alternant [ndɾ], the language otherwise lacking /d/ (Chevrier 2017:356), and in which contour nasals are not found in any context other than prerhotic clusters.[29]

Should the above reasoning be correct, PoA enhancement can exist in languages with no shielding (Wari'), or even alongside shielding, for distinct purposes. How, then, can these two enhancement processes be distinguished? First, we have argued that preconsonantal environments (e.g. prerhotic clusters) are likely to be PoA enhancement, not shielding, particularly when there is no underlying [±nasal] contrast for the following rhotic. PoA enhancement can be potentially distinguished from shielding based on the inventory. We have claimed that partial oralization occurring in the absence of a nasal/oral contrast on vowels is not shielding. Prestopped nasals are systematic in those Australian languages with a higher-than-average number of PoA distinctions. Thus, PoA enhancement would by hypothesis not exist in languages with only a single nasal place contrast. Similarly, one might expect PoA enhancement to be less likely in positions where there are other cues to the recoverability of place distinctions, such as in languages where the nasal stops in coda position are predictably followed by homorganic oral stops that can then cue their place. Conversely, PoA enhancement might be more likely when certain place contrasts (e.g. within-coronal distinctions) need additional cueing. Finally, Stanton (2017:100) reminds us that prestopping in Australian languages occurs for laterals as well as nasals, thereby demonstrating that protecting the

[28] Durvasula (2010:133–45) discusses the possibility of reducing the partial oralization phenomena to place gesture enhancement.

[29] Claudine Chamoreau (p.c.)

preceding vowel from nasalization is not at stake in these cases, but rather PoA enhancement. If partially nasal consonants arise as phonetic variants not necessarily for enhancing purposes, the subsequent systematic recruitment of these sounds in shielding (or PoA) environments should be considered a secondary development, in line with the program of variation and change as laid out in Weinreich et al. 1968:187, and related to the potential availability given the catalyst of areal features. We return to this possibility in §5 below.

5. Open frontiers: diachronic reinterpretation, NC clusters, and areality. In this section we return to the original 'reinterpretation' of nasal contours (from shielding to venting, or vice versa) as raised in Haudricourt's 2017 [1970] work, within a more general discussion of how diachronic reinterpretation of the surface form of nasal contours may reflect reanalysis of the underlying system. These issues inevitably intersect with the question of the areal status of contour segments, which may lead to their reinterpretation or emergence now as venting, now as shielding, now as PoA enhancement, and sometimes simply as heterosyllabic clusters.

The comparison of shielding in Kaingang and venting in Maxakalí leads to the question of the reconstruction of the two-way contrast in the proto-Macro-Jê stock (of which both are members; Rodrigues 1999). Not all Macro-Jê languages include such dramatic cases of shielding as in Kaingang; circumoralization of this type is not widely reported for other Macro-Jê languages (though exact parallels are reported in the geographically and genetically faraway case of Karitiana reported in Storto 1999). For example, while Kaingang simply has no instances of plain [b], languages such as Maxakalí have surface instances of [b], found both in the native vocabulary and as a result of loanword incorporation. In Nikulin's 2016 reconstruction of Proto-Macro-Jê, there is a nasal series with /m/ but no oral series with /b/. This suggests that Maxakalí is 'innovative' within the family, having reanalyzed shielding variants like [m^b] as ultimately coming from /b/, with venting.[30] It bears underscoring how the same analytical indecision that exists among analysts of individual languages of the type under investigation arises when it comes to reconstructing the sound system of protolanguages.

At this point it is worth returning in a bit more detail to the reconstruction of New Caledonian Unya and its predecessor, Goro, as discussed in Haudricourt 2017 [1970] (based on data found in more complete form in Rivierre 1973).

(19) Reinterpretation of nasal contours in the evolution of New Caledonian

	Goro		Unya	path of evolution
'earthworm'	[^{m}bie]	>	[pie]	devoicing
'currency'	[mĩẽ]	>	[mĩẽ]	no change
'wet'	[mie]	>	[m^bie]	shielding
	[p]	>	[p]	no change

[30] According to Nikulin (2018), at some point in the history of Maxakalí, the Proto-Macro-Jê contrast between /p/ and /m/ was neutralized, with the voiceless stops occurring exclusively in oral syllables and the nasal consonants in nasal syllables. In other words, the original contrastive sounds had become allophones of a single consonant class—as is the case of coda position in modern Maxakalí, for which only PoA is contrastive (Wetzels 2009). However, alongside the consonant system used in the spoken language, a different system was used in ritual songs (see Campos 2011 for a thorough description), in which voiced and voiceless consonants contrast in oral syllables, the voiced ones representing Proto-Macro-Jê nasal consonants. If one assumes Nikulin's reconstruction, the voiced consonants that occur in oral syllables in contemporary Maxakalí may have been catalyzed by register mixture with ritual songs, indeed alongside the numerous loans from Brazilian Portuguese that preserve voiced consonants in the process of adaptation. Campos (2011:178) also observes that voiceless consonants of spoken Maxakalí frequently correspond to voiced ones in the ritual songs.

All voiced stops neutralized to their voiceless counterparts in Unya. With the wholesale loss of [b], however, Unya had no need to further 'use' nasal contours as venting: there were no longer any voiced stops left to vent. But the apparent availability of nasal contours did not go to waste; it was simply repurposed for another distinct function: that of shielding.

These kinds of reanalyses of contour segments (from venting to shielding) are in large part most likely related to independent changes in the inventory. For example, the phonetic similarity between [^{m}b] and [m^{b}] may lead to an inference that the latter (as in Unya) is the main allophone in question and that as such, it arises as a variant of underlying /m/. What led to the reinterpretation in Maxakalí where the /m ~ p/ system represented by Kaingang (and in Proto-Macro-Jê) became a /b ~ p/ system? Arguably it was the pervasive syllable-level nasal harmony, also found in Nɨkak, Bribi, and Puinave. With pervasive nasal harmony driven by an autosegmental source (or a stressed vowel) as the contrastive locus of nasality in the word, instances of surface [m], occurring alongside an even broader range of predictable conditioners, may in turn become reinterpreted as reflecting an underlying /b/, which surfaces in its elsewhere form only in the unpredictable absence of such conditioners. Learners that pay attention to intervocalic instances of [b] as the unconditioned form can therefore derive an underlying /b/ as their source. In fact, Haudricourt (2017 [1970]:4) asserts that '[p]renasalized consonants are not very common across languages; they can evolve rapidly into (oral) voiced stops'. As extensively shown in a range of case studies (e.g. Hyman 1975, Michaud et al. 2012), what is often called the evolution of /m/ > /mb/ > /b/ would in our view be /m/ ([m$^{(b)}$]) > /b/ ([$^{(m)}$b]), where the optionality of hypervoicing found within the later stage eventually becomes pruned. Maxakalí, however, is arguably 'still' (perhaps healthily stable) within this penultimate state, with optional venting-driven prenasalization only in word-initial position.

How do we know that a reinterpretation has happened? In a case that represents the converse of the shift from Goro to Unya, the remaining surface instances of [m^{b}] have not gone to waste in Maxakalí: they have simply been re-recruited as hypervoiced enhancements of /b/ (as evidenced by the present-day interspeaker variation between [b] and [^{m}b] as targets in word-initial position, clearly shown in loanwords). In Kaingang, however, partially oralized cases such as [m^{b}] (representing the older form) are variants of target [m]. Given that word-initial position is often where venting occurs more consistently, intervocalic position, in fact, may be one of the most useful places for learners to look: Maxakalí, Nɨkak, and Puinave have intervocalic instances of plain [b], with intervocalic [m] conditioned only by harmony. Kaingang, by contrast, has intervocalic instances of plain [m], with no instances of intervocalic [b] whatsoever.

Reinterpretation of Kaingang-type shielding in intervocalic position has also apparently occurred in Panará, as witnessed in the following comparison (Lapierre et al. 2016).

(20) Apinajé shielding reinterpreted as clusters in Panará

	Mebengrokre	Apinajé	Panará	
a.	[mɨ]	[mbɨ]	[impɨ]	'man'
b.	[na]	[nda]	[inta]	'rain'
c.	[ɲã]	[ɲã]	[insa]	'to bite'
d.	[ŋo]	[ŋgo]	[iŋko]	'water'
e.	[ma]	[mba]	[impa]	'liver'
f.	[ŋrɛ]	[ŋgrɛ]	[iŋkrɛ]	'egg'
g.	[pa]	[pa]	[ipa]	'arm'
h.	[tɛ]	[tɛ]	[itɛ]	'leg'

Mebengokre has no shielding at all (and indeed, has a three-way /p, b, m/ contrast; cf. Salanova 2001).[31] Apinajé, in turn, lacks phonemic voiced stops such as /b/ (Salanova 2001) and has developed postoralized shielding of the type found in Kaingang. Panará, however, has apparently reinterpreted these sequences as clusters. This seems particularly inevitable given the fact that, as shown in 20g–h, all Panará words of this shape have taken on a new prefixal (or epenthetic) *i*-. In this case, a shielding-based nasal contour such as [m^b], originally an enhanced version of /m/, has now been reinterpreted as a heterosyllabic cluster [im.ba], likely because of the sudden absence of word-initial [m^b] sounds. Clear evidence that these are now distinct segments in distinct syllables comes from their concomitant changes in voicing and frication: once the presence of the oral portion is no longer tied to a realization of the nasal, it can evolve into a voiceless, and indeed fricative, element, as witnessed in cases such as [n.k] and [n.s].[32] These no longer fill the profile of providing shielding. Their reinterpretation as a cluster has resulted in sequences of nasal + voiceless stop and nasal + fricative, of the type found in Bantu, which at least for a large range of cases, Hubbard (1995) and Downing (2005) have argued are indeed heterosyllabic clusters.

The availability of cluster interpretations of nasal contour segments, as found in Panará, is related to whether the language more generally provides syllable structure compatible with such an interpretation. The reinterpretation of [mb] as a cluster, as in Panará, is expected under the typology developed by Riehl (2008:51–52):

> Many languages have prenasalized stops to the exclusion of NC clusters, as well as to the exclusion of most other cluster-types. In fact, an interesting observation about languages with prenasalized stops is that they seem to disproportionately have only open syllables … one can speculate as to why this might be the case. Inseparability of NC components is the strongest piece of evidence for unary segmenthood. If a language has codas, it will likely have nasal codas; if there are nasal codas word-medially, there will be contexts where a nasal and a following stop are adjacent, meaning clear NC clusters. Once there are clear NC clusters in the language, it might be the case that all NC sequences are more likely to be interpreted as clusters.

This is indeed what has happened in Panará. Conversely, we would argue that if a language lacks clusters throughout its inventory, then the occasional potential creation of nasal contours may be less problematic than otherwise.

Indeed, a counterexample to our hypothesis developed at the outset of this article can be found in some of the Maku languages, which have the three-way contrastive series /p, b, m/, but nonetheless exhibit instances of preoralization for the purpose of shielding. This may be enabled by a mechanism of 'Areality proposes, presence of clusters disposes', to be explained below. The existence of contour nasals within lowlands South America as an areal feature has been noted by several scholars; see Henderson 1965 and Ratliff 2015 for a discussion of prenasalization as an areal feature in Southeast Asia. While investigation of South America as a linguistic area is a rich topic of current investigation (see Clem & Michael 2016), we take it as uncontroversial that in some form or other, nasal contours being an areal feature may therefore spread more

[31] Given its three-way contrast, Mebengokre (still Macro-Jê) is predicted to have neither shielding nor venting. Salanova (2001:25) presents a handful of instances of apparent venting in Mebengokre, characteristic of lengthened, emphatic speech.

[32] A plausible historical scenario leading to the development of these postnasal voiceless segments in Panará is the one outlined in Beguš 2016 involving a series of ordered changes, whereby postnasal stops first become affricates, and then later undergo deaffrication and devoicing. This deaffricating path would provide an account for the fricative found after [n]. Alternatively, the fricative could result from reanalysis of postnasal aspiration (Hamann & Downing 2015).

widely than if they were to arise endogenously, even for cases where they have less phonological traction otherwise. Consider, in this light, preoralization in the syllable coda in the Maku languages Dâw in 21 (from Martins 2004:46) and Yuhup in 22 (from Ospina Bozzi 2007:79), in which nasals that follow oral vowels are preoralized.[33]

(21) Dâw preoralization

/cón/	[cóː^{d}n]	‘become hungry’
/pam/	[pa^{b}m]	‘beat against the floor’
/ʃeɲ/	[ʃe^{ɟ}ɲ]	‘stumble and fall’
/ʃón/	[ʃóː^{g}n]	‘elbow’

(22) Yuhup preoralization

/păm/	[pă^{b}m]	‘measles’
/pûn/	[pû^{d}n]	‘breast’
/tâɟ/	[tâ^{ɟ}n]	‘maracas’
/ăŋ/	[ă^{g}ŋ]	‘fruit’

The shielding found in 21–22, from /p, b, m/ languages, would seem to thwart the answer we posed at the outset to why preoralized nasals are not found, say, in French, in order to protect oral vowels (e.g. /po$^{[b]}$m/ for *pomme*). According to Riehl’s reasoning, as developed above, nasal contour segments and two-segment consonant clusters of identical form cannot coexist within a language—and indeed clusters, including [bm], do not exist in the Maku languages, enabling the possibility of shielding variants to emerge. French, by contrast, which has words with intervocalic stop-nasal clusters such as [bm], [dn], in words like *submerger* [sybmɛʁˈʒe] ‘inundate’ or *cadenasser* [kadnaˈse] ‘to padlock’, would be ineligible for contour nasals as the result of preoralization. Indeed, Stanton (2017:217) finds that while languages can have contrastive prenasalization (e.g. [nd] clusters contrasting with [n]) without having shielding, no language has both prevocalic shielding and contrastive prenasalization of this sort, supporting the conclusion that the possibility of shielding arising depends on the free availability of such a sequence not otherwise employed.

The Maku pattern of coda shielding, even given the presence of a three-way contrast, is facilitated by the lack of clusters, thereby admitting a role for an external impetus from areality, in the manner formulated by Blevins (2017:98): ‘The external stimulus of a contact sound pattern shifts the odds of the same pattern evolving in a neighboring language, but it could have evolved in that language independently of contact, only with much lower probability’. Blevins notes that this kind of areal catalyst occurs specifically in cases where they would have what we call ‘enhancing’ properties: ‘Phonetic features that are not central to signalling contrast in a language are more likely to be co-opted into new category formation than others’ (2017:115). This is precisely the case for the co-opting of noncontrastive preoralization in the Maku languages.

The interplay of areality and noncontrastive enhancement processes in contour nasals opens up much analytic territory to be explored. Despite forty years of research on the topic and varying strands in the literature that have already identified the articulatory and perceptual sources of prenasalization and postoralization, a clear functional division between the two has rarely been cleanly juxtaposed and compared within a single discussion. We can begin to make progress on answering questions of the type identified in this final section—as to the diachronic reinterpretation among the poles of [^{m}b],

[33] See also Andrade 2014 for oral and nasal airflow measurements confirming this description of preoralized nasal consonants.

[m^b], and [mb] in terms of analyses of the function each may play in a given phonological system—only once the kind of phonological housekeeping initiated in this article has taken root.

REFERENCES

Anderson, Stephen R. 1976. Nasal consonants and the internal structure of segments. *Language* 52.326–44. DOI: 10.2307/412563.

Andrade, Wallace. 2014. A nasalização na língua Dâw. São Paulo: Universidade de São Paulo master's thesis.

Apontes, Selmo A. 2015. *Descrição gramatical do Oro Waram, variante Wari'Norte (Pakaa Nova, Txapakura): Fonologia, morfologia e sintaxe*. Belo Horizonte: Federal University of Minas Gerais dissertation.

Bacelar, Laércio N. 2004. *Gramática da língua Kanoê, descrição gramatical de uma língua isolada e ameaçada de extinção, falado ao sul do estado de Rondônia, Brasil*. Nijmegen: Radboud University dissertation.

Baraúna, Fabíola, and Gessiane Picanço. 2017. Tendências na implementação fonética de consoantes nasais em Tupí-Guaraní. *LIAMES: Línguas Indígenas Americanas* 17.143–57. DOI: 10.20396/liames.v17i1.8648521.

Bartholomew, Doris. 1960. Some revisions of Proto-Otomi consonants. *International Journal of American Linguistics* 26.317–29. DOI: 10.1086/464591.

Beguš, Gašper. 2016. Post-nasal devoicing and a probabilistic model of phonological typology. Cambridge, MA: Harvard University, ms. Online: http://ling.auf.net/lingbuzz/003232.

Blevins, Juliette. 2017. Areal sound patterns: From perceptual magnets to stone soup. *The Cambridge handbook of areal linguistics*, ed. by Raymond Hickey, 88–121. Cambridge: Cambridge University Press.

Boersma, Paul. 1998. *Functional phonology: Formalizing the interaction between articulatory and perceptual drives*. The Hague: Holland Academic Graphics.

Boersma, Paul, and Bruce Hayes. 2001. Empirical tests of the gradual learning algorithm. *Linguistic Inquiry* 32.45–86. DOI: 10.1162/002438901554586.

Boersma, Paul, and David Weenink. 2017. Praat: Doing phonetics by computer. Online: http://www.praat.org/.

Botma, Bert. 2004. *Phonological aspects of nasality: An element-based dependency account*. Amsterdam: University of Amsterdam dissertation.

Bradley, C. Henry. 1970. *A linguistic sketch of Jicaltepec Mixtec*. Mexico City: Summer Institute of Linguistics.

Braga, Gabriela. 2017. *Fonologia Negarotê: Análise fonológica da língua do grupo Negarotê (família Nambikwára)*. Amsterdam: Vrije Universiteit, and Recife: Universidade Federal do Pernambuco dissertation.

Buckley, Eugene. 1994. *Theoretical aspects of Kashaya phonology and morphology*. Stanford, CA: CSLI Publications.

Butcher, Andrew. 1999. What speakers of Australian aboriginal languages do with their velums and why: The phonetics of the nasal/oral contrast. *Proceedings of the 14th International Congress of Phonetic Sciences (ICPhS)*, San Francisco, 479–82. Online: https://www.internationalphoneticassociation.org/icphs-proceedings/ICPhS1999/papers/p14_0479.pdf.

Campos, Carlo Sandro de Oliveira. 2011. Considerações sobre a língua usada nos cantos Maxakalí. *Línguas e culturas Tupí, vol. 3 & Línguas e culturas Macro-Jê, vol. 2*, ed. by Ana SuellyArruda Câmara Cabral, Aryon Dall'Igna Rodrigues, Jorge Domingues Lopes, and Maria Risolêta Silva Julião, 172–93. Campinas: Editora Curt Nimoendajú.

Cardoso, Valéria Faria. 2009. Sistematização da fonologia Kaiowá: Nasalização e/ou oralização. *Sínteses* 14.31–72. Online: http://revistas.iel.unicamp.br/index.php/sinteses/article/view/1218.

Chan, M. 1987. Post-stopped nasals in Chinese: An areal study. *UCLA Working Papers in Phonetics* 68.73–119. Online: https://escholarship.org/uc/item/56t0x9z3.

Chevrier, Natacha. 2017. *Analyse de la phonologie du Bribri (Chibcha) dans une perspective typologique*. Lyon: Université Lumière Lyon 2 dissertation.

Clem, Emily, and Lev Michael. 2016. Exploring typological diversity and its areal and genealogical basis in South America. Paper presented at Arealphonologie, Hanse-Wissenschaftskolleg, Germany.

Clements, George N., and Sylvester Osu. 2002. Explosives, implosives and nonexplosives: The linguistic function of air pressure differences in stops. *Laboratory phonology 7*, ed. by Carlos Gussenhoven and Natasha Warner, 299–350. Berlin: Mouton de Gruyter. DOI: 10.1515/9783110197105.2.299.

Cohn, Abigail. 1990. *Phonetic and phonological rules of nasalization*. Los Angeles: University of California, Los Angeles dissertation.

Constenla Umaña, Adolfo. 1981. *Comparative Chibchan phonology*. Philadelphia: University of Pennsylvania dissertation.

Costa, Consuelo de Paiva G. 2007. *Apynga rupigwa: Nasalização em Nhandewa-Guarani*. Campinas: UNICAMP dissertation.

D'Angelis, Wilmar da Rocha. 1999. Gradient versions of pre-, post-, and circum-oralized consonants in Kaingang (Brazil). *Proceedings of the 14th International Congress of Phonetic Sciences (ICPhS)*, San Francisco, 1043–46. Online: https://www.internationalphoneticassociation.org/icphs-proceedings/ICPhS1999/papers/p14_1043.pdf.

D'Angelis, Wilmar da Rocha. 2007. Sistema vocálico e escrita do Kaingang. *Línguas e culturas Macro-Jê*, ed. by Aryon Rodrigues and Ana Sueli Cabral, 85–96. Brasília: Ed. Universidade de Brasília.

Daly, John P. 1973. *A generative syntax of Peñoles Mixtec*. Mexico City: Summer Institute of Linguistics.

Do Bui, Bien. 2018. *Grammaire de l'amuzgo de Xochistlahuaca, langue otomangue orientale*. Paris: Université Paris-Sorbonne dissertation.

Dos Anjos, Zoraide. 2011. *Fonologia e gramática Katukina-Kanamari*. Amsterdam: Vrije Universiteit dissertation. [Published, Utrecht: LOT, #281.] Online: https://www.lotpublications.nl/Documents/281_fulltext.pdf.

Downing, Laura J. 2005. On the ambiguous segmental status of nasals in homorganic NC sequences. *The internal organization of phonological segments*, ed. by Marc van Oostendorp and Jeroen van de Weijer, 183–216. Berlin: Mouton de Gruyter.

Durvasula, Karthik. 2010. *Understanding nasality*. Newark: University of Delaware dissertation.

Eberhard, David M. 2009. *Mamaindê grammar: A Northern Nambikwara language and its cultural context*. Amsterdam: Vrije Universiteit dissertation.

Evans, Nicholas. 1995. Current issues in the phonology of Australian languages. *The handbook of phonological theory*, ed. by John Goldsmith, 723–61. Malden, MA: Blackwell.

Everett, Daniel L., and Barbara Kern. 1997. *Wari': The Pacaas Novos language of Western Brazil*. London: Routledge.

Flemming, Edward. 2007. Stop place contrasts before liquids. *Proceedings of the 16th International Congress of Phonetic Sciences (ICPhS)*, Saarbrücken, 233–36. Online: http://www.icphs2007.de/.

Flemming, Edward. 2017. Dispersion theory and phonology. *The Oxford research encyclopedia of linguistics*, ed. by Mark Aronoff. DOI: 10.1093/acrefore/9780199384655.013.110.

Flynn, Darin. 2012. Phonology 1: The distinctive features of speech sounds. Calgary: University of Calgary, ms.

Gabas, Nilson, Jr. 1989. Estudo fonológico da língua Karo (Arara de Rondônia). Campinas: UNICAMP master's thesis.

Girón, Jesús M. 2008. *Una gramática del Wã'nsöjöt (Puinave)*. Amsterdam: Vrije Universiteit dissertation. [Published, Utrecht: LOT, #185.] Online: https://www.lotpublications.nl/Documents/185_fulltext.pdf.

Girón, Jesús M., and W. Leo Wetzels. 2006. Tone in Wãnsöhöt (Puinave), Colombia. *Language endangerment and endangered languages: Linguistic and anthropological studies with special emphasis on the languages and cultures of the Andean-Amazonian border area* (Indigenous languages of Latin America), ed. by W. Leo Wetzels, 129–56. Leiden: Research School of Asian, African, and Amerindian Studies, Leiden University.

Gomez-Imbert, Elsa. 1997. *Morphologie et phonologie barasana: Approche non-linéaire*. Paris: Université Paris 8, Saint-Denis dissertation.

Gudschinsky, Sarah C.; Harold Popovich; and Frances Popovich. 1970. Native reaction and phonetic similarity in Maxakalí phonology. *Language* 46.77–88. DOI: 10.2307/412408.

Hamann, Silke, and Laura Downing. 2015. *NT revisited again: An approach to postnasal laryngeal alternations with perceptual Cue constraints. *Journal of Linguistics* 53.85–112. DOI: 10.1017/S0022226715000213.

Haudricourt, André-Georges. 2017 [1970]. Nasal and prenasalized consonants in the evolution of phonological systems, trans. by Alexis Michaud. Online: https://halshs.archives-ouvertes.fr/halshs-01631485, accessed October 1, 2018. [Original publication: Consonnes nasales et demi-nasales dans l'évolution des systèmes phonologiques. *Actes du Xe Congrès International des Linguistes*, 105–8. Bucharest: Editions de l'Académie de la République Socialiste de Roumanie, 1970.]

Hayes, Bruce, and Tanya Stivers. 2000. Postnasal voicing. Los Angeles: University of California, Los Angeles, ms.

Henderson, Eugénie J. A. 1965. The topography of certain phonetic and morphological characteristics of South East Asian languages. *Lingua* 15.400–434. DOI: 10.1016/0024-3841(65)90020-3.

Herbert, Robert K. 1986. *Language universals, markedness theory, and natural phonetic processes*. Berlin: Mouton de Gruyter.

Hercus, Luise. 1972. The pre-stopped nasal and lateral consonants of Arabana-Waŋgaŋguru. *Anthropological Linguistics* 14.293–305. Online: https://www.jstor.org/stable/30029330.

Hinskens, Frans; Roeland van Hout; and W. Leo Wetzels. 1997. Balancing data and theory in the study of phonological variation and change. *Variation, change and phonological theory*, ed. by Frans Hinskens, Roeland van Hout, and W. Leo Wetzels, 1–33. Amsterdam: John Benjamins.

Hubbard, Kathleen. 1995. 'Prenasalised consonants' and syllable timing: Evidence from Runyambo and Luganda. *Phonology* 12.235–56. DOI: 10.1017/S0952675700002487.

Hyman, Larry. 1975. Nasal states and nasal processes. *Nasalfest*, ed. by Charles A. Ferguson, Larry M. Hyman, and John J. Ohala, 249–64. Stanford, CA: Department of Linguistics, Stanford University.

Inkelas, Sharon, and Stephanie S. Shih. 2017. Looking into segments. *Proceedings of the 2016 Annual Meeting on Phonology*. DOI: 10.3765/amp.v4i0.3996.

Itô, Junko. 1986. *Syllable theory in prosodic phonology*. Amherst: University of Massachusetts, Amherst dissertation.

Iverson, Gregory K., and Joseph C. Salmons. 1996. Mixtec prenasalization as hypervoicing. *International Journal of American Linguistics* 62.165–75. Online: https://www.jstor.org/stable/1265774.

Jeong, Sunwoo. 2012. Directional asymmetry in nasalization: A perceptual account. *Studies in Phonetics, Phonology, and Morphology* 18.437–69. DOI: 10.17959/sppm.2012.18.3.437.

Jun, Jongho. 1995. *Perceptual and articulatory factors in place assimilation: An optimality theoretic approach*. Los Angeles: University of California, Los Angeles dissertation.

Kawasaki, Haruko. 1986. Phonetic explanation for phonological universals: The case of distinctive vowel nasalization. *Experimental phonology*, ed. by John J. Ohala and Jeri Jaeger, 81–103. Orlando: Academic Press.

Keyser, Samuel Jay, and Kenneth Noble Stevens. 2006. Enhancement and overlap in the speech chain. *Language* 82.33–63. DOI: 10.1353/lan.2006.0051.

Kindell, Gloria E. 1972. Kaingang phonemics. Appendix to *Die phonologische und grammatische Struktur der Kaingang Sprache*, by Ursula Wiesemann. The Hague: Mouton.

Lapierre, Myriam; Bernat Bardagil-Mas; and Andrés Salanova. 2016. The nasal consonants of Panará. Paper presented at the Workshop on the Structure and Constituency of the Languages of the Americas (WSCLA), Université du Québec à Montréal.

Lombardi, Linda. 1995. Laryngeal neutralization and syllable wellformedness. *Natural Language and Linguistic Theory* 13.39–74. DOI: 10.1007/BF00992778.

Mahecha, Dany. 2019. *Fonologia y gramatica Nikak*. Amsterdam: Vrije Universiteit dissertation, to appear.

Martins, Silvana A. 2004. *Fonologia e gramática Dâw*. Amsterdam: Vrije Universiteit dissertation. [Published, Utrecht: LOT, #98.] Online: https://www.lotpublications.nl/Documents/98_fulltext.pdf.

Merrill, John. 2015. Nasalization as a repair for voiced obstruent codas in Noon. Paper presented at the annual meeting of the Linguistic Society of America, Portland, OR, January 8–11, 2015.

Michaud, Alexis; Jacques Guillaume; and Robert L. Rankin. 2012. Historical transfer of nasality between consonantal onset and vowel: From C to V or from V to C? *Diachronica* 29.201–30. DOI: 10.1075/dia.29.2.04mic.

Navarro, Eduardo de Almeida. 2006. *Metodo moderno de Tupi Antigo*. São Paulo: Global.

Nevins, Andrew Ira, and Mário André Coelho da Silva. 2017. Maxakalí nasality and field recording with earbud microphony. *Revista de Estudos da Linguagem* 25.1011–42. DOI: 10.17851/2237-2083.25.3.1011-1042.

Nikulin, Andrey. 2016. Historical phonology of Proto-Northern Jê. *Journal of Language Relationship* 14.165–85. Online: http://www.jolr.ru/index.php?article=191.

Nikulin, Andrey. 2018. Algumas considerações sobre a fonologia do Proto-Maxakalí. Londrina: Universidade Estadual de Londrina, ms.

Ohala, John J. 1983. The origin of sound patterns in vocal tract constraints. *The production of speech*, ed. by Peter MacNeilage, 189–216. New York: Peter Springer.

Ohala, John J. 1997. Emergent stops. *Proceedings of the 4th Seoul International Conference on Linguistics*, 84–91.

Ohala, John J., and Manjari Ohala. 1993. The phonetics of nasal phonology: Theorems and data. *Phonetics and phonology, vol. 5: Nasals, nasalization, and the velum*, ed. by Marie K. Huffman and Rena Krakow, 225–49. New York: Academic Press.

Ospina Bozzi, Ana Maria. 2007. *Las estructuras elementales del Yuhup, lengua de la Amazonia Colombiana*. Paris: Université Paris 7, Denis Diderot dissertation, revised edition.

Oswalt, Robert L. 1961. *A Kashaya grammar (Southwestern Pomo)*. Berkeley: University of California dissertation.

Padgett, Jaye. 1994. Stricture and nasal place assimilation. *Natural Language and Linguistic Theory* 12.465–513. DOI: 10.1007/BF01118137.

Pessoa, Katia Nepomuceno. 2012. *Análise fonética e fonológica da língua krenak e abordagem preliminar de contos botocudo*. Campinas: UNICAMP dissertation.

Picanço, Gessiane Lobato. 2005. *Mundurukú: Phonetics, phonology, synchrony, diachrony*. Vancouver: University of British Columbia dissertation.

Piñeros, Carlos-Eduardo. 2003. Accounting for the instability of Palenquero voiced stops. *Lingua* 113.1185–1222. DOI: 10.1016/S0024-3841(02)00164-X.

Pulleyblank, Douglas. 1998. Introduction to nonlinear phonology. Vancouver: University of British Columbia, ms.

Ratliff, Martha. 2015. Word-initial prenasalization in Southeast Asia. *Languages of Mainland Southeast Asia*, ed. by N. J. Enfield and Bernard Comrie, 31–50. Berlin: De Gruyter Mouton.

Rice, Keren D. 1993. A reexamination of the feature [sonorant]: The status of 'sonorant obstruents'. *Language* 69.308–44. DOI: 10.2307/416536.

Riehl, Anastasia. 2008. *The phonology and phonetics of nasal obstruent sequences*. Ithaca, NY: Cornell University dissertation.

Rivierre, Jean-Claude. 1973. *Phonologie comparée des dialectes de l'extrème-sud de la Nouvelle Calédonie*. Marseille: Société d'Études Linguistiques et Anthropologiques de France.

Rodrigues, Aryon D. 1999. Macro-Jê. *The Amazonian languages*, ed. by Robert M. W. Dixon and Alexandra Y. Aikhenvald, 164–206. Cambridge: Cambridge University Press.

Roessler, Eva-Maria. 2008. Aspectos da gramática achê: Descrição e reflexão sobre uma hipótese de contato. Campinas: UNICAMP master's thesis.

Salanova, Andrés Pablo. 2001. A nasalidade em Mebengokre e Apinayé: O limite do vozeamento soante. Campinas: UNICAMP master's thesis.

Silva, Oziel Marques. 2003. A arquitetura das representações fonológicas dos empréstimos portugueses em Oro Mon (Wari' Norte, Rondônia). Guajará-Mirim: Universidade Federal de Rondônia master's thesis.

Singerman, Adam Roth. 2016. Nasal harmony and phonotactic well-formedness in Tupari. *International Journal of American Linguistics* 82.453–85. DOI: 10.1086/688603.

Solé, Maria-Josep. 2014. The perception of voice-initiating gestures. *Laboratory Phonology* 5.37–68. DOI: 10.1515/lp-2014-0003.

Solé, Maria-Josep. 2018. Articulatory adjustments in initial voiced stops in Spanish, French and English. *Journal of Phonetics* 66.217–41. DOI: 10.1016/j.wocn.2017.10.002.

Solé, Maria-Josep, and Ronald L. Sprouse. 2011. Voice-initiating gestures in Spanish: Prenasalization. *Proceedings of the 17th International Congress of Phonetic Sciences (ICPhS)*, Hong Kong, 72–75. Online: https://www.internationalphoneticassociation.org/icphs-proceedings/ICPhS2011/OnlineProceedings/SpecialSession/Session1/Sole/Sole.pdf.

Stanton, Juliet. 2017. *Constraints on the distribution of nasal-stop sequences: An argument for contrast*. Cambridge, MA: MIT dissertation.
Stanton, Juliet. 2018. Environmental shielding is contrast preservation. *Phonology* 35.39–78. DOI: 10.1017/S0952675717000379.
Steriade, Donca. 1993. Closure, release, and nasal contours. *Phonetics and phonology, vol. 5: Nasals, nasalization, and the velum*, ed. by Marie K. Huffman and Rena A. Krakow, 401–70. San Diego: Academic Press.
Steriade, Donca. 1997. Phonetics in phonology: The case of laryngeal neutralization. Los Angeles: University of California, Los Angeles, ms.
Steriade, Donca. 2008. The phonology of perceptibility effects. *The nature of the word*, ed. by Kristin Hanson and Sharon Inkelas, 151–79. Cambridge, MA: MIT Press.
Storto, Luciana. 1999. *Aspects of Karitiana grammar*. Cambridge, MA: MIT dissertation.
Thomas, Guillaume Pierre Yves. 2014. A split analysis of nasal harmony in Mbyá. *Revista Linguíftica* 10.75–105. Online: https://revistas.ufrj.br/index.php/rl/article/view/4605.
Van linden, An. 2019. Harakmbut. *Amazonian languages: An international handbook*, ed. by Patience Epps and Lev Michael. Berlin: De Gruyter Mouton, to appear.
Walker, Rachel. 1999. Guaraní voiceless stops in oral versus nasal contexts: An acoustical study. *Journal of the International Phonetic Association* 29.63–94. DOI: 10.1017/S0025100300006423.
Weinreich, Uriel; Marvin Herzog; and William Labov. 1968. Empirical foundations for a theory of language change. *Directions for historical linguistics: A symposium*, ed. by Winfred Lehmann and Yakov Malkiel, 97–195. Austin: University of Texas Press.
Westbury, John R. 1983. Enlargement of the supraglottal cavity and its relation to stop consonant voicing. *The Journal of the Acoustical Society of America* 74.1322–36. DOI: 10.1121/1.389236.
Westbury, John R., and Patricia A. Keating. 1986. On the naturalness of stop consonant voicing. *Journal of Linguistics* 22.145–66. DOI: 10.1017/S0022226700010598.
Wetzels, W. Leo. 2008. Thoughts on the phonological interpretation of {nasal, oral} contour consonants in some indigenous languages of South-America. *Alfa: Revista de Lingüística* 52.251–78. Online: https://periodicos.fclar.unesp.br/alfa/article/view/1500.
Wetzels, W. Leo. 2009. Nasal harmony and the representation of nasality in Maxakalí: Evidence from Portuguese loans. *Loan phonology*, ed. by Andrea Calabrese and W. Leo Wetzels, 241–70. Amsterdam: John Benjamins.
Wetzels, W. Leo. 2010. Word prosody and the distribution of oral/nasal contour consonants in Kaingang. *Linguistics and archaeology in the Americas: The historization of language and society*, ed. by Eithne Carlin and Simon van de Kerke, 253–70. Leiden: Brill.
Wiesemann, Ursula. 1964. Phonological syllables and words in Kaingang. *Völkerkundliche Abhandlungen, Band I: Beiträge zur Völkerkunde Südamerikas: Festgabe für Herbert Baldus zum 65. Geburtstag*, ed. by Hans Becher, 307–13. Hannover: Niedersächsisches Landesmuseum Abteilung für Völkerkunde.

[w.l.m.wetzels@vu.nl]
[a.nevins@ucl.ac.uk]

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