Effects of allophonic nasalization on NC clusters: a contrast-based analysis[*]

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1. Introduction

In many languages, sequences of nasal-consonant clusters are dispreferred (*NC_1VNC_2). In languages where this restriction is active, there are a number of attested repairs. For example, in many cases, NC_1 is realized as a plain nasal consonant (1); this process is well-known in the Bantu literature as Meinhof's Law. Other repairs include the realization of NC_2 as a plain oral consonant (2); this process is also known as the Kwanyama Law.

(1) *NC_1 nasalization in Ngaju Dayak (Blust 2012:372)*

- a. /ma**N+b**a**nd**o/ → [ma-**m**a**nd**o] 'turn against' (cf. [mam-bagi] 'divide')
- b. /ma**N+g**u**nd**u/ → [ma-**ŋ**u**nd**ul] 'wrap up' (cf. [maŋ-gila] 'drive crazy')

(2) *NC_2 oralization in Gurindji (McConvell 1988:138)*

- a. /ka**ɲɟ**u+**mp**al/ → [ka**ɲɟ**u-**p**al] 'across below' ([kajiɽa-mpal] 'across the north')
- b. /ka**nk**a+**mp**a/ → [ka**nk**a-**p**a] 'upstream' (cf. [kani-mpa] 'downstream')

In this paper, I address the following question: what is the nature of the markedness constraint that drives these alternations? There are two existing answers to this question. Many analysts (e.g. Alderete 1997, Blust 2012) claim that the alternations in (1–2) are examples of dissimilation driven by an OCP constraint, penalizing words containing more than one nasal-stop cluster. Others (Jones 2000, see also Herbert 1986) argue that these alternations are driven by a constraint on contrast: NC_1VNC_2 is perceptually dispreferred.

I argue, following Herbert and Jones, that (1–2) are responses to a constraint that penalizes insufficiently distinct contrasts. In NC_1VNC_2, anticipatory nasalization from NC_2 renders NC_1 insuficiently distinct from a plain nasal consonant. The repairs, then, are motivated by a desire to avoid insufficiently distinct N–NC contrasts. Arguments for this view

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come from the typology of nasal cluster effects. In section 2, I show that the contrast-based approach correctly predicts conditions on possible repairs to NC_1VNC_2. In sections 3 and 4, I show that the contrast-based approach correctly predicts implicational generalizations as to which NC_1VNC_2 sequences are repaired, as well as the locality of repairs. The alternative OCP-motivated analysis, by contrast, cannot account for these generalizations.

2. Motivating nasal cluster effects

The source of the cross-linguistic dispreference for NC_1VNC_2 can be linked to the fact that, in most languages, vowels preceding nasals are nasalized.[1] In most languages, then, the vowel that intervenes in an NC_1VNC_2 sequence will be nasalized. This is diagrammed in (3); the percentages in this diagram and others are for illustrative purposes only.

(3) *Vowel nasalization in NC_1VNC_2*

NC_1 | $V_{25\%}$ | $\tilde{V}_{75\%}$ | NC_2

The anticipatory vowel nasalization shown in (3) likely reduces important cues to the contrast between NC_1 and a plain nasal (N). Experimental work has shown that perception of the contrast between Ns and NCs is, at the very least, aided by the presence of a following vowel. For the contrast between Ns and voiced NCs (NDs), Beddor & Onsuwan (2003) have shown that, for speakers of Ikalanga (Bantu), presence of the appropriate external cues is essential to perception of the contrast. For accurate identification, Ns must be followed by nasal vowels and NDs by oral vowels. Work by Kaplan (2008) suggest that the presence of a following vowel is also an cue to the contrast between Ns and voiceless NCs (NTs).

Thus the dispreferred sequence, NC_1VNC_2, is one in which the N–NC_1 contrast is compromised. The claim is that nasal cluster effects occur in order to avoid this situation. To formalize this analysis, I make a simplifying hypothesis, to be revisited later: for the contrast between N and NC to be maximally distinct, N must be followed by a fully nasal vowel ($\tilde{V}$), and NC must be followed by a fully oral vowel. We can state this requirement as a MINDIST constraint (Flemming 2002), ΔV, as defined in (4).

(4) MINDIST N–NC = ΔV: For each contrasting N–NC pair, N must be followed by a fully nasal vowel ($\tilde{V}$) and NC must be followed by a fully oral vowel (V). One * for each violating pair.

A contrast that satisfies ΔV is [NCV] vs. [N$\tilde{V}$] (5). As NC is followed by a fully oral vowel and N is followed by a fully nasal vowel, the consonantal contrast is sufficiently distinct.

(5) *ΔV satisfied in [NCV] vs. [N$\tilde{V}$]*

NC | $V_{100\%}$ N | $\tilde{V}_{100\%}$

[1] Note that the extent of coarticulatory nasality varies by language (see e.g. Jeong 2012) and to some extent by context: this latter point will be addressed in section 3.

A pair of representations that violates ΔV is [NC_1VNC_2] vs. [$N_1\tilde{V}NC_2$] (6). While N_1 is followed by a fully nasal vowel, NC_1 is not followed by a fully oral vowel; anticipatory nasalization from NC_2 renders the contrast between N and NC_1 insufficiently distinct.

(6) *ΔV violated in [NC_1VNC_2] vs. [$N_1\tilde{V}NC_2$]*

NC_1	$V_{25\%}$	$\tilde{V}_{75\%}$	NC_2	N_1	$\tilde{V}_{100\%}$	NC_2

A question arises at this point. If anticipatory nasalization stemming from NC_2 reduces cues to the N–NC_1 contrast, why don't speakers avoid nasalizing the pre-NC_2 vowel? While this would maximize the cues to N–NC_1, it would also minimize cues to the contrast between NC_2 and a plain oral consonant (C). The quality of a preceding vowel is likely an important cue to the contrast between Cs and NCs: Beddor & Onsuwan (2003) have shown that, for Ikalanga speakers, rates of identification for voiced Cs (Ds) and NDs are highest if D is preceded by an oral vowel and ND is preceded by a nasal vowel. Thus while reducing the amount of nasal coarticulation in the vowel between the two NCs would enhance the cues to N–NC_1 (7a–b), it would reduce the cues to C–NC_2 (7a–c).

(7) *Enhancing cues to N–NC_1 reduces cues to C–NC_2*

a.	NC_1	$V_{25\%}$	→	$\tilde{V}_{50\%}$	NC_2	cues enhanced
b.	N_1	$\tilde{V}_{100\%}$			NC_2	cues reduced
c.	NC_1	$V_{100\%}$			C_2	

As shown above, in NC_1VNC_2 sequences, constraints on contrast conflict: it is impossible to simultaneously render NC_1 distinct from N and NC_2 distinct from C.

Having elaborated the motivation behind nasal cluster effects, we can now ask: when NC_1VNC_2 is banned, what is the set of possible repairs? A language might delete the nasal from either NC_1 or NC_2 (*oralization*), or it could delete the stop from either NC_1 or NC_2 (*nasalization*). A survey of 63 languages[2], drawing from previous literature, shows that these four repairs are attested (8). The preponderance of NC_1 nasalization is likely representative of the fact that there is a large pre-existing literature on Meinhof's Law.

(8) *Repairs to banned NC_1VNC_2*

Repair	Description (changes bolded)	No.	Example
a. NC_1 oralization	/$\mathbf{NC_1}$ V NC_2/ → [$\mathbf{C_1}$ V NC_2]	2	Timugon Murut (Blust 2012)
b. NC_2 oralization	/NC_1 V $\mathbf{NC_2}$/ → [NC_1 V $\mathbf{C_2}$]	11	Kwanyama (Herbert 1977)

[2]An appendix containing more information about the languages surveyed is available online at `http://web.mit.edu/juliets/www/nels46appendix.pdf`.

c. NC_1 nasalization	/$\mathbf{NC_1}$ V NC_2/ $\rightarrow$ [$\mathbf{N_1}$ V NC_2]	49	Ngaju Dayak (Blust 2012)
d. NC_2 nasalization	/NC_1 V $\mathbf{NC_2}$/ $\rightarrow$ [NC_1 V $\mathbf{N_2}$]	1	Gurindji, Western (McConvell 1988)

The typology of repairs is consistent with the predictions of a contrast-based and an OCP-motivated account. Under an OCP-motivated analysis, all repairs eliminate an NC. Under a contrast-based analysis, all repairs alleviate the perceptual problem posed by NC_1VNC_2. NC_1 oralization (8a) reduces the amount of nasality surrounding NC_1: presumably the contrast between C and N is less endangered by the presence of a following nasal vowel than is the contrast between NC and N. NC_2 oralization (8b) deletes the trigger of nasalization: in an NC_1VC_2 sequence, the intervening vowel is oral, and the N–NC_1 contrast is not compromised. NC_1 nasalization (8c) neutralizes the N–NC_1 contrast. Note that Jones (2000) argues that NC_2 nasalization (8d) does not improve perceptibility of N–NC_1, as vowels preceding Ns are still nasalized. In many languages, however, vowels preceding prevocalic nasals are less nasalized than those preceding NCs (e.g. Jeong 2012). Thus N–NC_1 has the potential to be more distinct in $NC_1VN_2(\dots)$, when N_2 is prevocalic, than in NC_1VNC_2.[3]

The contrast-based analysis predicts that NC_2 nasalization should be possible only if the language in question (i) exhibits less nasalization in $NC_1VN_2(\dots)$ than $NC_1VNC_2(\dots)$, (ii) prefers nasalization to oralization, and (iii) prefers to modify NC_2 rather than NC_1 (e.g. because NC_1 is part of the root but NC_2 is not). All three conditions are necessary. Without (iii), NC_2 would not be the target of the repair; without (ii), oralization would occur, as NC_2 oralization better solves the problem posed by NC_1VNC_2; and without (i), NC_2 nasalization would not occur, as its application would not render N–NC_1 more distinct. The western dialects of Gurindji appear to satisfy all of these conditions (see McConvell 1988 for discussion). To the extent that contrast-based account can predict the conditions that must hold for a language to exhibit NC_2 nasalization, this is a point in its favor. For the OCP-motivated account, by contrast, NC_2 nasalization is just another possible repair.

3. Asymmetries in repaired sequences

So far, I have introduced the factors that motivate nasal cluster effects, and provided a preliminary analysis. In this section, we will see that known phonetic asymmetries correctly predict generalizations regarding the kinds of NC_1VNC_2 sequences that are repaired.

3.1 Asymmetries in the extent of nasal coarticulation

Recall that the MINDIST constraint introduced in (4), ΔV, claims that N must be followed by a fully nasal vowel, and NC by a fully oral vowel, for the N–NC contrast to be distinct. In this section, I acknowledge the more realistic possibility that not all languages impose such a strict requirement. For example, a language might require N to be followed by a

[3] Given this, there is a prediction that some languages might disprefer NC_1VNC_2 and $NC_1VN_2\#$ but not NC_1VNC_2V. For an example of this pattern, see McConvell (1988) on Gurindji.

vowel that is only halfway nasal, and NC by one that is only halfway oral. We can state this requirement as a MINDIST constraint, $\Delta V_{\geq 50\%}$, as defined in (9):

(9) MINDIST N–NC = $\Delta V_{\geq 50\%}$: For each contrasting N–NC pair, N must be followed by a nasal vowel that is at least 50% nasal ($\tilde{V}_{\geq 50\%}$) and NC must be followed by a vowel that is at least 50% oral ($V_{\geq 50\%}$). One * for each violating pair.

Depending on the amount of nasalization in an intervening vowel, the contrast between NC_1VNC_2 and N_1VNC_2 may or may not satisfy $\Delta V_{\geq 50\%}$. The pair of representations in (10), for example, violates $\Delta V_{\geq 50\%}$, as the vowel intervening between the two NCs in (10a) is only 25% oral. The pair of representations in (11), however, satisfies $\Delta V_{\geq 50\%}$, as the vowel intervening between the two NCs in (11a) is 50% oral.

(10) *NC_1VNC_2 where V is 25% oral*

a. NC_1 | $V_{25\%}$ | $\tilde{V}_{75\%}$ | NC_2

b. N_1 | $\tilde{V}_{100\%}$ | NC_2

Violates $\Delta V_{\geq 50\%}$

(11) *NC_1VNC_2 where V is 50% oral*

a. NC_1 | $V_{50\%}$ | $\tilde{V}_{50\%}$ | NC_2

b. N_1 | $\tilde{V}_{100\%}$ | NC_2

Satisfies $\Delta V_{\geq 50\%}$

In a language where $\Delta V_{\geq 50\%}$ is undominated, we would expect for only the pair of representations in (10) to be modified at the expense of faithfulness constraints (see (12)). As the pair of representations in (11) satisfies $\Delta V_{\geq 50\%}$, no modification is necessary (see (13)). The inputs considered here contain predictable phonetic information; following Flemming (2008), I assume that the inputs to phonotactic grammar are phonetically realized.

(12) *$\Delta V_{\geq 50\%}$ violated, $NCV_{25\%}NC$ modified*

$NCV_{25\%}NC$ $N\tilde{V}NC$	$\Delta V_{\geq 50\%}$	FAITH
a. $NCV_{25\%}NC$ $N\tilde{V}NC$	*!	
☞ b. $N\tilde{V}NC$ $N\tilde{V}NC$		*

(13) *$\Delta V_{\geq 50\%}$ satisfied, $NCV_{50\%}NC$ not modified*

$NCV_{50\%}NC$ $N\tilde{V}NC$	$\Delta V_{\geq 50\%}$	FAITH
☞ a. $NCV_{50\%}NC$ $N\tilde{V}NC$		
b. $N\tilde{V}NC$ $N\tilde{V}NC$		*!

Note that modification of the pair of representations in (11) asymmetrically implies modification of the pair in (10). A strict MINDIST constraint, like ΔV (4), penalizes both (10) and (11); if ΔV is high-ranked, it will motivate modification of both. A less strict MINDIST constraint, like $\Delta V_{\geq 50\%}$, penalizes only (10); if $\Delta V_{\geq 50\%}$ is high-ranked, it will only motivated modification of (10). No MINDIST constraint, however, can penalize only (11).

This is important because, within a language, some Ns induce more nasal coarticulation than others. For example, when there is an asymmetry, languages exhibit temporally more extensive nasal coarticulation before NTs than they do before NDs (Beddor 2009). And as mentioned above, languages exhibit temporally more extensive coarticulation before non-prevocalic nasals than they do before prevocalic nasals (e.g. Schourup 1973). If a language employs a less restrictive MINDIST constraint, like $\Delta V_{\geq 50\%}$, we might expect to find these phonetic asymmetries reflected in the typology. Repairs to NC_1VNC_2 when the intervening vowel is less nasalized should asymmetrically imply repairs when the intervening vowel is more nasalized. As shown below, this prediction is correct.

3.1.1 Voicing in NC clusters

Cross-linguistically, the nasal portion of voiceless NC (NT) clusters is shorter than the nasal portion of voiced NC (ND) clusters. While N takes up the large majority of the total time allotted to ND, for NT the time is more or less equally divided between N and T. For phonetic data from a variety of languages, see e.g. Maddieson & Ladefoged (1993), Ladefoged & Maddieson (1996): 4.3, Riehl (2008), Coetzee & Pretorius (2010), Cohn & Riehl (2012). But although the duration of the nasal consonant varies according to the identity of the NC sequence, the overall duration of the velum opening gesture does not: N's duration is inversely correlated with the amount of anticipatory nasal coarticulation it induces. Short Ns induce more; long Ns induce less. See Beddor (2009: 789-795) for results demonstrating that this holds true for speakers of American English (also Cohn 1990); for evidence from other systems see Beddor (2009: 788). For our purposes, what is important is that we expect to find more nasalization pre-NT (where N is shorter) than pre-ND (where N is longer). This asymmetry is diagrammed schematically in (14).

(14) *Inverse correlation between N duration and extent of V nasalization*

NC_1 | $V_{55\%}$ | $\underbrace{\tilde{V}_{45\%} \mid N}_{\text{velum gesture}}$ | D

NC_1 | V | $\underbrace{\tilde{V}_{75\%} \mid N}_{\text{velum gesture}}$ | T

We might expect, then, for NC_2 voicing to have an effect on the relative distinctiveness of the $N–NC_1$ contrast. In (14a), the post-NC_1 vowel is less nasalized than it is in (14b). So $N–NC_1$ should be more distinct when NC_2 is voiced than it is when NC_2 is voiceless.

This asymmetry leads to a typological prediction. If a language repairs NC_1VND_2 in response to a MINDIST violation, this asymmetrically implies that it also repairs NC_1VNT_2. This prediction is hard to assess: in most descriptions, the role of NC_2 voicing in nasal cluster effects is not discussed. But in Mori Bawah (Blust 2012: 367-370), there is an asymmetry in the predicted direction. NC_1VNT_2 is repaired, but NC_1VND_2 is not (15).

(15) *NC_1 oralization in Mori Bawah*

a. *Triggered by NT_2*
   (i) /mo**N-s**o**ŋk**a/ → [mo-**s**o**ŋk**a] ‘arrange’
   (ii) /mo**N-t**a**mp**ele/ → [mo-**t**a**mp**ele] ‘hit, smack’

b. *Not triggered by ND_2*
   (i) /mo**N-s**o**mb**u/ → [mo**n-s**o**mb**u] ‘connect, join’
   (ii) /mo**N-t**o**nd**a/ → [mo**n-t**o**nd**a] ‘follow’

Note that in the model assumed here (Flemming 2008), where faithfulness constraints are assessed against phonetically specified inputs, NC_1 oralization is not the expected repair to *NC_1VNC_2. NC_1 oralization entails both the loss of a consonant and the loss of nasality on the preceding vowel, resulting in a more salient, and therefore less faithful change (Steriade 2009), than NC_1 nasalization. Here I assume that NC_1 oralization is preferred because any other repair would result in the deletion of a root segment; more broadly, the assumption is that morphological considerations can take priority over P-map faithfulness.

3.1.2 Vocalic context of N_2

So far, we have focused our attention solely on repairs to NC_1VNC_2. The analysis developed to explain why many languages ban these sequences, though, predicts that NC_1VN_2V should be dispreferred as well, as prevocalic Ns also induce anticipatory nasalization.

But this prediction comes with a caveat: N’s vocalic context influences the amount of nasalization that it induces. It has been documented for many languages that prevocalic Ns induce less nasality in a preceding vowel than do non-prevocalic Ns. A survey of nasalization patterns compiled by Jeong (2012) documents this pattern for French and Modern Greek; Krakow (1993) documents it for American English; Herbert (1977) for a number of languages, including Pashto, Malagasy, and Delaware; and Schourup (1973:191) concludes, on the basis of a large typological survey, that “in no language examined are vowels nasalized before prevocalic nasals when they are not also nasalized before all preconsonantal and word-final nasals.” This means that most, if not all, languages, exhibit the asymmetry schematized below: in $NC_1VN_2(\ldots)$ sequences, the intermediate vowel is more nasalized when N_2 is non-prevocalic (16) than it is when N_2 is prevocalic (17).

(16) *Intervening vowel more nasalized when N_2 is non-prevocalic*

NC_1	$V_{25\%}$	$\tilde{V}_{75\%}$	NC_2	N_1	$\tilde{V}_{100\%}$	NC_2

(17) *Intervening vowel less nasalized when N_2 is prevocalic*

NC_1	$V_{50\%}$	$\tilde{V}_{50\%}$	N_2V	N_1	$\tilde{V}_{100\%}$	N_2V

Given the asymmetry schematized above, we might expect for $N–NC_1$ to be more distinct when N_2 is prevocalic, as the intervening vowel is less nasalized than it is when N_2

is non-prevocalic. This leads to a typological prediction: if a language repairs NC_1VN_2V, where N–NC_1 is more distinct, it must also repair NC_1VNC_2, where N–NC_1 is less distinct. As shown in (18), this prediction is almost completely correct. Of the 63 languages surveyed, 30 languages ban both NC_1VNC_2 and NC_1VN_2V; 32 ban NC_1VNC_2 only.

(18) *Contexts of nasal cluster effects (* = effects, ✓ = no effects)*

	*NC_1VN_2V	✓NC_1VN_2V
*NC_1VNC_2	30	32
✓NC_1VNC_2	1	*n.a.*

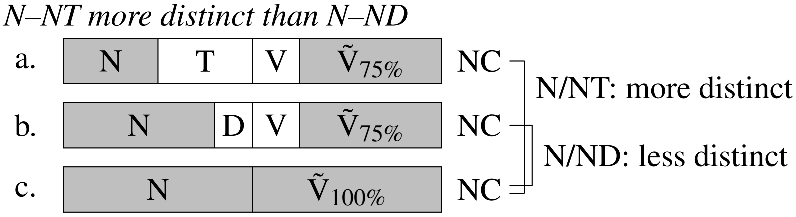
The one language that bans NC_1VN_2V only is Bolia (Niger-Congo; Mamet 1960, Meeussen 1963). In Bolia, however, this restriction is only visible when the plural morpheme /ɲɟ/ is realized as [ɲ] preceding a VNV-initial word. Further details of the language are necessary to determine if there is an available analysis that can make sense of this apparent exception.

3.2 On the role of NC's oral release

In section 3.1, we saw that the identity of NC_2 can play a decisive role in determining whether or not nasal cluster effects are motivated. In this subsection, we will see that the identity of NC_1 plays a role as well.

The discussion up to this point has focused on the importance of external (or transitional) cues to the N–NC contrast, but internal cues also play an important role. Beddor & Onsuwan (2003) have shown that, for Ikalanga speakers, an additional cue to the N–ND contrast is the presence of ND's oral closure and release. As the oral portion of ND increases in duration and burst amplitude, listeners become less likely to identify it as N and more likely to identify it as ND. Extrapolating from this, we can infer that the longer the oral portion of NC (and the louder its release), the more distinct the N–NC contrast will be. As noted in section 3.1, voiceless NCs (NTs) have a longer oral portion than do voiced NCs (NDs), so we might expect for N–NT to be more distinct than N–ND, even if external cues to the contrast are reduced (see (19) for a schematic illustration).

(19) *N–NT more distinct than N–ND*



So far, the MINDIST constraints that have been introduced refer only to the external cues to the N–NC contrast, i.e. the quality of the vowels that follow. To acknowledge the role of internal cues, we can write a disjunctive MINDIST constraint, requiring the presence of one out of a number of cues (see Flemming 2002: 57ff). For example, we could say that for the N–NC contrast to be sufficiently distinct, either sufficient external cues or a significant difference in the duration of consonantal orality must be present (21).

(20) MinDist N–NC = $\Delta V_{\geq 50\%}$ or ΔLongOrality: For N–NC to be sufficiently distinct, either (i) N must be followed by a vowel that is at least 50% nasal and NC by a vowel that is at least 50% oral, or (ii) NC's oral portion must make up at least 50% of its total duration. A * for each violating pair.

The contrast between (19a–c) satisfies $\Delta V_{\geq 50\%}$ or ΔLongOrality: even though NT is not followed by a vowel that is at least 50% oral, 50% of the NC sequence is oral. The contrast between (19b–c), however, violates $\Delta V_{\geq 50\%}$ or ΔLongOrality: ND is neither followed by a vowel that is at least 50% oral, nor is 50% of the consonantal sequence oral.

If $\Delta V_{\geq 50\%}$ or ΔLongOrality is undominated, assuming the phonetics in (19), we would expect for ND_1VNC_2 to be modified (21), but for NT_1VNC_2 to be faithful (22).

(21) $\Delta V_{\geq 50\%}$ or ΔLongOrality *violated, NDV$_{25\%}$NC modified*

NDV$_{25\%}$NC N$\tilde{V}$NC	$\Delta V_{\geq 50\%}$ or ΔLongOrality	Faith
a. NDV$_{25\%}$NC N$\tilde{V}$NC	*!	
☞ b. N$\tilde{V}$NC N$\tilde{V}$NC		*

(22) $\Delta V_{\geq 50\%}$ or ΔLongOrality *satisfied, NTV$_{25\%}$ not modified*

NTV$_{25\%}$NC N$\tilde{V}$NC	$\Delta V_{\geq 50\%}$ or ΔLongOrality	Faith
☞ a. NTV$_{25\%}$NC N$\tilde{V}$NC		
b. N$\tilde{V}$NC N$\tilde{V}$NC		*!

Under a contrast-based analysis, the opposite asymmetry cannot be derived. While it is possible to write a MinDist constraint that can penalize ND_1VNC_2 and NT_1VNC_2 (e.g. ΔV, defined in (4)), as well as a MinDist constraint that penalizes only ND_1VNC_2, it is impossible to write a MinDist constraint that penalizes only the more distinct N–NC_1 contrast in NT_1VNC_2. This makes a typological prediction. If a given language repairs NT_1VNC_2 in response to a MinDist violation, this implies that it must also repair ND_1VNC_2.

This prediction is difficult to assess, for reasons that are completely consistent with the discussion above: there are just not that many systems that repair NT_1VNC_2. For example, while NC_1 nasalization has consistently targeted ND_1 in Bantu, it has never targeted NT_1. Herbert (1977: 365) attributes this to the facts discussed above: he notes that "in a post-nasal environment, the voiced stops evidence the most reduction and are therefore the most susceptible to nasalization... voiceless stops and fricatives are more distinctive in this environment." In the small number of languages that do repair NT_1VNC_2, confounding factors prevent us from finding an asymmetry. In Gurindji (McConvell 1988) and other Australian languages in the survey, for example, obstruent voicing is not distinctive.

There is, however, some evidence from Ngaju Dayak (Blust 2012) that the duration of NC_1's oral component plays a role in the motivation of nasal cluster effects. In Ngaju Dayak, the rate of application of NC_1 nasalization varies according to NC_1's place of articulation. As shown in (23), bilabial NCs are targeted more often than palatals and velars.[4]

[4]The data for alveolars have been omitted, as there are very few /d/-initial CVNCVC bases. While Blust (2012: 374) claims that 50% of alveolar NCs are targeted, this is based on a sample size of four forms.

(23) *Ngaju Dayak rates of NC_1 nasalization by PoA (after Blust 2012: 373-374)*

PoA	Targeted	Not targeted	Rate of application
Bilabial (b–)	63	2	94%
Palatal (dʒ–)	2	11	15%
Velar (g–)	16	9	64%

Although this has not been specifically documented for Ngaju Dayak, a fairly uniform cross-linguistic observation is that, the further back a stop's place of articulation, the longer its VOT (Maddieson 1996). In (23), we find that the rate of NC_1 nasalization is inversely correlated with the stop's VOT. Stops that generally have shorter VOTs (i.e. bilabials) are more frequent targets; those that generally have longer VOTs (i.e. palatal affricates) are less frequent targets. Assuming that stops with longer VOTs (or more generally, more salient releases) are more distinct from nasals, the data in (23) are completely consistent with the predictions of a contrast-based account. Less distinct N–NC_1 contrasts are targeted more often by NC_1 nasalization; more distinct N–NC_1 contrasts are targeted less often.[5]

3.3 The role of homorganicity

In some systems, nasal cluster effects only occur when one of NC_1 or NC_2 (which one depends on the language) is homorganic. In Nhanda, for example, NC_2 oralization occurs when NC_1 is homorganic (24a), but does not occur when NC_1 is heterorganic (24b). The data below are from Blust (2012: 376); see Blevins (2001) for the original description.

(24) *NC_2 oralization in Nhanda*

a. *Occurs when NC_1 is homorganic*
   (i) mi**njdʒ**u-**g**u 'purse-ERG'
   (ii) wu**mb**a-**g**ula 'hide-AMB'

b. *Does not occur when NC_1 is heterorganic*
   (i) thu**rnb**a-**ŋg**u 'dove-ERG'
   (ii) wu**ɲjb**a-**ŋg**ula 'whistle-AMB'

Although phonetic differences between homorganic and heterorganic NCs are not widely discussed in the literature, work by Slis (1974) shows that, in Dutch, heterorganic clusters are slightly longer than are homorganic clusters. While it is unclear how the extra duration afforded to heterorganic NC clusters is distributed between N and C, one possibility is that things scale: the Cs in homorganic clusters are shorter than those in heterorganic clusters, and the Ns in homorganic clusters are shorter than those in heterorganic clusters (for some evidence that the latter part of this is true, see Fletcher et al. 2010 on Bininj Gun-wok).

If this is the case, then we potentially can say something about the role of homorganicity in triggering nasal cluster effects. If the Cs in homorganic NC clusters are shorter than

[5]In a number of Bantu languages, only velar NC_1 undergoes NC_1 nasalization; see Meeussen (1963). Without knowing about the phonetics of velar NC clusters in these languages, it's hard to know what to make of this. Compounding this difficulty is the fact that NC_1 nasalization in most Bantu languages is unproductive.

the Cs in heterorganic NC clusters, then homorganic N–NC_1 might be less distinct than heterorganic N–NC_1 in the NC_1VNC_2 context (see section 3.2). And if the Ns in homorganic NC clusters are shorter than the Cs in heterorganic NC clusters, then homorganic NC_2 might induce more anticipatory coarticulation than heterorganic NC_2, and more greatly endanger the cues to N–NC_1 (see section 3.1.1). Given this, the homorganicity requirement has the same explanation as the rest of the asymmetries discussed in this section: nasal cluster effects are first observed in contexts where the N–NC_1 contrast is less distinct.

3.4 Are there alternatives?

In this section, we have seen that a contrast-based analysis correctly predicts several implicational generalizations regarding the types of $NC_1VN_2(\ldots)$ sequences repaired (25).

(25) *Verified predictions of the contrast-based account*

a. Repair of NC_1VND_2 implies repair of NC_1VNT_2.
b. Repair of NC_1VN_2V implies repair of NC_1VNC_2.
c. Repair of NT_1VNC_2 implies repair of ND_1VNC_2.

An OCP-motivated analysis of nasal cluster effects cannot predict the generalizations in (25), nor is it clear that it could account for any of them in a principled manner. The generalization in (25b) is particularly difficult: while the ban on NC_1VNC_2 can plausibly be analyzed as an OCP effect, the ban on NC_1VN_2V cannot be. It is difficult to explain, under an OCP-motivated analysis, why repair of NC_1VN_2V implies satisfaction of the OCP constraint. Furthermore, even if it were possible to engineer an OCP constraint that could penalize both NC_1VNC_2 and NC_1VN_2V, without further amendment this constraint would not make predictions about directionality: it would also penalize N_1VNC_2V. This is not the empirical result we want: restrictions on NC_1VN_2V are widely discussed in the literature, but restrictions on N_1VNC_2V are not. This directional asymmetry is, however, predicted by a contrast-based account. In N_1VNC_2V, all else equal, NC_2 will be preceded by a nasalized vowel and followed by an oral vowel, rendering it maximally distinct from N and C.

4. Locality

Another area where the contrast-based account makes testable predictions regards the locality of nasal cluster effects. The analysis developed above claims that these effects are local: when NC_1 is followed by an acoustically nasalized vowel, cues to the N–NC_1 contrast are compromised. So if something were to intervene between NC_1 and NC_2 to block the spread of nasality, we would not expect to find nasal cluster effects. The prediction here is that if non-local nasal cluster effects exist, then the set of possible interveners should be limited to the set of segments that nasality can spread through. In almost all languages surveyed, this prediction is vacuously true: nasal cluster effects are only transvocalic.

The one exception to this generalization is Gurindji (Pama-Nyungan, McConvell 1988). As with all other languages, nasal cluster effects can apply locally. What sets Gurindji apart is that nasal cluster effects can also apply apparently non-locally, but only when certain kinds of segments intervene. As shown in (26), non-local application of NC_2 oralization can occur across all and only continuant continuants.[6] Beyond this constraint on intervening material, NC_2 oralization in Gurindji is unbounded (see McConvell 1988: 144).

(26) *Non-local NC_2 oralization*

a. ja**ŋk**i-wu**p**alŋ ‘to avoid asking’ (cf. ɟalŋak-kumpalŋ ‘to avoid riding’)
b. ɟawuɾa-**ɲ-k**ari-wu**ɟ**a ‘with another thief’ (cf. ŋaɟi-wunɲɟa ‘with father’)

McConvell does not address the phonetics of nasality, but the set of segments that can intervene in NC_2 oralization mirrors known generalizations about the typology of nasal spreading (e.g. Schourup 1973, Walker 2000). These generalizations are illustrated in (27), where the ability of nasality in a given language to spread through a segment type with some value *x* implies its ability to spread through all segment classes with lower values.

(27) *Implicational hierarchy in nasal spreading (adapted from Walker 2000: 26)*

$\boxed{1}$ Vowels $\boxed{2}$ Glides $\boxed{3}$ Liquids $\boxed{4}$ Fricatives $\boxed{5}$ Stops $\boxed{6}$

high ⟷ (compatibility with nasalization) ⟷ low

Given this, one interpretation of the facts in (26) is that nasality spreads through segment types with a value of 4 or lower (i.e. liquids, glides, and vowels) in Gurindji. But in the $NC_1(\ldots)NC_2$ context, the spread of nasality from NC_2 is prevented through deletion of N_2, in order to avoid compromising the cues to the N–NC_1 contrast.[7] Under this interpretation, nasal cluster effects in Gurindji are, as in all other known languages, exclusively local.

It is common for dissimilatory effects to be contextually restricted (e.g. to adjacent syllables in Woleaian; Suzuki 1998: 127-134 and references there). But accounting for the Gurindji pattern, where the application of nasal cluster effects depends on what kind of material intervenes, is difficult for an OCP-motivated analysis. It is incredibly uncommon, if not unattested, for the application of an OCP constraint to depend on the nature of the material that intervenes between the offending (sequences of) segments.[8] An OCP constraint capable of accounting for the Gurindji pattern would have to place restrictions on the kind of material that can intervene between the two NCs. This move is unwarranted elsewhere.

[6] A process that lenites underlyingly intervocalic /p/ and /k/ is evident in some of these forms: compare underlying /kumpalŋ/ to its lenited realization, [wupalŋ], in (26b). NC_2 oralization can apply across lenited Cs, but the Cs that result from NC_2 oralization cannot be lenited (e.g. the resulting [p] in [wupalŋ]).

[7] This analysis, when fleshed out, amounts to a claim that NC_2 oralization in Gurindji is an example of *trigger deletion*, a type of non-myopic interaction that has been argued to be unattested (see McCarthy 2009: 12). I leave a fuller elaboration of the analysis and its implications to future work.

[8] Cser (2010) claims that, in Latin, intervening non-coronals block l-dissimilation, citing examples like *legalis* ‘legal.’ There are, however, other forms in which intervening non-coronals do not block l-dissimilation, like *vulgaris* ‘extended to all.’ As dissimilation can also fail to apply across coronals (e.g. *letalis*, ‘lethal’), further work is necessary to compare rates of dissimilation failure across different interveners.

5. Discussion and conclusions

If we treat nasal cluster effects as perceptually-motivated contrast neutralization, many superficially dissimilar facts about the typology fall out. The contrast-based analysis correctly predicts a number of typological generalizations, ranging from conditions on possible repairs, to asymmetries in the types of sequences repaired, to restrictions on the locality of repairs. The true strength of the contrast-based approach is that it provides a unified account of these seemingly unrelated generalizations, based on a small set of well-established phonetic facts. The take-home point, then, is that nasal cluster effects occur in response to a constraint that penalizes insufficiently distinct contrasts. No existing alternative can account for all of the generalizations that the contrast-based analysis can predict.

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