Optimality Theory in Phonology

A Reader | Edited by John J. McCarthy

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Austronesian Nasal Substitution and Other NÇ̥ Effects

Editor's Note

It is a fundamental result of OT that the same markedness constraint can be satisfied in different ways in different languages or even under different conditions within a single language (see McCarthy 2002: 93ff for further explanation). This chapter was the first work to exemplify this result for segmental phonology. Moreover, with its attention to the substantive basis for the *NÇ̥ markedness constraint, it helped to initiate the study of functionally based phonological models within OT. It should therefore be read in conjunction with chapter 15, which also addresses this topic.

Introduction

Nasal substitution occurs in Austronesian languages as far flung as Chamorro (Topping 1969, 1973) and Malagasy (Dziwirek 1989), as well as in several African languages (Rosenthall 1989: 50). However, it is most famous for its appearance in the Indonesian *məN*-prefixation paradigm (see e.g., Halle and Clements 1983: 125). Nasal substitution refers to the replacement of a root-initial voiceless obstruent by a homorganic nasal (1a). If the obstruent is voiced, a homorganic cluster results instead (1b). As illustrated by the data in (1c), NÇ̥ (nasal/voiceless obstruent) clusters are permitted root internally:

(1)	a.	/məN+pilih/	məmilih	'to choose, to vote'
		/məN+tulis/	mənulis	'to write'
		/məN+kasih/	məŋasih	'to give'
	b.	/məN+bəli/	məmbəli	'to buy'
		/məN+dapat/	məndapat	'to get, to receive'
		/məN+ganti/	məŋganti	'to change'

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c. əmpat 'four'
untuk 'for'
muŋkin 'possible'

The standard analysis invokes two ordered rules to generate the single nasal from the underlying pair of segments: nasal assimilation, followed by a rule of root-initial, post-nasal, voiceless consonant deletion (e.g., Topping 1973: 49; Onn 1980: 15; Herbert 1986: 252; Teoh 1988: 156; though cf. Lapoliwa 1981: 111, Uhrbach 1987: 72). In this paper, I reanalyze nasal substitution as fusion of the nasal and voiceless obstruent, driven by a phonetically motivated constraint that disallows nasal/voiceless obstruent clusters (*NC̥).

Nasal substitution is just one of a range of processes that languages make use of to rid themselves of NC̥ clusters, which also include post-nasal voicing, nasal deletion, and denasalization. Permutation of the constraint rankings posited for nasal substitution is all that is needed to provide a unified account of these NC̥ effects. Nasal substitution occurs when the anti-fusion constraint Linearity is dominated by *NC̥ and the other Faithfulness constraints. Each of the other NC̥ effects is similarly generated when the Faithfulness constraint that it violates falls to the bottom of the hierarchy. Especially strong motivation for a unified treatment of the NC̥ effects comes from the existence of languages in which two of the processes act in a 'conspiracy' (Kisseberth 1970) to eliminate NC̥ clusters. In this paper I provide evidence of conspiracies between nasal substitution and each of nasal deletion and post-nasal voicing, as well as between post-nasal voicing and each of nasal deletion and denasalization.

1 *NC̥

In a wide variety of languages, NC̥ clusters seem to be disfavoured. That is, Input NC (nasal/voiced obstruent) sequences are represented faithfully in the Output, while NC̥'s are somehow altered. The usual result is for the obstruent to be voiced, though there are other possibilities, as enumerated in the Introduction, and below.

The fact that these NC̥ effects, in particular post-nasal voicing, occur with such frequency has long been assumed to stem from the ease of articulation of NC̬ clusters relative to NC̥ (see Kenstowicz and Kisseberth 1979: 37, Herbert 1986), but without a specific hypothesis about the articulatory difficulty inherent in NC̥ being proposed. However, Huffman's (1993: 310) observation that the raising of the velum occurs very gradually during a voiced stop following a nasal segment, with nasal airflow only returning to a value typical of plain obstruents during the release phase, suggests an articulatory basis for an *NC̥ constraint, since an NC̬ cluster allows a more leisurely raising of the velum than an NC̥. Put another way, an NC̥ cluster requires an unnaturally quick velar closure. The fact that this constraint is asymmetrical (i.e. *NC̥, and not *C̥N – see the discussion in section 5) can then be understood in light of Zuckerman's (1972) finding that 'the velum can be lowered more quickly and with greater precision than it can be raised' (Herbert 1986: 195).[1] Ohala and Ohala (1991: 273 – cited in Ohala and Ohala 1993: 239) provide the following complementary perceptually oriented explanation for nasal deletion in the NC̥ configuration:

(2)

> Among the auditory cues for a voiced stop there must be a spectral and amplitude discontinuity with respect to neighbouring sonorants (if any), low amplitude voicing during its closure, and termination in a burst; these requirements are still met even with velic leakage during the first part of the stop as long as the velic valve is closed just before the release and pressure is allowed to build up behind the closure. However, voiceless stops have less tolerance for such leakage because any nasal sound – voiced or voiceless – would undercut either their stop or their voiceless character.

See also Hayes (1999) for a somewhat different hypothesis about the phonetic grounding of *NC̥.

Additional evidence for the markedness of NC̥ clusters comes from Smith's (1973: 53) observation that they emerged considerably later than NC's in his son's speech, with the nasal consonant of adult NC̥'s being deleted in the child's production. This pattern has also been observed in the speech of learners of Greek (Drachman and Malikouti-Drachman 1973) and Spanish (Vogel 1976). Thus, data from typology, phonetics, and acquisition all converge on the existence of a universal, but violable, *NC̥ constraint:

(3) *NC̥
No nasal/voiceless obstruent sequences

One of the primary strengths of a constraint-based theory like Optimality Theory is that phonetically grounded contextual markedness statements like *NC̥ can be directly incorporated into the phonology (Mohanan 1993: 98, Prince and Smolensky 1993: §5, Archangeli and Pulleyblank 1995; see Flemming 1995, Hayes 1999, Jun 1995, Kirchner 1995, and Steriade 1995b for extensive development of this sort of approach within Optimality Theory). In what follows, I demonstrate how the interaction between *NC̥ and constraints on Input–Output Correspondence creates grammars that generate nasal substitution, as well as the other NC̥ effects.[2]

2 *NC̥ and Segmental Correspondence

2.1 Segmental fusion

Rather than positing discrete steps of nasal assimilation and voiceless consonant deletion, or of complete assimilation of the voiceless consonant to the nasal and degemination (Uhrbach 1987: 72; cf. Herbert 1986: 252), I assume that the relationship between Input *məN+pilih* and Ouput *məmilih* is mediated by fusion, or coalescence of segments (Lapoliwa 1981: 111).

To formalize the fusional Input–Output mapping, I draw on McCarthy and Prince's (1994b, 1995, 1999) proposal that the relationship between Input and Output is directly assessed by constraints on Correspondence. In this theory, deletion is penalized by a MAX constraint that demands that every segment in the Input map to a segment in the Output, in other words, that every Input segment have an Output correspondent. Fusion is a two-to-one mapping from Input to Output: two Input segments stand in correspondence with a single Output segment (McCarthy and Prince 1995; see also Gnanadesikan 1995 and Lamontagne and Rice 1995). This mapping satisfies MAX, as shown in (4), where subscripting is used to indicate the crucial correspondence relationship:

(4) $\text{mə}N_1\text{+}p_2\text{ilih}$ (Input) $\text{məm}_{1,2}\text{ilih}$ (Output)

Even though fusion satisfies MAX, it does incur violations of other constraints. At the featural level, fusion between non-identical segments violates constraints demanding Identity between Input and Output segments (see section 3 below for elaboration of Identity constraints, and for an example in which NC̥ fusion is overruled by a Featural Identity constraint). Because fusion incurs violations of Featural Identity, it tends to occur between segments that are identical, or nearly so (cf. McCarthy and Prince 1993a: 163, where fusion is restricted to identical elements). However, even fusion between identical segments is not automatic or universal, so it must violate at least one constraint other than Featural Identity. One such constraint is LINEARITY, which is independently needed in Correspondence Theory to militate against metathesis.[3] McCarthy and Prince's (1995) formulation of LINEARITY is as in (5), where S_1 and S_2 refer to Input and Output strings (or any other string of correspondent segments, such as Base and Reduplicant):

(5) LINEARITY
S_1 reflects the precedence structure of S_2, and vice versa.

In the fusional I,O relationship depicted in (4), /N/ precedes /p/ in the Input, but not in the Output, so LINEARITY is violated.[4] To command a violation of LINEARITY, *NC̥ must be ranked above the Faithfulness constraint, as illustrated in the tableau in (6). Unless noted otherwise, all of the following tableaux apply to Indonesian.

(6) Nasal substitution: *NC̥ ≫ LIN

Input: $\text{mə}N_1\text{+}p_2\text{ilih}$	NC̥	LIN
a. ☞ $\text{məm}_{1,2}\text{ilih}$		*
b. $\text{məm}_1p_2\text{ilih}$	* !	

2.2 Morphological conditions on fusion

The fact that fusion violates LINEARITY leads to a straightforward account of the lack of root-internal nasal substitution in Indonesian. McCarthy and Prince (1994b)

and Urbanczyk (1996) show that a large number of disparate phonological phenomena, reduplicative and otherwise, result from stricter Faithfulness requirements within the root than elsewhere in the word. The ranking of a root-specific LINEARITY (ROOTLIN) above *NC̥ will block substitution within the root:

(7) Root-internal NC̥ tolerance: ROOTLIN ≫ *NC̥

$\text{ə}m_1p_2\text{at}$	ROOTLIN	*NC̥	LIN
a. ☞ $\text{ə}m_1p_2\text{at}$		*	
b. $\text{əm}_{1,2}\text{at}$	* !		*

ROOTLIN rules out fusion within the root because fusion destroys the precedence relationship between Input root segments /m/ and /p/ (7b). Since the nasal in /məN+pilih/ is not part of the root, nasal substitution across the morpheme boundary does not disturb the precedence structure of root elements, and ROOTLIN is obeyed.[5]

ROOTLIN is effective in blocking substitution within the root because it is a constraint on the relationship between Input and Output strings, rather than between individual Input and Output segments, or features. If we attempted to rule out root-internal fusion with a root-specific constraint on Identity between Input and Output correspondents, substitution in the middle of the root and at the beginning of it would be assessed equally, since both would turn a voiceless obstruent belonging to the root into an Output nasal. As Donca Steriade (p.c.) has pointed out, it is not at all clear how a theory with Faithfulness constraints demanding only faithful segmental and featural parsing would handle these and other segmental 'derived environment' effects (see Kiparsky 1993 for recent discussion). The main difference between Indonesian nasal substitution, and more commonly discussed cases such as the Sanskrit Ruki rule and Finnish assibilation, is that the latter involve segmental change, rather than segmental fusion. However, if linearity is generalized to sub-segmental elements, such that it forces their underlying precedence relationship to be maintained, and if these cases can all be analyzed as involving partial segmental overlap, then root-specific rankings of sub-segmental linearity would generate non-derived environment blocking effects. Clearly, a great deal of work needs to be done to determine the empirical coverage of root-specific LINEARITY constraints, but it seems plausible that the ranking of morpheme-specific Faithfulness constraints above phonotactic constraints is the source of this sort of phenomenon.

2.3 Segmental deletion and insertion

So far we have only considered candidates with and without NC̥ fusion. Deletion and epenthesis could also satisfy *NC̥, without incurring violations of LINEARITY. This means that in Indonesian, the constraints MAX and DEP, which are violated by deletion and epenthesis respectively (McCarthy and Prince 1995), must be ranked above LINEARITY. In fact, these constraints must be placed even higher in the hierarchy, above *NC̥, since neither deletion nor epenthesis is used to resolve *NC̥ violations root-internally, where fusion is ruled out by RootLin:

(8) Deletion and epenthesis blocked by Max, Dep ≫ *NC̥

əmpat	Max	Dep	*NC̥
a. ☞ əmpat			*
b. əpat	* !		
c. əməpat		* !	

Though neither deletion nor epenthesis is resorted to in Indonesian to avoid *NC̥ violations, permutation of the rankings of these constraints (Prince and Smolensky 1993: §6) predicts the existence of other languages in which Max and Dep are dominated by *NC̥ and the other Faithfulness constraints, producing NC̥ deletion and NC̥ epenthesis.

Examples of segmental deletion in the NC̥ configuration include the aforementioned cases of child English (Smith 1973: 53), child Greek (Drachman and Malikouti-Drachman 1973), and child Spanish (Vogel 1976). Amongst the adult languages with NC̥ deletion is the Kelantan dialect of Malay, which differs from standard Johore Malay in that it lacks nasals before voiceless obstruents, though it permits homorganic NC̥ clusters (Teoh 1988). This pattern is replicated in African languages such as Venda (Ziervogel, Wetzel, and Makuya 1972: cited in Rosenthall 1989: 47), Swahili, and Maore (Nurse and Hinnebusch 1993: 168), as well as several others cited by Ohala and Ohala (1993: 239).[6]

What unites all of these examples is that the nasal, rather than the obstruent, is deleted. This parallels the nasal/fricative cluster effects detailed in Padgett (1994), which sometimes involve nasal, but never fricative, deletion. One way to capture this is to posit a fixed ranking of an obstruent-specific Max constraint (ObsMax) above the nasal-specific NasMax. Establishing the phonetic basis and typological correctness of this presumed fixed ranking is beyond the purview of this study, but it can be noted that its universality is supported by the observation that a few languages lack nasals, but none are without oral segments (Maddieson 1984, cited in McCarthy and Prince 1994a, who provide a different explanation for this generalization).

The tableau in (9) demonstrates how an /NT/ cluster would be treated in a language such as Kelantan Malay, in which *NC̥ dominates Max (note that all other Faithfulness constraints, including Linearity, are also ranked above Max):

(9) Tableau for Kelantan-like languages

N_1T_2	*NC̥	ObsMax	NasMax
a. ☞ T_2			*
b. N_1		* !	
c. N_1T_2	* !		

In future tableaux, I will merge the two Max constraints, and show only the candidate with the deleted nasal.

For some reason, languages seem not to make use of epenthesis to resolve *NC̥ violations. One might stipulate that Dep universally dominates *NC̥, but without any independent motivation for this fixed ranking, such a formalization would remain in the realm of description, rather than explanation. With this potential gap in the typology of NC̥ effects duly noted, I will now turn to the featural changes that can be used to satisfy *NC̥, and propose constraints to rule them out in Indonesian. In these instances, we will see the predicted factorial typology is indeed fulfilled.

3 *NC̥ and Featural Faithfulness

3.1 Denasalization

Instead of completely deleting the nasal, another way to meet the *NC̥ requirement is to change the underlying nasal into an obstruent. There are at least three languages that take this route: Toba Batak (Hayes 1986), Kaingang (Henry 1948; cf. Piggott 1995), and Mandar (Mills 1975). Mandar, a language spoken in South Sulawesi, is particularly interesting because it has a prefixation paradigm that differs minimally from that of Indonesian. A homorganic nasal appears before voiced obstruents (10a), but instead of nasal substitution with the voiceless ones, there is gemination (10b) (in Toba Batak and Kaingang, the resulting obstruent retains its place specification, and can be heterorganic with the following consonant).

(10) Mandar maN- prefixation

a.	/maN+dundu/	mandundu	'to drink'
b.	/maN+tunu/	mattunu	'to burn'

In Mandar, unlike Indonesian, the prohibition against NC̥ extends throughout the language:

(11)

> Nowhere in my material nor in Pelenkahu's extensive lists of minimal pairs is there a single instance of nasal plus voiceless stop. Where such a cluster would be expected, because of cognate items or at certain morpheme boundaries, there is invariably a geminate voiceless stop. In this respect, [Mandar] is far more consistent than [Buginese]; perhaps it reflects greater freedom from outside influence. (Mills 1975: 82)

There are a number of potential constraints, or sets of constraints, that could rule out denasalization in Indonesian, as well as in languages like Kelantan Malay that have nasal deletion. Before turning to them, a short discussion of featural Faithfulness within Correspondence Theory is in order.

To replace the containment-based Parse Feature (see e.g., Itô, Mester, and Padgett 1995) in Correspondence Theory, McCarthy and Prince (1994a, 1995) outline two approaches. One is to extend Correspondence into the featural domain, and require mappings between instances of features such as [voice] in the Input and Output. The one that McCarthy and Prince adopt, however, invokes a set of identity requirements between segmental correspondents. A general formulation for such constraints is given in (12):

(12) Featural Identity – IDENT-(F)
Correspondents are identical in their specification for F.

Formulated in this way, featural Faithfulness is not violated if a segment is deleted, since if an Input segment has no Output correspondent, Identity constraints do not come into force.

In cases of fusion, however, the simple statement of Featural Identity given in (12) leads to some complications. Consider the Input–Output mappings in (13):

(13)

	a.	b.
Input	n t	n t
	\/			
Output	n	t t

Nasal substitution is represented in (13a), and denasalization in (13b). One consequence of the symmetrical nature of Identity is that IDENT[NAS] is violated to the same degree in (13a) and (13b), since in both instances a nasal and a voiceless obstruent stand in correspondence with one another. Nasal substitution also violates LINEARITY, so in terms of the constraints considered thus far, it is impossible for a language to prefer (13a) over (13b), since the Faithfulness violations incurred by (13b) are a subset of those for (13a).

One might consider ruling out (13b) with constraints against coda obstruents, and/or gemination. By using a syllable structure constraint to rule out denasalization, however, the resulting prediction should be that languages that display nasal substitution have tight restrictions on possible codas. To some extent, this is borne out. However, Chamorro, which has nasal substitution in *man-* and *fan-* prefixation, also has geminates and coda obstruents (Topping 1973: 36–49), even in prefixes, such as *hat-*, *chat-*, and *tak-* (Topping 1973: 66). Thus, nasal substitution does not appear to be driven by a desire to avoid coda obstruents, or gemination.

Another response to this problem is to elaborate Identity somewhat, so that we have a way of stating that in nasal substitution an Input nasal maps to an Output one, while in denasalization an Input nasal maps to an obstruent. With this shift away from symmetry the theory of featural Faithfulness begins to look more like segmental Correspondence, which could have separate MAX and DEP constraints.

(14) IDENTI→O[F]
Any correspondent of an Input segment specified as F must be F.

Nasal substitution does not violate IDENTI→O[NAS], while denasalization does. [NAS] here would refer to the feature [Nasal] in monovalent feature theory, or

[+Nasal] if bivalent features were assumed. The choice is not crucial, but since the feature [–Nasal] seems not to be active in any phonological process, I will assume there is but a single monovalent feature [Nasal] (Piggott 1993, Rice 1993, Steriade 1993, Trigo 1993, cf. Cohn 1993). Note that if bivalent features were used, and Featural Identity were stated without any reference to the value of the feature (i.e. 'any correspondent of Input segment X must be identical to X in its specification for F'), then the effects of this constraint would remain symmetrical, and the problem of differentiating I→O and O→I Identity would remain.

For a language like Mandar, IDENTI→O[NAS] is ranked beneath *NC̥ and the rest of the Faithfulness constraints. In Indonesian, IDENTI→O[NAS] is ranked above LINEARITY, so that fusion is preferred over denasalization. A tableau for Mandar is given in (15):

(15) Mandar denasalization: *NC̥ ≫ IDENTI→O[NAS]

maN_1+$t_2$unu	DEP	MAX	LINEARITY	*NC̥	IDENTI→O[NAS]
a. ☞ mat_1t_2unu					*
b. $man_{1,2}$unu			*!		
c. man_1t_2unu				*!	
d. mat_2unu		*!			
e. $ma\eta_1at_2$unu	*!				

Some further motivation for the recognition of separate IDENTI→O[NAS] and IDENTO→I[NAS] constraints comes from the fact that there is at least one language in which a geminate nasal is created to avoid an *NC̥ violation (the South Sulawesi language Konjo – Friberg and Friberg 1991: 88). To distinguish Konjo from its near neighbour Mandar, IDENTO→I[NAS] can be ranked beneath IDENTI→O[NAS], so that having an Output nasal in correspondence with an Input obstruent (i.e. NT → NN) is a better resolution of *NC̥ than having an Input nasal in correspondence with an Output obstruent (i.e. NT → TT). In Mandar, of course, the ranking between these constraints would be reversed.[7]

3.2 Post-nasal voicing

The most common, and most widely discussed, NC̥ effect is post-nasal voicing (see Itô, Mester, and Padgett 1995 for another account in Optimality Theory). A particularly relevant, and perhaps less familiar, example is that of the Puyo Pungo dialect of Quechua (Orr 1962, Rice 1993). As shown in (16), post-nasal voicing only affects affixal consonants. Root-internally, post-nasal consonants can remain voiceless.

(16) Puyo Pungo Quechua
a. Root-internal NC̥:
šiŋki 'soot' čuntina 'to stir the fire' pampalʸina 'skirt'

b. Suffixal alternations:

sinik-pa	'porcupine's'	kam-ba	'yours'
sača-pi	'in the jungle'	hatum-bi	'the big one'
wasi-ta	'the house'	wakin-da	'the others'

Obviously, post-nasal voicing satisfies *NC̥. Again, the question of what it violates is not as straightforward as it might at first seem. Compare the I,O correspondences for nasal substitution and post-nasal voicing:

(17)

	a.	b.
Input	n t	n t
	\\/	| |
Output	n	n d

If we assume full specification of the traditional set of features (i.e. those of Chomsky and Halle 1968), Ident[Voice] is the only constraint violated in (17b), yet it is also violated in (17a) since Input /t/ corresponds to Output /n/. Nasal substitution violates Linearity, while post-nasal voicing does not, so again, there is some difficulty in establishing how Indonesian could prefer (17a) over (17b).

In this case, it is pointless to consider constraints that would rule out the NC̥ configuration itself, since this does occur in Indonesian as the Output of an underlying NC̥ sequence. Nor does the problem lie in the symmetry of Identity, since in both cases a voiceless Input segment stands in correspondence with a voiced Output segment. Rather, it is due to the mistaken assumption that [Voice] on a sonorant, and on an obstruent, are equivalent (see Chomsky and Halle 1968: 300, Lombardi 1991, Rice and Avery 1989, Piggott 1992, Rice 1993, and Steriade 1995a for discussion from a variety of perspectives). Because the exact method adopted for capturing the non-equivalency of sonorant and obstruent [Voice] is of no particular consequence in the present context, I will simply invoke an Identity constraint that specifically targets obstruent [Voice]. There is no need to specify the constraint as applying from I-to-O or O-to-I:

(18) Obstruent Voice Identity – Ident[ObsVce]
Correspondent obstruents are identical in their specification for [Voice].

As it applies only to obstruents in correspondence, this constraint is not violated by nasal substitution, in which an obstruent is in correspondence with a nasal. For Indonesian, we can thus block post-nasal voicing by ranking Ident[ObsVce] above *NC̥. In Puyo Pungo Quechua, a root-specific version of Ident[ObsVce] ranks above *NC̥, and the general Ident[ObsVce] ranks below it, thus producing affixal post-nasal voicing only.

As this completes the analysis of nasal substitution, it is appropriate to provide an illustrative tableau:

(19) Final tableau for nasal substitution

/məN$_1$+p$_2$ilih/	Dep	IdentI→O [Nas]	Max	Ident [ObsVce]	*NC̥	Lin
a. ☞ məm$_{1,2}$ilih						*
b. məm$_1$p$_2$ilih					*!	
c. məp$_1$p$_2$ilih		*!				
d. məm$_1$b$_2$ilih				*!		
e. məp$_2$ilih			*!			
f. məŋ$_1$əp$_2$ilih	*!					

Noteworthy in this tableau is the fact that all of the non-optimal candidates, with the exception of the epenthetic (19f), do turn up as optimal in other languages, and that each of these cases can be generated simply by having one of the constraints fall beneath all the others. Candidate (19b) is generated if *NC̥ ranks beneath the Faithfulness constraints, as in languages that permit NC̥ clusters. With IdentI→O[Nas] at the bottom of this hierarchy, candidate (19c) is made optimal, as we have seen in Mandar. Candidate (19d) is preferred when Ident[ObsVce] is lowest ranked, as in Puyo Pungo Quechua. Finally, candidate (19e) wins with Max dominated by the others, as in Kelantan Malay.

With the introduction of constraints such as RootLin that disallow one of the NC̥ effects in a particular environment, we would also expect to see cases where an alternate process takes place in the environment in which the usual one is ruled out. Such conspiracies between NC̥ effects can be modelled simply by having both of the relevant Faithfulness constraints ranked beneath *NC̥. It is a powerful argument for this approach that this expectation is indeed fulfilled.

3.3 NC̥ fusion overruled by Featural Identity

In this section, I show how a high ranking Featural Identity constraint can disallow fusion between particular segments. This discussion also serves to introduce evidence of a conspiracy between nasal substitution and nasal deletion. The data to be accounted for involve a parametric difference between Austronesian and African nasal substitution. In all the Austronesian examples of which I am aware, the fricative /s/ undergoes substitution:[8]

(20)

/məN+sapu/	[məɲapu]	'to sweep'	(Indonesian)
/man+saga/	[maɲaga]	'stay'	(Chamorro: Topping 1973: 50)
/N+sambuŋ/	[ɲambuŋ]	'to connect'	(Javanese: Poedjosoedarmo 1982: 51)

African languages with nasal substitution demonstrate a split in behaviour between stops and fricatives, as in the following examples cited by Rosenthall (1989: 49) (see also Odden and Odden 1985 on Kíhehe):

(21) a. /N+tuma/ [numa] 'I send'
/N+seva/ [seva] 'I cook' (Umbundu: Schadeberg 1982)

b. /N+tabi/ [nabi] 'prince'
/N+supa/ [supa] 'soup' (Si-Luyana: Givón 1970)

To stem any suspicion that deletion before the fricatives is motivated solely by the markedness of nasal/fricative clusters (see Padgett 1994), note that voiced fricatives undergo post-nasal hardening in Kíhehe (Odden and Odden 1985: 498). This shows that *NC̥ is needed for deletion in a nasal/voiceless fricative sequence, since one would otherwise predict that /ns/ should surface as [nt].

As in Indonesian, fusion with the voiceless stops can be attributed to the ranking of LINEARITY beneath *NC̥ and the rest of the Faithfulness constraints, including MAX. However, unlike Indonesian, deletion occurs with root-initial voiceless fricatives instead of fusion. This indicates that preservation of Input continuancy is more highly valued than preservation of the Input nasal segment in these languages, in other words, that IDENTI→O[CONT] dominates MAX. The fact that deletion does occur rather than *NC̥ violation places *NC̥ above MAX. Combining these rankings, we get *NC̥, IDENTI→O[CONT] ≫ MAX ≫ LINEARITY. The following tableaux show how this hierarchy generates the different responses to *NC̥ violations in fricative-initial and stop-initial roots:

(22) Fusion with stops

N_1+$t_2$abi	*NC̥	IDENTI→O [CONT]	MAX	LIN
a. ☞ $n_{1,2}$abi				*
b. $n_1t_2$abi	* !			
c. $t_2$abi			* !	

With a stop-initial root, IDENT[CONT] is satisfied in fusion, so MAX is free to choose fusion (22a) over deletion (22c) as the best alternative to *NC̥ violation (22b).

When the root begins with fricative, as in (23), fusion creates a violation of IDENTI→O[CONT], since an Input fricative has a stop as an Output correspondent (assuming an undominated constraint against nasal fricatives in all these languages – see Cohn 1993, Padgett 1994). With IDENTI→O[CONT] ≫ MAX, the candidate with deletion (23a) becomes optimal in this instance:

(23) Deletion with fricatives

N_1+$s_2$upa	*NC̥	IDENTI→O [CONT]	MAX	LIN
a. ☞ $s_2$upa			*	
b. $n_1s_2$upa	* !			
c. $n_{1,2}$upa		* !		*

Austronesian nasal substitution evinces the opposite ranking MAX ≫ IDENT[CONT], since loss of Input continuancy, as in (23c), is preferred to deletion.

4 Other *NC̥ Conspiracies

As Kisseberth (1970) originally pointed out, cases in which two processes conspire to avoid a single configuration provide strong motivation for the formal recognition of output constraints. Under a purely rule-based analysis of nasal substitution, such as the standard one of nasal assimilation followed by voiceless consonant deletion, the functional connection between nasal substitution and nasal deletion would have to be stated independently of the rules themselves; their shared property of eliminating NC̥ clusters is only obliquely retrievable from the rule formulation. This contrasts with the above Optimality Theoretic analysis of African nasal substitution and nasal deletion, in which the functional motivation for these processes is directly incorporated into the formal explanation, thus allowing for a perspicuous account of the conspiracy between them.[9]

There are in fact several other examples of NC̥ conspiracies. OshiKwanyama, a western Bantu language discussed by Steinbergs (1985), demonstrates a conspiracy between nasal substitution and post-nasal voicing. Loanwords are modified by voicing the post-nasal obstruent. The following are borrowings from English:

(24) Postnasal voicing in OshiKwanyama loanwords
[sitamba] 'stamp'
[pelenda] 'print'
[oinga] 'ink'

Root-initially in native words, nasal substitution, rather than post-nasal voicing, occurs to resolve underlying NC̥ sequences (nasal/voiced obstruent clusters remain intact, though Steinbergs provides no examples):

(25) Root-initial nasal substitution in OshiKwanyama
/e:N+pati/ [e:mati] 'ribs'
/oN+pote/ [omote] 'good-for-nothing'
/oN+tana/ [onana] 'calf'

A straightforward analysis of OshiKwanyama is obtained under the assumptions of the present study. As in Indonesian, root-internal nasal substitution can be ruled out by a root-specific ranking of LINEARITY above *NC̥, while root-initial substitution is permitted because the general LINEARITY constraint is dominated by *NC̥.[10] However, unlike Indonesian, IDENT[OBSVCE] is also ranked beneath *NC̥, so that post-nasal voicing occurs root-internally.

The phonology of Greek dialects (Newton 1972) provides examples of conspiracies between post-nasal voicing and each of nasal deletion and denasalization. In Modern Greek, post-nasal voicing (26a, c) applies except when the post-nasal obstruent is itself followed by a voiceless obstruent (a fricative). In this situation, nasal deletion applies instead (26b, d), thus avoiding voicing disagreement between obstruents, which is generally prohibited in Greek:

(26)	a. /pemp+o/	[pembo]	'I send'
	b. /e+pemp+s+a/	[epepsa]	-aorist
	c. /ton#topo/	[tondopo]	'the place'
	d. /ton#psefti/	[topsefti]	'the liar' (Cypriot)[11]

In the Greek dialect spoken on Karpathos (Newton 1972), post-nasal voicing applies except when the obstruent is word-initial, in which case denasalization occurs instead, as in (27):

(27)	/tin+porta/	[tipporta]	'the door'
	/tin+kori/	[tikkori]	'the girl'

In both of these cases, an analysis of the conspiracy can be obtained by having *NC̥ dominate two faithfulness constraints. The choice between the repairs is made by the ranking of the two faithfulness constraints, and by relevant higher ranked constraints (i.e. constraints favouring regressive voicing assimilation, or maintenance of the voicing specification of the stem-initial consonant; see Pater 1996 for details).

5 Conclusions

I have argued that nasal substitution is best analyzed as fusion of a nasal and voiceless obstruent, driven by a phonotactic constraint against this sequence, *NC̥, which can also be satisfied by nasal deletion, denasalization, and post-nasal voicing. The fact that languages exercise a range of options in dealing with *NC̥ violations, along with the existence of conspiracies between these NC̥ effects, provides strong support for the Optimality Theoretic program of decoupling phonotactic constraints from Faithfulness constraints, and allowing them to be freely ranked with respect to one another. However, the apparent lack of NC̥ epenthesis raises an intriguing question for future research: Is it the case that every phonotactic constraint is satisfied in all of the ways predicted by the permutation of the rankings between it and the Faithfulness constraints? Gaps in factorial typologies often serve as indications that constraints must be reformulated, but persistent links between marked configurations and the processes used to repair them would seem to force a more fundamental shift in theoretical assumptions. Either that, or we could settle for a theory of grammar that is in some respects only 'exegetically adequate', as opposed to 'explanatorily adequate', that is, we could rest content with having 'made some progress in understanding the facts as they are, though not in the sense of showing that they could not be otherwise' (Anderson 1979: 18). Such resignation would be disappointing though, in light of the strides that Optimality Theory has made toward predictive explanatory adequacy in many areas of phonology.

There are also some broader conclusions to be drawn from the study of NC̥ effects. Though post-nasal voicing is extremely widespread, there are no reported cases of regressive voicing triggered by nasals only. The progressive nature of nasal-obstruent voicing is particularly striking since more general forms of voicing assimilation tend to be regressive (Lombardi 1991; Mohanan 1993). This directional asymmetry, which is a fundamental property of post-nasal voicing, points to a difficulty for any attempt to construct a restrictive theory of segmental phonology on the basis of a restrictive set of features freely combined with operational parameters (or constraint-based reformulations thereof). If nasal [Voice] can spread right, then why can it not spread left? This asymmetry, along with the NC̥ conspiracies, provides strong support for any theory of segmental phonology based on substantive output constraints, of which Optimality Theory is one instantiation.

Notes

1 I am grateful to John Kingston and Donca Steriade for very helpful discussion of the phonetic facts, though I hasten to claim sole responsibility for any errors of interpretation.

2 The discussion here abstracts from two other NC̥ effects: nasal devoicing and obstruent aspiration. These processes cannot be captured by the simple statement of *NC̥ in (3). It is conceivable that the articulatory or perceptual difficulties of post-nasal voicelessness could be overcome by enhancement with aspiration and/or extension of the duration of voicelessness. However, a proper treatment of these phenomena would force a long digression from the central concerns of this paper, since at least the following rather complex questions would have to be answered: What is the nature of the interaction between these processes: does devoicing result from aspiration, or vice versa (Herbert 1986, Nurse and Hinnebusch 1993)? Are voiceless nasals [–Voice], or [+Aspirated] (Lombardi 1991, Huffman 1994)? Are the voiceless nasals in fact even entirely voiceless (Maddieson and Ladefoged 1993: 262)? Related to the last question, are these processes categorical or more implementational in nature? Therefore, for present purposes I leave *NC̥ in its perhaps overly simple form.

3 Instead of LINEARITY, one might also invoke a separate UNIFORMITY constraint to block fusion (McCarthy and Prince 1995, 1999).

4 Here I am assuming that the Input is made up of a linearly sequenced set of morphemes. It is not crucial to the analysis that this position be maintained, since it is only LINEARITY within the root that must be obeyed, and there are other ways of ruling out trans-morphemic nasal substitution, such as through the use of DISJOINTNESS constraints (McCarthy and Prince 1995; see the following note).

5 It should be noted that fusion is not free to occur between any two morphemes. Both the prefix+prefix and root+suffix boundaries are impermeable to nasal substitution (e.g., /məN+pər+besar/ → [məmpərbesar] 'to enlarge' and /məN+yakin+kan/ → [məyakinkan] 'to convince'). To encode this

sort of morphological conditioning, constraints are needed to render particular morpheme boundaries opaque to fusion. In particular, McCarthy and Prince's (1995) DISJOINTNESS constraints, which require that the sets of correspondents (or exponents) of morphemes be non-overlapping, could be recruited for this purpose.

6 For ease of exposition, I assume that prenasalized stops are composed of two segments. On two root node theories of prenasalized stops, see Piggott (1988), Rosenthall (1989), Steriade (1993), and Trigo (1993).

7 This leaves a not insignificant problem unresolved. How do we distinguish between nasalization of the voiceless stop, and nasal substitution? In terms of the constraints considered thus far, nasal substitution incurs all the violations that nasalization does, plus a LINEARITY violation that is avoided by nasalization. One possibly key difference is that in fusion, one of the underlying correspondents of the Output nasal is a nasal, while in nasalization the second member of the cluster has as its sole correspondent a voiceless obstruent. I should also note here that Konjo nasalization is subject to considerable morphological conditioning. In fact, the prefix that causes nasalization has a homophonous counterpart that differs only in that it fails to nasalize the following voiceless obstruent.

8 These examples also demonstrate the well-known complication that /s/ becomes a palatal nasal under substitution. The apparent oddness of this alternation is somewhat tempered by the independent evidence from a Javanese morpheme structure constraint that Austronesian /s/ is in fact itself phonologically palatal (Mester 1986). A related complication is that nasal substitution often fails to occur with a /c/ initial root (/c/ is variously described as a palatal stop or an alveo-palatal affricate); see Onn (1980: 62) for discussion.

9 See Pater (1996) for discussion of the inability of Itô, Mester, and Padgett's (1995) analysis of post-nasal voicing to generalize to any of the other NC̥ effects.

10 Steriade (2001) points out that loanwords have post-nasal voicing rather than nasal substitution root-initially. This may indicate the activity of a LINEARITY constraint specific to the loanword stratum (cf. Itô and Mester 1999).

11 In all dialects, the nasal is deleted within the word (26b), and in most dialects, including Cypriot, it is deleted in an article preceding a noun, except in 'slow, deliberate speech' (26d).

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Study and Research Questions

1 Construct tableaux similar to (19) for the other languages discussed. In other words, provide tableaux that dispose of the full range of relevant candidates and include all of the faithfulness constraints discussed in this chapter.
2 Fill in the details of the argument above in (3). Why should children learning English, Greek, or Spanish delete the nasal in NC̥ clusters even though these clusters are found in the adult language?
3 Re-read section 2.2 and the associated note, then read about a more recent proposal in Pater (2001: 171ff). Discuss and evaluate the various solutions to the morphological conditioning problem, or develop one of your own.
4 Read and discuss Archangeli et al. (1998), which is a rejoinder to this chapter.
5 Solve the thusfar unsolved problem of why *NC̥ never leads to epenthesis (see the end of section 2.3).