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78. Nasal Harmony

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Nasal harmony refers to phonological patterns where nasalization is transmitted in long–distance fashion. The long–distance nature of nasal harmony can be met by the transmission of nasalization either to a series of segments or to a non–adjacent segment. Nasal harmony usually occurs within words or a smaller domain, either morphologically or prosodically defined. This chapter introduces the chief characteristics of nasal harmony patterns with exemplification, and highlights related theoretical themes. It focuses primarily on the different roles that segments can play in nasal harmony, and the typological properties to which they give rise. The following terminological conventions will be assumed. A *trigger* is a segment that initiates nasal harmony. A *target* is a segment that undergoes harmony. An *opaque segment* or *blocker* halts nasal harmony. A *transparent segment* is one that does not display nasalization within a span of nasal harmony, but does not halt harmony from transmitting beyond it.

Three broad categories of nasal harmony are considered in this chapter. They are (i) nasal vowel–consonant

harmony with opaque segments, (ii) nasal vowel–consonant harmony with transparent segments, and (iii) nasal consonant harmony. Each of these groups of systems show characteristic hallmarks. Nasal vowel–consonant harmony refers to systems in which vowels and consonants participate in the pattern as either triggers or targets. Sundanese manifests one of the most limited forms of nasal vowel–consonant harmony, where vowels and laryngeal segments are targets of harmony. Other systems are more liberal in the scope of their targets, including some or all sonorant consonants, and sometimes even obstruents. In many patterns of nasal vowel–consonant harmony, Sundanese included, the segments that are not targets are blockers. In other systems, some or all obstruents are transparent, while vowels, laryngeals and sonorant consonants are targets. On the other hand, in nasal consonant harmony, only consonants participate, and vowels are transparent. Certain categories of consonants are also transparent in cases where nasal consonant harmony can occur at any distance within its domain. Nasal stops trigger harmony in these systems, and the targets are typically drawn from the set of stops and/or approximant consonants.

A core topic of theoretical debate revolves around whether systems of nasal vowel–consonant harmony with opaque segments and those with transparent segments should be analyzed as the same or different with respect to the driving force for harmony and the types of representations involved. Further, the distinct properties of nasal consonant harmony and nasal vowel–consonant harmony have led to proposals about their formal differences, such as the level at which the feature [nasal] spreads in the structure; more recently, an approach has been advocated in which consonant harmony is achieved through relations constructed between similar segments rather than feature spreading. Signposted throughout this chapter will be many other issues in phonology with which the topic of nasal harmony intersects. For instance, nasal harmony has played a significant role in discussions that concern the grounding of phonological patterns in phonetic principles, contrast and speech planning. The nature of locality in phonology is another primary theme. Directionality effects are also examined in this chapter.

1 Nasal vowel–consonant harmony with opaque segments

Nasal vowel–consonant harmony refers to nasal harmony in which both vowels and consonants participate as triggers and/or targets (see [CHAPTER 75: CONSONANT–VOWEL PLACE FEATURE INTERACTIONS](#)). A central typological observation that emerges from cross–linguistic studies is that nasal vowel–consonant harmony with opaque segments respects the implicational scale in (1). Categories further to the right are progressively disfavored as targets, and the inclusion of any category as a target in a harmony pattern implies that all categories to its left will be targets ([Schourup 1972](#); [Piggott 1992, 2003](#); [Cohn 1993a, 1993b](#); [Walker and Pullum 1999](#); [Walker 2000a](#); see [Hume and Odden 1996](#) for related discussion). The category “laryngeals” refers to [hʔ].

(1) vowels > laryngeals > glides > liquids > fricatives > obstruent stops

The hierarchy in (1) summarizes a pervasive generalization that emerges from nasal vowel–consonant harmony patterns across languages. However, some fine–tuning may be needed, as discussed in connection with particular cases below. The hierarchy has been suggested to have a phonetic basis, whereby nasalization of segments that are lower on the scale is disfavored for reasons of articulation, aerodynamics, and/or perceptibility (see [Walker 2000a](#) and references therein). Maintenance of a system of contrasts has also been suggested to underlie the hierarchy in (1) (e.g. [Flemming 2004](#)). This scale shows a striking similarity to the sonority hierarchy, on which see [CHAPTER 49: SONORITY](#). Nevertheless, they are distinct in the ranking of nasal stops, which are usually situated between liquids and obstruents in the sonority hierarchy, but could plausibly be located at the top left of the scale in (1). Furthermore, consensus is lacking on the placement of laryngeals in the sonority scale. I return to this issue later in this section, in the context of the impedance hierarchy proposed by [Hume and Odden \(1996\)](#); for further discussion, see [Cohn \(1993a\)](#), [Gnanadesikan \(1995\)](#), [Boersma \(1998, 2003\)](#), and [Walker \(2000a\)](#).

Following the exemplification of hierarchical effects in the typology, some ways of formalizing them are discussed. The exemplification of nasal vowel–consonant harmony with opaque segments begins with patterns that show a narrower set of blockers and progresses to ones with blocking by more categories.

The dialect of Scottish Gaelic spoken in Applecross (Ross–shire), henceforth “Applecross Gaelic,” displays a nasal harmony where nasalization is reported to target all segment categories except obstruent stops ([Ternes 2006](#)). Nasalization spreads from a stressed nasal vowel. Stress is usually – but not always – assigned to the initial syllable. Progressive nasalization is halted by an obstruent stop. In addition, consonants in the onset of a syllable with a stressed nasal vowel are nasalized except obstruent stops.

- (2) a. *Monosyllables*
- | | | |
|---------|---------------|----------------------|
| ĩʷũ·m | 'bare, naked' | |
| ĩʷaǰ | 'hand' | |
| mĩã·ř | 'finger, toe' | <i>lenited</i> vĩã·ř |
| kʰřɛ·ak | 'maggot' | |
| strãĩ·ŷ | 'string' | |
| tãŷ | 'ox, stag' | |
- b. *Polysyllabic words*
- | | |
|--------------|------------------------|
| 'friaũn | 'root (PL)' |
| 'kãã·x̃ | 'sand' |
| 'ĩʷã·hũk | 'axe, hatchet' |
| 'sãhĩ | 'tame' |
| 'tʰřĩřãř | 'plate' |
| 'řɛnɛ·vãř | 'grandmother' |
| 'kʰũspaxk | 'wasp' |
| 'minĩřtar | 'minister (clergyman)' |
| 'snʷã·nĩdian | 'thread' |

Transcriptions of nasalized fricatives in Applecross Gaelic follow Ternes; however, the realization of such segments in general have been the subject of debate. Nasalized fricatives present an aerodynamic confound with consequences for perception: an increase in velopharyngeal opening tends to reduce frication and a decrease in velopharyngeal aperture can reduce perceptible nasalization (CHAPTER 28: THE REPRESENTATION OF FRICATIVES). Gerfen (1999, 2001) has brought instrumental research to this question for the nasal harmony of Coatzacoapan Mixtec. See Shosted (2006) and Solé (2007a) for recent reviews of the issues and experimental investigations. Whether and how the gradient trade-offs in realization should be represented in phonology remains an open question.

Color and height distinctions in nasal vowels of Applecross Gaelic are a proper subset of those in its oral vowels. The mid-high vowel series /e ə o/ is always oral, and, like the obstruent stops, they block nasal harmony. Examples with blocking by [ə] are given in (3). All other vowel qualities in the language ([i ÷ u e ɔ a]) can be phonemically oral or nasal and can become nasalized through nasal harmony.

- (3) 'sãũĩʷəxkən' 'to compare'
 'ãǰəlʷ 'angel'
 'n'ĩən 'girl, daughter'
 kʰã'tʰřĩãnə 'Catherine'

Blocking of nasal harmony by mid vowels is also attested in Mòbà Yoruba, discussed in §2. The resistance of mid-high vowels to contrastive or contextual nasalization has plausible origins in effects of nasalization on the perception of vowel height. The perceived distance of a height distinction between two oral vowels is reduced when those same vowels are nasalized (e.g. Wright 1986), which could give rise to the restriction of nasalization to a subset of the oral vowel heights in Applecross Gaelic (Homer 1998; Walker 2000a). In general, the number of nasal vowels in a language never exceeds the number of oral vowels, and it is relatively common for one or more mid nasal vowels to be missing relative to the oral inventory in a language. Nasalization may interfere most with detection of height distinctions involving mid vowels; also perceptual integration of nasalization and height in vowels disfavors mid percepts (Kingston 2007). This suggests the possibility that the descriptive hierarchy in (1) could be moderated by or interact with the effects of contrast, an issue to which I return later in this section.

Given that Applecross Gaelic has nasal stops, the question arises whether they too can trigger nasal harmony. When they occur in the onset to a stressed syllable with an oral vowel, they do not.

- (4) mur 'sea'
 mara·v 'dead person'

These examples do not necessarily demonstrate that triggers of nasal harmony in Applecross Gaelic must be stipulated to exclude nasal stops. It is conceivable that stressed vowels not only trigger nasal harmony when they are nasal, but also block it when they are oral; that is, they can spread nasalization but do not alter their own phonemic oral/nasal quality. A situation of this kind in Guaraní is discussed in §2. I found no examples in

Applecross Gaelic with a stressed oral vowel and a following nasal with which to test whether a nasal stop triggers harmony in a following unstressed syllable. The scarcity of such forms is likely because vowel nasalization in Applecross Gaelic in most cases arose historically from a nasal consonant in the vicinity that was either retained, lost, or lenited. In some cases, the nasal consonant is still reflected in the orthography: [t̪aŋ] *damh* ‘ox, stag’, [ʰs̪ã·hũx̃] *sàmhach* ‘quiet’.

A pattern of nasal harmony that includes a supralaryngeal fricative among its blockers is found in Epena Pedee (Saija), a Chocó language of Colombia (Harms 1985, 1994). Nasal vowels trigger progressive nasal harmony, as shown in (5a). Certain consonants in the onset of a syllable that contains a nasal vowel also become nasalized, as will be discussed presently. Of particular relevance is the set of consonants that block progressive nasal harmony, seen in (5b); this includes /s/, which is the only supralaryngeal fricative phoneme in the language, as well as other obstruent phonemes and the trill /r/.¹ Within the stem, non-continuant obstruents become prenasalized following a nasal vowel (Harms 1994). The phonemic analysis and phonetic description for these examples follow Harms. Some phonemic forms are constructed on the basis of his orthography, which is close to phonemic.

Regressive nasalization occurs within syllables containing a nasal vowel but does not usually transmit beyond the onset.² Syllables in Epena Pedee are open and begin with a consonant; consonant clusters are infrequent. A consonant that is tautosyllabic with a nasal vowel becomes nasalized except for [p^h t^h k^h tʃ] ([p t k] and [r] do not occur preceding a nasal vowel). In contrast to their behavior in the progressive harmony, /s/ is characterized as nasalized when preceding a nasal vowel and voiced stops become full nasals. Harms analyzes [m n] as allophones of voiced stops; they are not part of the phonemic inventory. Harms includes [ʔ] in the category of segments that do not become nasalized in the onset to a nasal vowel. While nasalization would not be audible during [ʔ], it is possible that the velum is lowered during this segment. The status of [ʔ] in nasal harmony in general is discussed later in this section.

(5) a.	/ˈdāwe/	[ˈnāwē] ³	‘mother’
	/peˈrōra/	[peˈrōrã]	‘guagua (a groundhog-like animal)’
	/k ^h aˈjara/	[k ^h aˈnãrã]	‘than’
	/hēˈsã:/	[hēˈsã:]	‘stinging ant’
	/hebēˈdē/	[hemēˈnē]	‘to play’
b.	/k ^h ĩˈsia/	[k ^h ĩˈsia] ⁴	‘think’
	/ˈbĩasu/	[ˈmĩasu]	‘spear’
	/ˈaʃi/	[ˈʔãʃi]	‘they’
	/ˈhōp ^h e/	[ˈhō ^m p ^h e]	‘fish (sp.)’
	/k ^h ũˈtra:/	[k ^h ũˈtrã:]	‘young man’
	/ĩˈbisi/	[ĩˈmbisi]	‘neck’
	/wãhiˈda/	[wãhĩˈnda]	‘go (PAST PL)’
	/ˈãigi/	[ˈʔãigi]	‘daughter-in-law’
	/ˈtũ:ra/	[ˈtũ:ra] ⁵	‘pelican’

Blocking of nasal harmony by /r/ is likely due to the aerodynamic and perceptual difficulties that a nasal trill would present (Solé 2002, 2007b). Solé points out that “an open velopharyngeal port would bleed the intraoral pressure required to make a relaxed oscillator vibrate for trills” (2002: 677). In addition, a velopharyngeal opening that was small enough to not impair a trill would likely be of insufficient size to produce perceptible nasalization. However, Solé observes that a tap is compatible with nasalization. This is consistent with the pattern that Epena Pedee displays. The distinct behavior of taps and trills suggests that the category of liquids in the scale of targets for nasal harmony should be segregated into a category that includes taps, flaps, and lateral approximants and another lower-ranked category that contains trills. A case where taps and laterals are both targets to the exclusion of obstruents occurs in Ijò, a Niger–Congo language of Nigeria (Williamson 1965, 1969, 1987).

The prenasalization of non-continuant obstruents following a nasal vowel raises questions about their representation. One issue is whether the feature [nasal] is specified for a portion of these segments, and if it is, how the nasal-oral sequence is represented.⁶ Prenasalized segments have been represented by some researchers as a single root or slot with specifications for both [+nasal] and [-nasal] (e.g. Bivin 1986; Sagey 1990), but Padgett (1995) and Piggott (1997) have analyzed prenasalization as a combination of nasal and oral segments. Steriade (1993) proposes aperture-based representations in which the closure and release phases of a stop can each form a separate anchor for [nasal], in which case a prenasalized stop has [nasal] associated with the closure but not the

release. Tied in with Steriade's representation is a claim that [nasal] is a privative feature (see also [Trigo 1993](#); [Steriade 1995](#)), which supports a bipositional representation for prenasalized plosives. [Beckman \(1999\)](#) applies the aperture-based approach to prenasal stops in Guaraní, which may occur at the boundary between a nasal span and an oral span (see §2). While much contemporary research concurs with the need for a sequence of segments or phases within a segment, the specifics of the representation remain at issue. On a related topic, [Botma \(2009\)](#) proposes that post-nasalized stops that trigger nasal harmony in Yuhup are underlyingly nasals that have undergone denasalization in a particular context.

Epera (also known as Ēperā) has a nasal harmony that is roughly similar to Epena Pedee, to which it is related, but it differs in the respect that voiced stops do not block progressive nasal harmony within a morpheme ([Morris 1978](#); [Bivin 1986](#)). Thus, nasal harmony transmits through vocoids, laryngeals, flaps and voiced stops, but is blocked by voiceless obstruents, as illustrated in (6). The availability of this pattern could be connected to the lack of contrast between voiced and nasal stops in the language. Like Epena Pedee, nasal stops [m n] have been analyzed as allophones of voiced stops. However, not all languages that lack this contrast target voiced stops, as Epena Pedee shows. Nasalization in the underlying form is shown on the first vowel in a segment sequence that shows nasal harmony.

(6)	/bēa/	[mēã]	'bush'
	/hī-/	[hī-]	'to tie'
	/bēra/	[mēřã]	'greetings'
	/pōsoa/	[pō ^h soa]	'termite'
	/sāki/	[sã ^h ki]	'which'
	/ībaba/	[īmãmã]	'tiger' ⁷

Nasal harmony that affects voiced stops (in some cases ones that are prenasalized in oral contexts) and that is blocked by voiceless obstruents is also reported for Orejon ([Pulleyblank 1989](#)) and Parintintin ([Pease and Betts 1971](#); [Bivin 1986](#)). These languages, too, seem to lack a contrast between oral and nasal voiced stops, although more detailed descriptions are needed. These patterns suggest that when voiced stops and nasals are not in contrast, voiced stops are more prone to undergo nasal harmony. Whether the voiced stops in such patterns should be analyzed as obstruents is open to debate. For particular cases where oral stops that alternate with nasals in nasal harmony have been analyzed as sonorants, see [Piggott \(1992\)](#), [Rice \(1993\)](#), [Piggott and van der Hulst \(1997\)](#), [Botma \(2004, 2009\)](#), and [Botma and Smith \(2007\)](#), although most often voiceless obstruents are transparent in such patterns (see also [CHAPTER 8: SONORANTS](#)).

Arabela, a Zaparoan language of Peru, shows a nasal harmony that targets only vowels and glides, as illustrated in (7) ([Rich 1963](#)). Nasalization spreads progressively from nasal stops and /h̃/. The glottal fricative is nasal in all contexts in this language and lacks an oral counterpart. [ʔ] occurs to close a phonological phrase and is non-phonemic.

(7)	'nēēnūʔ	'to turn over'
	'h̃ānūʔ	'to fly'
	'mj̃ænūʔ	'swallow'
	'nūw̃ãʔ	'partridge'
	'h̃ij̃ænīʔ	'old woman'
	'nj̃æã'riʔ	'he laid it down' ⁸
	'kironīʔ	'deep'
	'kom̃h̃īʔ	'over there'
	'm̃w̃ēēgur'h̃ūnūʔ	'wiggling'
	'h̃ēēgiʔ	'termites'
	'nēj̃ã'tuʔ	'daughter'
	'nī'tj̃ænūʔ	'to carry on the back'

Sundanese, an Austronesian language spoken in Western Java, has a progressive nasal harmony that targets only vowels and glottals ([Robins 1957](#); [Cohn 1990, 1993a](#)). Nasal stops are the triggers.

(8)	nāīān	'wet (ACTIVE)'
	nāūr	'say (ACTIVE)'
	mīhāk	'take sides (ACTIVE)'
	kumāhā	'how?'
	biṅhār	'to be rich'
	nūṽūs	'dry (ACTIVE)'
	ṅajak	'sift (ACTIVE)'
	ṅawih	'sing (ACTIVE)'
	ṅūliat	'stretch (ACTIVE)'
	mārios	'examine (ACTIVE)'
	ṅōbah	'change (ACTIVE)'
	ṅīsər	'displace (ACTIVE)'
	ṅātur	'arrange (ACTIVE)'

The status of the laryngeals, [hʔ], in nasal harmony systems deserves comment. Laryngeals rarely – perhaps never – block nasal harmony (Walker and Pullum 1999; Walker 2000a). Blocking by a glottal stop has been reported for Rejang (Austronesian) (McGinn 1979: 187), but field research by Robert Blust suggests otherwise (Walker and Pullum 1999: 776, n. 17). In Kaiwá (Tupí–Guarani), nasal harmony transmits through [ʔ] at a normal speech rate, but [ʔ] is reported to block nasal harmony in slow speech (Harrison and Taylor 1971: 17). It would be valuable to verify these descriptions with modern investigative techniques. Across languages, the overwhelming tendency is for nasal harmony to transmit through laryngeals. This has prompted researchers to situate laryngeals above the category of glides in the hierarchy that characterizes cross–language variation in targets of nasal vowel–consonant harmony, as in (1) (Schourup 1972; Piggott 1992; Walker and Pullum 1999). Levi (2005) has proposed a refinement in which laryngeals are situated higher than phonemic glides in particular, that is, higher than glides that are not derived from vowels rather than glides that are the non–syllabic realization of vowels.

Laryngeals have sparked discussion about the representation of nasal segments and the definition of the feature [nasal] (CHAPTER 7: FEATURE SPECIFICATION AND UNDERSPECIFICATION; CHAPTER 17: DISTINCTIVE FEATURES; CHAPTER 27: THE ORGANIZATION OF FEATURES). If [nasal] reports to the supralaryngeal node in the feature geometry, then laryngeal segments could not be phonologically nasal, whereas if [nasal] were a dependent of the root node, any segment could potentially be specified for [nasal] in the phonology (Cohn 1990, 1993a). Cohn assumes the former representation, but leaves the issue open for further research. Under the assumption that [nasal] is dependent on the supralaryngeal node, laryngeals are phonetically nasalized in the context of nasal segments but they do not participate in nasal processes in the phonology or have the capacity to show nasal contrasts. Piggott (1992) takes a different perspective, in which laryngeals can be phonologically [nasal], and may therefore undergo nasal harmony. In the geometry that he assumes, [nasal] can be dependent on a soft palate node, which reports to the root. He supposes, however, that a nasalized glottal stop is not phonetically possible, because of its lack of egressive nasal airflow. Accordingly, Piggott postulates a feature co–occurrence restriction over [nasal] and [constricted glottis] that applies at the later level of phonetic implementation.

Walker and Pullum (1999) also contend that laryngeals can be phonologically specified for [nasal]. Support they cite for this claim includes patterns in which [h̃] triggers nasal harmony (e.g. Arabela) or contextual vowel nasalization. For two such languages (Kwangali, Seimat), they note evidence for a phonemic contrast between [h] and [h̃]. In addition, Walker and Pullum observe that the scarcity of blocking of nasal harmony by laryngeals points to their being highly compatible with acquired nasalization, a tendency that can be straightforwardly captured if laryngeals can be phonologically nasal. To allow the possibility of nasalized laryngeals, they conclude that [nasal] should be defined as corresponding to an open velopharyngeal port rather than requiring nasal airflow (see also Cohn 1993a; Padgett 1995; Hume and Odden 1996). Therefore, a glottal stop can be nasalized by virtue of the lowered velum posture even though there is no airflow through the nasal cavity. In accordance with this perspective, laryngeals are transcribed as nasalized in this chapter when they occur within a nasal harmony span. It is plausible that [ʔ] at the periphery of a nasal harmony span, e.g. in Epena Pedee and Arabela, should likewise be treated as specified for [nasal]. Because of the lack of airflow, nasalization will not be perceptible during [ʔ]. This makes it unlikely that glottal stops will show a phonemic contrast in nasality (but see Walker and Pullum 1999 for a hypothesized scenario).

The language data presented above illustrate the scale of targets in patterns of nasal harmony that show blocking. All of the particular cases considered show progressive harmony, with regressive harmony in the syllable in some instances. However, some patterns show more robust regressive harmony, as discussed in §4. The scalar effects

for targets have been analyzed by Walker (2000a) as the result of a hierarchy of feature co-occurrence constraints abbreviated as in (9) (excluding laryngeals, discussed below). The constraint *NAS-OBSTRUENTSTOP prohibits a lowered velum during a segment that also has the features that characterize an obstruent stop, a segment that is highly difficult if not impossible. Nasalization during an articulation with stoppage in the oral cavity usually results in a sonorant stop (e.g. [m n ŋ], etc.).

(9) *Nasalized segment constraint hierarchy*

*NAS-OBSTRUENTSTOP >> *NAS-FRICATIVE >> *NAS-LIQUID >> *NAS-GLIDE >>
*NAS-VOWEL

In addition to nasal harmony surveys, this markedness scaling gains support from other facts about nasal patterns, such as segment inventories and nasal place assimilation (e.g. Pulleyblank 1989; Cohn 1993a; Padgett 1995). The constraint hierarchy can be used to obtain cross-language differences in the sets of targets and opaque segments by ranking a harmony-driving constraint at different breaks in the hierarchy. Feature co-occurrence constraints that dominate the harmony driver will correspond to blocking segments and ones that are dominated will correspond to targets.

Walker suggests that the hierarchy of constraints is grounded in factors of articulatory compatibility, aerodynamic difficulty, and ease of perceptibility. However, some researchers have observed that conflating these factors is problematic with regard to inventory contrasts and laryngeals. Ní Chiosáin and Padgett (1997) point out that with respect to articulatory compatibility, a constraint against [̤] is expected to be low-ranked, likely at the same level or even below *NAS-VOWEL. However, because of the lack of perceptibility of nasalization during a glottal stop, [̤] vs. [ʔ] makes a poor phonemic contrast. If the hierarchy in (9) included *[̤] at or near the bottom, it would correctly predict the lack of blocking by [ʔ] in nasal harmony, but it would not account for the disfavored status of a contrast between [̤] and [ʔ]. Ní Chiosáin and Padgett propose that *[̤] is low-ranked in the articulatory markedness hierarchy, but attribute the contrastive distribution to the activity of a separate constraint CONTRAST[nas], which penalizes a [̤]/[ʔ] distinction. Flemming (2004) goes a step further, suggesting that blocking effects in nasal harmony are a consequence of constraints governing the maintenance of contrasts, a possibility also noted by Ní Chiosáin and Padgett (CHAPTER 2: CONTRAST). Under Flemming's formalization, the constraint hierarchy in question scales nasalized segments according to their proximity to a nasal stop. Thus nasalized fricatives are conceived as highly indistinct from nasal stops, but nasalized vowels and laryngeals are at the upper end of the scale of distinctness from a nasal stop. Boersma (2003) proposes an account of the nasal glottal stop that distinguishes its articulation and perception but with different implementation.

Other work that emphasizes the role of segmental distinctions includes Homer (1998), who employs contrast-sensitive constraints to obtain blocking in nasal harmony. Piggott (2003) proposes faithfulness constraints specific to categories of blocking segments (stop, fricative, liquid, glide) that simultaneously prohibit segment deletion and feature change (CHAPTER 63: MARKEDNESS AND FAITHFULNESS CONSTRAINTS). He argues that this prevents the possibility that a less favored segment category could undergo nasal harmony to the exclusion of preferred targets, by replacement of the less favored category with a nasal stop. For example, replacement of a liquid with a nasal stop would bypass the violation of a feature co-occurrence constraint on nasalized liquids, in which circumstance a nasal harmony system could be expected to exist that allows liquids to undergo harmony, but not glides. A faithfulness-based approach to hierarchical nasal harmony effects is also proposed by Boersma (1998, 2003), using constraints that penalize adding nasalization in consonants. Constraints for consonants with greater oral constriction are generally ranked higher, as nasalization is posited to have a greater perceptual effect in these segments.

Another perspective on the basis of an implicational scale of targets makes a connection with its similarity to the sonority hierarchy, mentioned earlier. Hume and Odden propose that the effects of both hierarchies reduce to an impedance hierarchy, where impedance is defined as “the resistance offered by a sound to the flow of air through the vocal tract above the glottis” (1996: 358), a concept reminiscent of Boersma's reference to degree of oral constriction. Among supra-laryngeal segments, obstruent stops have the greatest impedance, and vowels and glides the least. Segments with low impedance values are favored as syllable peaks, a characteristic traditionally diagnostic of high-sonority segments, and they show greater susceptibility to nasalization. Laryngeals have an impedance value of 0. This renders them highly susceptible to nasalization, but their inability to constitute a syllable peak follows from an assumption that a syllable peak has some impedance value, i.e. a non-zero value. This addresses the earlier-mentioned discrepancy concerning laryngeals in scales governing nasal harmony and

what are traditionally sonority-based phenomena (i.e. syllabification), yet it posits a common underlying basis from which scalar effects across these phenomena are derived. This approach is extended by [Clements and Osu \(2003\)](#), who interpret resistance to nasalization in terms of a scale of obstruence, a near-synonym of impedance. Their study revolves around Ikwere, an Igboid language of Nigeria, in which nasal harmony transmits through vowels, approximants, and non-explosive stops, but is blocked by fricatives and obstruent stops. This leads them to add a category consisting of implosives and other non-explosive stops between liquids and fricatives on the nasalizability scale.

Despite the differences in formal perspectives on patterns of nasal harmony with opaque segments, there is broad consensus that groups of targets *vs.* blockers essentially conform to the descriptive hierarchy in (1). In addition to new case studies, like that of Ikwere, future research bearing on these approaches may rest largely on the scope of coverage and emphasis, for example the treatment of sonority or contrast in the theory, which situate the account of nasal harmony in a wider context. Where explanatory overlap exists, general issues of theoretical implementation will also be relevant. For instance, future work on the division of labor between contrast, segmental markedness, and faithfulness in the theory could inform the types of constraints that are expected to be possible.

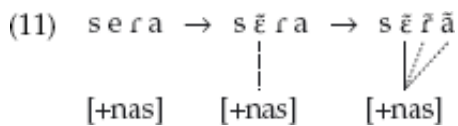
2 Nasal vowel-consonant harmony with transparent segments

Patterns of nasal vowel-consonant harmony with transparent segments are also attested. Whether the hierarchy in (1) is relevant for these patterns is a matter of debate, intersecting with fundamental questions about the kinds of representations that are involved and whether these systems are of the same basic “type” as ones with opaque segments.

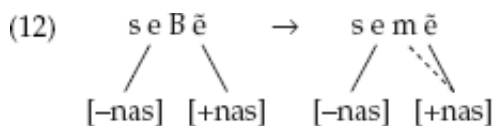
A well-known pattern of nasal vowel-consonant harmony with transparent segments is widely attested in the Tucanoan family. Typically, all voiced segments in a morpheme are either nasal or oral. Voiceless obstruents are consistently oral. They may occur in nasal morphemes, and do not prevent nasal harmony from operating among flanking voiced segments. Examples of nasal harmony in morphemes and words of Tucano, spoken in Colombia, are given in (10a), and oral items are provided in (10b) ([West and Welch 1967](#); [Noske 1995](#)).⁹ Although not marked as nasal in the sources, I show laryngeals as nasalized in nasal morphemes (see discussion in §1). Noske notes that [h̃] occurs in nasal contexts in other Eastern Tucanoan languages and she tentatively postulates that /h/ is likewise realized as nasal in Tucano.¹⁰

- (10) a. $\tilde{w}\tilde{e}\tilde{o}$ 'panpipe flutes'
 $\tilde{w}\tilde{i}\tilde{?}m\tilde{a}$ 'child'
 $\tilde{i}m\tilde{i}$ 'man'
 $\tilde{w}\tilde{a}\tilde{t}\tilde{i}$ 'devil'
 $\tilde{m}\tilde{a}\tilde{h}\tilde{a}$ 'macaw'
 $\tilde{m}\tilde{a}\tilde{?}a$ 'trail'
 $\tilde{n}\tilde{i}\tilde{t}\tilde{i}$ 'charcoal'
 $\tilde{j}\tilde{o}\tilde{h}\tilde{k}\tilde{a}$ 'a drink made from bitter manioc'
 $\tilde{s}\tilde{e}\tilde{r}\tilde{a}$ 'pineapple'
 $\tilde{m}\tilde{a}\tilde{s}\tilde{a}$ 'people'
 $\tilde{?}\tilde{e}\tilde{?}k\tilde{e}\tilde{a}$ 'nose'
 $\tilde{s}\tilde{u}\tilde{k}\tilde{u}\tilde{a}$ 'small of back'
- b. jai 'jaguar'
 $j\epsilon s\epsilon$ 'pig'
 oho 'banana'
 $kahpea$ 'eye'
 oso 'bat'
 ake 'monkey'
 $patu$ 'coca'
 $paga$ 'stomach'
 $s\epsilon r\epsilon$ 'a skin disease'
 ${}^m b\epsilon ?ro$ 'later'
 ${}^n di\epsilon ri$ 'eggs'
 $etagi$ 'the one who is arriving'

In Tucano, a complementary distribution exists between nasal stops and voiced stops (realized as oral or prenasalized, depending on context), with the former occurring in nasal morphemes and the latter in oral morphemes. In nasal morphemes, [Noske \(1995\)](#) postulates that [+nasal] is a feature of the entire morpheme, and it is floating, i.e. unassociated, in the underlying representation. She assumes that [+nasal] links to the first vowel in the word and spreads within the morpheme, as illustrated in (11).¹¹



Tucano has a small number of disharmonic roots that contain both nasal and oral vowels, e.g. [$k\tilde{o}{}^m p\epsilon$] 'left', [$s\epsilon m\tilde{e}$] 'paca'. Noske treats these with [\pm nasal] features that are specified for individual segments underlyingly. She argues that [-nasal] specifications are needed in addition to [+nasal], to prevent [+nasal] from spreading to all voiced segments. This is shown in (12). /B/ represents the phoneme that is variously realized as a nasal or voiced labial stop.¹²



In systems where voiceless obstruents do not impede harmony, descriptions largely converge on the realization of these consonants as voiceless obstruents in nasal harmony contexts. Consider the case of nasal vowel-consonant harmony in Guaraní, where voiceless consonants are reported to be transparent.¹³ An acoustic study of voiceless stops in nasal harmony contexts in unsuffixed Guaraní words found no evidence of nasal airflow energy during the stop closure, nor was the closure fully voiced ([Walker 1999](#)). On the ongoing debate about instrumental evidence for nasalized fricatives, see the aforementioned references on that topic. Examples of nasal harmony in Guaraní are given in (13). The data are from [Gregores and Suárez \(1967\)](#), [Rivas \(1975\)](#), [Piggott and Humbert \(1997\)](#), and [Kaiser \(2008\)](#). Nasal harmony that targets voiced segments and laryngeals is triggered by a stressed nasal vowel (a, b), and stressed syllables that contain an oral vowel block harmony (b). Harmony is robust in the regressive direction and is also triggered by a prenasalized stop (c).¹⁴ Progressive harmony might be more

restricted.¹⁵ There is a long history of discussion of the Guaraní pattern in the theoretical literature. For overviews, see [Piggott and Humbert \(1997\)](#), [Beckman \(1999\)](#) and [Walker \(2000a\)](#).

- (13)
- | | | | |
|----|--|---|-------------------------|
| a. | / ⁿ do-roi- ⁿ du'pã-i/ | [nõrõĩnũ'pãĩ] | 'I don't beat you' |
| | /ro- ^m bo-po'rã/ | [rõmõpõ'rã] | 'I embellished you' |
| b. | /i ^d ja,kãra'ku/ | [ĩjã,kãrã'ku] | 'is hot-headed' |
| | /u'peifa,rõ/ | [u'peifã,rõ] ¹⁶ | 'then, because of that' |
| | | [nãsä,i ⁿ du] | 'moonlight' |
| c. | /ro- ^m bo-he ⁿ du/ | [rõmõhẽ ⁿ du] | 'I made you hear' |
| | /ro- ^m bo-u ^w a'ta/ | [rõ ^m bou ^w a'ta] | 'I made you walk' |

Mòbà Yoruba has a regressive nasal harmony in which both voiced and voiceless stops are transparent, as well as fricatives, as shown in (14). The harmony targets vowels, glides, and liquids ([Ajíbóyè 2001](#); [Piggott 2003](#); [Archangeli and Pulleyblank 2007](#)). However, as mentioned in §1, mid vowels block harmony. Mid vowels are always oral, with the exception of [ɔ̃] when it is an allophone of /ã/. In addition, despite the occurrence of phonemic /ã/ in the language, /a/ is opaque to harmony: [isã_̃] 'kind of pot', [agã_̃tã_̃] 'sheep'.

- (14)
- | | | |
|----------|---------|-------------------------|
| /uwã/ | [ũwã̃] | 'lie' |
| /jú/ | [nú] | 'go' |
| /ùrĩ/ | [ũrĩ] | 'walk' |
| /rù-orĩ/ | [roĩ] | 'to chew chewing stick' |
| /lá/ | [ná] | 'to spend' |
| /idá/ | [ĩdá] | 'magic' |
| /udù/ | [ũdù] | 'lover of sweet things' |
| /egigũ/ | [egĩgũ] | 'bone' |
| /ùgbí/ | [ũgbí] | 'snail' |
| /ì-sí/ | [ĩsí] | 'worship' |
| /itã/ | [ĩtã] | 'story' |
| /ikí/ | [ĩkí] | 'mucus' |

Piggott suggests that voiced stops are underlyingly obstruents in Mòbà Yoruba, unlike languages where voiced stops alternate with nasals in nasal harmony, for which he analyzes the voiced stops as sonorants (see also [Botma 2009](#)).

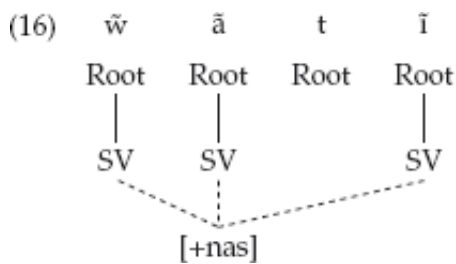
The patterns of nasal harmony in Guaraní and Mòbà Yoruba are also revealing with respect to possible domains of nasal vowel-consonant harmony. In Guaraní, harmony can be bounded at an edge by a stressed syllable, as seen in (13b). This has led some researchers to analyze some or all of Guaraní nasal harmony as operating within metrically defined constituents or via them (e.g. [Sportiche 1977](#); [Halle and Vergnaud 1978](#); van der [Hulst and Smith 1982](#); [Flemming 1993](#); [Piggott and Humbert 1997](#); see also [CHAPTER 40: THE FOOT](#); [CHAPTER 41: THE REPRESENTATION OF WORD STRESS](#)). [Beckman \(1999\)](#) offers a different perspective, in which the role of stressed syllables in Guaraní is attributed to the preservation of the underlying oral/nasal quality of segments in these positions. That approach also accounts for the limitation of phonemic nasality in vowels to stressed syllables.

Another level of prosodic structure has been suggested to be relevant for harmony in Mòbà Yoruba. In this language, nasal harmony can span a word boundary. Examples are given in (15). [Ajíbóyè \(2001\)](#) describes /ɛ̃/ as a particle and analyzes the domain of harmony as the prosodic word, a constituent that can contain more than a morphological word.

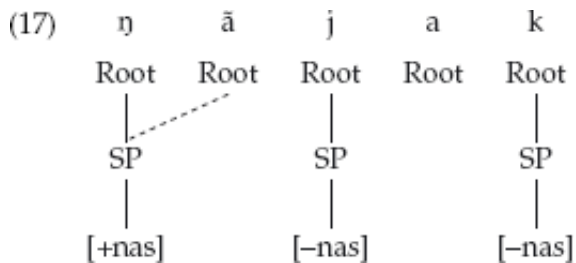
- (15)
- | | | | | | |
|---------|---------|----------------|---------|---------|----------------|
| /kí ì/ | [kí ì] | 'what is it?' | /kí à/ | [kí à] | 'what is it?' |
| /ìsí ì/ | [ìsí ì] | 'who is s/he?' | /ìsí à/ | [ìsí à] | 'who is s/he?' |

Returning to issues surrounding transparent segments and targets, for the Tucano-type patterns in particular, debate has surrounded their analysis and the conception of where they fit in the typology of nasal harmony. One primary approach to these systems posits that they involve different segmental representations from systems like those described in §1, with opaque segments ([Piggott 1992](#)). Specifically, they differ in the dependency of the feature [±nasal] in the feature geometry, and in the node that spreads in nasal harmony. In systems with transparent voiceless obstruents, [±nasal] is dependent on a spontaneous voicing node (SV), which is present in

sonorant segments. Harmony results from the spreading of [+nasal] among adjacent SV nodes, as depicted in (16). Voiceless stops are transparent to harmony because they lack an SV node. Voiced stops are treated as sonorants in these systems (see discussion in §1).¹⁷ Piggott suggests that sonorancy is the source of prenasalization of these consonants in certain oral contexts. The realization is attributed to an articulatory configuration needed to produce spontaneous voicing. Prenasalization in this circumstance thus does not involve a specification for [+nasal] but rather is an epiphenomenon of the sonorant stops' phonetic implementation.



In nasal harmony with opaque segments, [\pm nasal] is dependent on a soft palate (SP) node. An SP node is underlyingly specified in some consonants. Nasal harmony ensues from spreading of the SP node to segments that lack it, as shown in (17) for a Sundanese form. Under this approach, differences in the set of opaque segments arise from differences in the segments that are underlyingly specified for an SP node (governed by Piggott's Contrastive Nasality Principle).



In other work, nasal vowel–consonant harmony systems with transparency *vs.* blocking have been divided along the lines of relations between syllables and segments (Piggott 1996, 2003; Piggott and van der Hulst 1997). In nasal harmony with transparent consonants, [nasal] is considered to be licensed as a property of the syllable, whereas in harmony with blocking segments, the host for [nasal] is the segment. In the case of syllable licensing, [nasal] is associated with the syllable head – the nucleus (see CHAPTER 33: SYLLABLE–INTERNAL STRUCTURE) – and becomes associated with all other sonorant segments in the syllable (Piggott 2003; see Botma 2004, 2009 for a related claim). Locality is respected in harmony with transparent consonants, because no syllable heads are skipped in the propagation of nasal harmony. Noske (1995) also assumes a licensing relation between the syllable and [\pm nasal] for the Tucano pattern, but with some different specifics in her assumptions.

In another approach that posits a basic difference between nasal vowel–consonant systems, those with opaque segments are caused by articulatory spreading, whereas those with transparent consonants involve spreading that is perceptually based (Boersma 1998, 2003). Patterns with blocking are claimed to be driven by an articulatory constraint that penalizes shifts in the position of the velum. This constraint can favor persistence or early onset of a lowered velum in a word that contains a nasal segment. For patterns with transparent obstruents, such as the Tucano type of system, Boersma proposes that a perceptually based constraint drives harmony, causing nasalized segments that are interrupted by an oral segment to be perceived with a single value of [+nasal]. This perceptual representation is distinct from the articulation in which the nasalized segments are interrupted by a velum–raising gesture. Boersma suggests that the reason all sonorants become nasalized in patterns with transparency is connected to the lexical–level specification of nasality in these languages (see (11)). Boersma reasons that if [\pm nasal] is a suprasegmental feature, it is less likely to be specified for individual segments. Segments are thus less likely to have a [-nasal] specification to which to be faithful, and segments that do not become nasalized will be the ones that are inherently problematic in combination with nasalization, i.e. fricatives and plosives.

The notion that nasal vowel–consonant harmony patterns with transparency are tied to perception is also pursued in work by Sanders (2003). He proposes that nasal harmony in Tucano–type languages is driven by dispersion constraints on the perceptual distance of systemic contrasts. These constraints favor words that differ to the

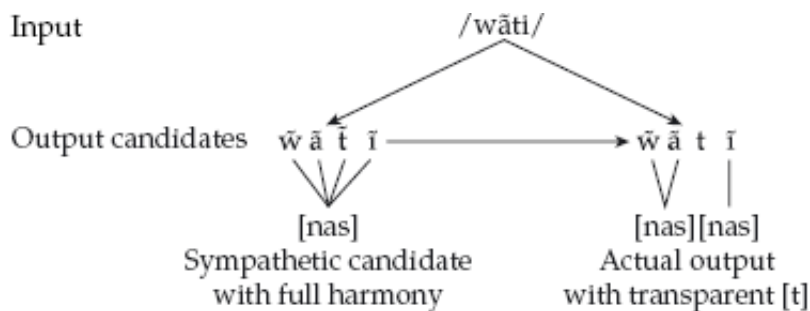
greatest extent possible in the perception of a nasal/oral contrast, while obeying higher-ranked constraints that prohibit nasalized voiceless obstruents, i.e. they favor the morphemes in which all segments besides voiceless obstruents are the same in nasality.

In contrast to analyses where patterns with transparent segments are analyzed as involving representations or harmony imperatives that are different from those with opaque segments, another approach analyzes these systems as having a common source (Walker 2000a, 2003). This account emphasizes a complementarity in the patterns: there is no nasal vowel-consonant harmony in which all of the segments become nasalized, yet there are systems in which obstruents are transparent and the remaining segments are targets. Obstruents form the focus of the complementarity. All segments except (some) obstruents have the potential to be targets in nasal vowel-consonant harmony and only obstruents are transparent. Walker proposes a treatment of the patterns that analyzes systems with transparent obstruents as cases that correspond to the right endpoint of the hierarchy in (1), where nasalization transmits through all segment categories. Walker adduces typological evidence in support of conceptualizing transparent obstruents as on a par with targets. She observes that when obstruents are transparent, all other segment categories are targets, a generalization that would be expected if obstruents were targets in these systems, because they are lowest-ranked on the target scale. More generally, a survey of over 75 languages with nasal vowel-consonant harmony reveals that if a segment is “permeated” by nasal harmony, that is, if it is targeted or behaves as transparent, then all segments belonging to categories that are higher-ranked in the target hierarchy of (1) are also permeated.

A pattern involving voiced stops is brought to bear on the claim that obstruent stops can be targets in nasal vowel-consonant harmony. The nasal harmony of Tuyuca, another Tucanoan language, has been characterized as showing a difference in blocking and transparency effects when it occurs across morphemes vs. within them. Like Tucano, in harmony within a morpheme, voiced stops alternate with nasals and voiceless obstruents are transparent to harmony. However, harmony from stem to suffix is blocked by fricatives and voiced and voiceless stops (Barnes 1996; Walker 2000a).¹⁸ Opaque voiced stops are realized as oral or nasal, depending on the nasality of the suffix to which they belong. (See Trigo 1988 and Walker 2000a on the separate phonological treatment of voiced/nasal velar stops.) Walker interprets the blocking of harmony by voiced stops across a morpheme boundary as evidence of their underlying obstruent status in Tuyuca (cf. Botma 2004); all suffixes that alternate in nasal harmony issuing from the stem therefore begin with a continuant sonorant or laryngeal.¹⁹ When voiced stops undergo harmony within a morpheme, they would then be an instance of voiced obstruent stops that are targets in nasal harmony.

In this approach, feature spreading is analyzed as strictly local at the level of the segment (CHAPTER 81: LOCAL ASSIMILATION). This implies that segments cannot be skipped in harmony; they must either participate in harmony or block it. As a consequence, it is assumed that a phonological representation is available in which a “transparent” obstruent is nasalized (see CHAPTER 91: VOWEL HARMONY: OPAQUE AND TRANSPARENT VOWELS). The model that Walker proposes is illustrated in (18), implemented using the concept of a sympathetic candidate (McCarthy 1999). A sympathetic candidate is a designated form to which the actual output is encouraged to be similar via the activity of a candidate-to-candidate correspondence relation between this form and the actual output. Arrows represent the existence of correspondence relations among representations, which mediate the enforcement of identity between related forms. Among the candidate outputs generated for an input with a [nasal] specification is one where the feature spreads to all segments in the morpheme, satisfying the constraint that drives harmony. This is the candidate that becomes designated as “sympathetic.” However, as [nasal] is not compatible with an obstruent stop, this candidate is not selected. Instead, a form is selected that is identical to the full harmony candidate except that the stop is oral. Because feature associations may not skip a segment, this candidate must have separate [nasal] specifications flanking the oral stop. The actual output is thus chosen not directly by the harmony-driving constraint but rather because of its similarity to a candidate that fares best with respect to that constraint.

(18) Input



This approach makes use of an abstract phonological representation in which obstruent stops are nasalized. Such representations do not occur within the actual output but they influence its selection. Another analysis that is similar in spirit posits the full harmony form as an intermediate level of representation that is generated as the product of a nasal spreading rule (Piggott 1988). A clean-up rule that prevents nasalized obstruents then causes the stop to be denasalized, to generate the derivational series: /wāti/ → w̄ā t̄ ī → [w̄ātī].

In summary, systems of nasal vowel-consonant harmony with transparent consonants have formed the center of discussion on several theoretical themes. One basic question is whether they should be considered the same “type” of nasal harmony as systems with opaque segments. Also at issue are the segmental representations involved, including the organization of [nasal] in the feature geometry, the level of structure at which [nasal] spreads, the locality of feature associations, and what kinds of abstract representations are involved. Questions about levels of representation have been touched upon, including whether there are distinct articulatory and perceptual representations and the possibility of intermediate or sympathetic forms. Finally, blocking and transparency effects in nasal vowel-consonant harmony have given rise to different perspectives on the harmony imperative and the sources that cause segments to block harmony or behave as transparent.

3 Nasal consonant harmony

In nasal consonant harmony systems, nasal harmony involves consonants only. Moreover, the participant consonants have been characterized as ones that are phonologically similar. These systems have been considered to differ from nasal vowel-consonant harmony in locality and the nature of participant segments, giving rise to proposals in which nasal consonant harmony involves a different harmony-driving imperative and/or different representations.

A prototypical case of nasal consonant harmony is found in Kikongo, a Bantu language spoken in the Democratic Republic of the Congo (Bentley 1887; Dereau 1955; Ao 1991; Odden 1994; Piggott 1996; Rose and Walker 2004; see also CHAPTER 77: LONG-DISTANCE ASSIMILATION OF CONSONANTS). The nasal stop phonemes of Kikongo are [m n]. Nasal consonant harmony causes voiced stops and /l/ to become nasal when following a prevocalic nasal stop at any distance in the stem. The stem constituent in Kikongo consists of the root and suffixes. Examples of alternations in the perfective active and applicative suffixes induced by nasal consonant harmony are shown in (19). The consonant in these suffixes is analyzed as /l/ underlyingly. In words where the conditions for nasal harmony are not met, /l/ is realized as [d] before [i]. Vowel quality alternations are due to vowel height harmony. Vowels and voiceless consonants are transparent to the nasal harmony; they remain oral when occurring between harmonizing consonants. The forms in (19) consist of stems, as indicated by the initial hyphen according to convention.

(19) a. *Perfective active forms*

-suk-idi	'wash'	-nik-ini	'grind'
-bud-idi	'hit'	-sim-ini	'prohibit'
-bak-idi	'catch'	-futumuk-ini	'revive, rise'
-sos-ele	'search for'	-le:m-ene	'shine'

b. *Applicative forms*

-sakid-il-a	'congratulate for'	-nat-in-a	'carry for'
-to:t-il-a	'harvest for'	-dumuk-is-in-a	'cause to jump for'

In addition to inducing alternations in suffixes, nasal consonant harmony is considered to operate within roots, which do not show a voiced stop or [l] after a prevocalic nasal stop.

Nasal stops that occur in an NC cluster do not trigger nasal consonant harmony (20a), nor do they prevent it from operating across them (20b). In addition, a voiced oral stop in an NC sequence does not undergo nasal harmony from a preceding prevocalic nasal.

(20) *Perfective active*

- a. -bantik-idi 'begin'
- kemb-ele 'sweep'
- bing-idi 'hunt'
- tond-ele 'love'
- b. -mant-ini 'climb'
- meng-ini 'hate'

Setting aside NC clusters, the targets of nasal consonant harmony are frequently voiced stops and approximant consonants (/l/ is the only approximant consonant in Kikongo). In some cases, nasal harmony is restricted to consonants separated by no more than a vowel. The Bantu language Ndonga shows this pattern (Viljoen 1973; Rose and Walker 2004). In Ngbaka, a Niger–Congo language spoken in the Democratic Republic of the Congo, the lack of co-occurrence of certain nasals and prenasalized stops within a morpheme has been analyzed as the product of nasal consonant harmony (Hansson 2001; Rose and Walker 2004). Ngbaka contrasts nasal, prenasalized, voiced, and voiceless stops (Thomas 1963, 1970; Wescott 1965). Nasals may occur together with voiced and voiceless stops in a morpheme but not with a prenasalized stop that has the same place of articulation as the nasal (Mester 1988; Sagey 1990; van de Weijer 1994; CHAPTER 29: SECONDARY AND DOUBLE ARTICULATION).

Certain root co-occurrence restrictions (see CHAPTER 86: MORPHEME STRUCTURE CONSTRAINTS) on consonants in Ganda (Bantu), discussed by Katamba and Hyman (1991), have also been analyzed as the outcome of nasal consonant harmony (Hansson 2001; Rose and Walker 2004). The patterns in question involve nasals, voiced stops, and voiceless stops. Some of the voiced stops display approximant variants: [b/β], [d/l], [ɟ/j]. Within a root, nasals do not usually occur with a voiced stop (or its approximant variant) that has the same place of articulation. This restriction is observed regardless of the order of the nasal and voiced oral consonant.²⁰ In addition, the combination of a nasal and a voiceless stop with the same place of articulation is systematically absent if the nasal precedes the stop. In attested roots, identical nasals co-occur, as do oral voiced stops/approximants with the same place of articulation, as shown in (21a). Also attested are roots that combine a nasal and voiced consonant with different places of articulation (21b), and roots in which a voiceless stop precedes a nasal (21c).

- (21) a. -mémèká 'accuse, denounce'
- nónà 'fetch, go for'
 - bábùlá 'smoke over fire to make supple'
 - gùgá 'curry favor with'
- b. -bónèká 'become visible'
- màlà 'finish'
- c. -táná 'grow septic, fester'

In the harmony-based analysis of the Ganda pattern, nasal consonant harmony operates within a root among oral stops and nasals with the same place of articulation. For voiced stops the harmony is bidirectional, whereas for voiceless stops it is progressive only. Hansson's (2001) treatment also takes into consideration restrictions on the co-occurrence of nasal stops and voiced prenasalized stops within a root in Ganda.

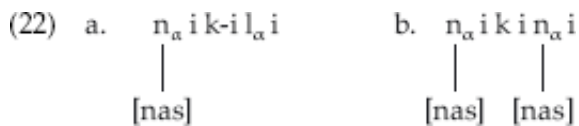
With respect to non-contour stops, surveys of nasal consonant harmony in Hansson (2001) and Rose and Walker (2004) reveal the following implications: (i) patterns that target voiceless stops with the same place of articulation as the nasal trigger also target voiced stops with the same place of articulation, and (ii) patterns that target voiced stops with a different place of articulation from the nasal trigger also target voiced stops with the same place of articulation as the nasal. An interpretation that has been brought to these generalizations is that nasal consonant harmony favors targets that are similar to nasals (Walker 2000b; Hansson 2001; Rose and Walker 2004). These patterns are suggested to have a basis in speech planning (i.e. the organization and sequencing of abstract units) and its physical execution (i.e. the motor controls that carry out the "plan"). The similarity hypothesis finds support from speech error research. It is well established that the likelihood of a speech error between two phonemes increases with their phonological similarity. A series of speech error elicitation tasks conducted by

Walker (2007) found that consonants that are more likely to interact in nasal consonant harmony are also more likely to participate in speech errors with speakers of English.

Prior to the extensive typological studies of consonant harmony by Hansson (2001) and Rose and Walker (2004), analyses of nasal consonant harmony were developed that involved nasal feature spreading at a node within the feature geometry (Ao 1991; Odden 1994; Hyman 1995) or at a suprasegmental level (Piggott 1996). The typological studies in question sharpened the characterization of the differences between nasal consonant harmony and nasal vowel–consonant harmony, leading the authors of those studies to analyze nasal consonant harmony as the product of a different harmony–driving mechanism and as involving different representations from those usually assumed for nasal vowel–consonant harmony.

Two of the chief differences between nasal consonant harmony and nasal vowel–consonant harmony involve locality and types of triggers and targets. Nasal consonant harmony targets segments that are phonologically similar to the nasal stop trigger, i.e. stops and approximant consonants. The harmonizing segments are usually non–adjacent, with at least a vowel intervening and sometimes longer transparent sequences. In contrast, in nasal vowel–consonant harmony, harmony affects a (near–)continuous sequence of segments, and vowels are never skipped. In the latter systems, favored targets follow the scale in (1), with vowels ranked at the top, a scaling suggested to have a basis in the segments’ phonetic compatibility with nasalization or in maintaining distinct contrasts. Consonants that do not become nasalized in nasal vowel–consonant harmony most often block harmony, although in some systems, (some of) the obstruents behave as transparent.²¹

The role of phonological similarity and the capacity for action–at–a–distance are emphasized in the correspondence–driven approach to nasal consonant harmony (Walker 2000b; Hansson 2001; Rose and Walker 2004). In this account, the occurrence of high phonological similarity between consonants can spur a formal correspondence relation to be established between them. Corresponding segments are co–indexed with one another, as illustrated in (22). Nasal harmony is effected via the correspondence relation. Constraints for individual features, such as [nasal], are postulated that enforce identical specifications in corresponding segments, thus producing nasal consonant harmony, as in (22b). Because nasal assimilation is accomplished through the correspondence relation in this structure, the harmonizing segments are not required to share a single [nasal] specification, unlike the outcome of [nasal] spreading, which is usually assumed for nasal vowel–consonant harmony. A representation like that in (22b) is suggested to accommodate the potential for nasal consonant harmony to occur among non–adjacent segments.



In the correspondence–based approach, patterns that show harmony only between consonants in adjacent syllables are analyzed using proximity–sensitive constraints governing corresponding segments. The neutrality of prenasantal nasals in a Kikongo–type system has been attributed to their dissimilarity from the potential target oral consonants, either in terms of their role in syllable structure (the nasals in NC clusters are codas, whereas the oral consonants are onsets) or in terms of their release status (the nasals in NC clusters are unreleased, whereas the oral consonants are released). It is suggested that a voiced stop in an NC cluster does not undergo harmony because of avoidance of geminate nasals, which do not occur in Kikongo. In Ngbaka, prenasalized stops are considered to be singleton consonants – not NC clusters, as in Kikongo – so these issues do not arise. Whether the representation and patterning of nasal contours in Ganda fall in line with these treatments has yet to be closely considered.

The correspondence approach to nasal consonant harmony has been applied to consonant harmony systems in general. The basis for that proposal is that other systems of consonant harmony also show effects of similarity and action–at–a–distance. See Hansson (2001), Rose and Walker (2004), and CHAPTER 77: LONGDISTANCE ASSIMILATION OF CONSONANTS.

4 Directionality

This section turns to directionality in nasal harmony. Some systems can be considered bidirectional, with no apparent difference in the pattern of harmony in either direction. Nasal consonant harmony involving voiced stops

in roots of Ganda is an example of this kind. Such patterns do not necessitate an overt statement of directionality. Also, root- or stem-controlled harmony where affixes in the domain of harmony occur only following or only preceding the root or stem can give the appearance of directional harmony but without requiring formal reference to a direction for harmony. However, other systems of nasal harmony show evidence of asymmetrical directionality, where harmony operates in only one direction or shows different patterns in its progressive vs. regressive operation.

A contrast in the direction of nasal vowel-consonant harmony with opaque segments is seen in the patterns of the Johore dialect of Malay, an Austronesian language of Malaysia, and Capanahua, a Panoan language spoken in Peru. Johore Malay shows a harmony from nasal stops that targets vowels, laryngeals and glides (Onn 1980). Liquids and obstruents block harmony. Examples in (23) show that the harmony is progressive only.

(23)	pənəŋāhān	'central focus'
	pəŋāwāsan	'supervision'
	pəmāndaŋān	'scenery'
	mākan	'to eat'
	baŋōn	'to rise'
	mānāwān	'to capture (ACTIVE)'
	mājāŋ	'stalk (palm)'
	māratappi ²²	'to cause to cry'
	mīnōm	'to drink'
	māʔāp	'pardon'

Like Johore Malay, Capanahua displays a nasal harmony that targets vocoids and laryngeals and is blocked by other segments (Loos 1969; Piggott 1992); however, the direction is regressive. The regressive direction cannot be predicted from the position of triggers in the syllable structure, as they occur in both syllable onsets and codas. Word-final nasals are enclosed in parentheses because they are deleted but still trigger harmony.²³

(24)	hāmawi	'step on it'
	hāmāʔōna	'coming stepping'
	kajatānai ²⁴	'I went and jumped'
	wurānai	'I pushed it'
	bīmi	'fruit'
	ʔipōŋki	'downriver'
	kūnʔap	'bowl'
	bāwī(n)	'catfish'
	warā(n)	'squash'
	pōjā(n)	'arm'
	ʔōnāmpā(n)	'I will learn'

An instance of directionality in nasal vowel-consonant harmony with transparent segments is found in Siriano, a Tucanoan language spoken in Colombia and Brazil (Bivin 1986). Suffixes in Siriano become nasalized following a nasal stem (excluding certain suffixes that are invariant in nasality). Examples of suffix alternations are given in (25). Underlying forms are as provided by Bivin.

(25)	a.	/wehe-gi/	[wehɛgi]	'when he is fishing'
		to fish-3SG MASC		
		/wēhē-gi/	[wēhɛŋi]	'when he is killing'
		to kill-3SG MASC		
	b.	/igo-re/	[ʔigoɾe]	'she (COMPLEMENT)'
		/igī-rɛ/	[ʔiŋinɛ] ²⁵	'he (COMPLEMENT)'

The data in (25) are compatible with nasal harmony where directionality is an epiphenomenon of root or stem control. However, a small group of suffixes harmonize with a following suffix rather than the root, as shown in (26). The suffixes that exhibit this behavior are /-ju/ (SECOND HAND INFORMATION), /-de:/ (PAST NOMINALIZER), /-bu/ (INCEPTIVE), and /-ku/ (PROBABILITY).

- (26) a. /wa:ju-pi/ [waʔjupi] 'they say he left'
to go+EVID:SECOND HAND+3SG MASC
/wa:ju-rã/ [waʔnũrã] 'they say they left'
to go+EVID:SECOND HAND+3PL ANIMATE
/ũhẽ-ju-pi/ [ũhẽjupi] 'they say he killed'
to kill+EVID:SECOND HAND+3SG MASC
- b. /wa:bu-gi/ [waʔbugi] 'about to go (SG MASC)'
to go+INCEPTIVE+SG MASC
/wa:bu-rã/ [waʔmũrã] 'about to go (PL)'
to go+INCEPTIVE+3PL ANIMATE
/ũhẽ-bu-gi/ [ũhẽbugi] 'about to kill (SG MASC)'
to kill+INCEPTIVE+SG MASC
- c. /wa:de:-ro/ [waʔaⁿdɛʔro] 'where he went'
to go+NOMINALIZER+LOC
/wa:de:-rã/ [waʔanẽʔrã] 'the ones who went'
to go+NOMINALIZER+3PL ANIMATE
/ũhẽ-de:-ro/ [ũhẽⁿdɛro] 'where he killed'
to kill+NOMINALIZER+LOC
- d. /wa:ku-a/ [waʔakoa] 'it left'
to go+PROBABILITY+INANIMATE
/wa:ku-bĩ/ [waʔakũmĩ] 'he left'
to go+PROBABILITY+EVID:3SG MASC
/ũhẽ-ku-a/ [ũhẽkua] 'it killed'
to kill+PROBABILITY+INANIMATE

Bivin notes that /-ju/ and /-ku/ are evidentials, which must appear with a person–number suffix. Although he does not have data to verify the facts for /-de:/ and /-bu/, he speculates that they too must be used with an additional suffix. We may wonder whether a stipulation for Siriano is needed that harmony with these suffixes is regressive or whether this directionality could be made to follow from morphological structure. Both possibilities have been considered. Bivin suggests that the suffixes in question form a separate lexical class. He treats regressive nasal harmony using a left spreading rule for [nasal] that applies to that lexical class. He also considers an approach that posits an internal word boundary at the left of these particular suffixes. This would block them from harmonizing with the root, as harmony occurs only within words. Bivin disprefers this account because he finds no evidence from other Tucanoan languages to support the presence of an internal word boundary, nor does he find evidence for an analogous occurrence of internal word boundaries elsewhere in Siriano. On the other hand, for Desano, a language closely related to Siriano, [Kaye \(1971\)](#) treats a similar directionality phenomenon as an epiphenomenon of morphological constituency. Like Siriano, Desano has a limited number of suffixes that derive their nasality from the following suffix rather than the preceding morpheme. Three of these suffixes are the same as those in Siriano ([Bivin 1986](#)). Kaye suggests that the suffixes targeted by regressive nasal harmony form a morphological constituent with the following suffix that is separate from the preceding stem.²⁶ He pairs this assumption with a bidirectional nasal assimilation rule that applies cyclically to obtain differences in the direction of harmony. Siriano and Desano, then, are cases where directionality in nasal harmony can perhaps be reduced to the organization of morphological structure, but further study on this issue is needed.

There is possible evidence of directionality in nasal consonant harmony. In the nasal consonant harmony of Kikongo, introduced in §3, harmony is progressive in the stem. The examples in (27) show apparent directionality; a voiced stop or consonantal approximant precedes a nasal in the stem but remains oral. (See also the discussion in [CHAPTER 77: LONG-DISTANCE ASSIMILATION OF CONSONANTS.](#))

- (27) -dumukina 'jump for'
-bilumuka 'assemble in crowd'

[Hansson \(2001\)](#) speculates that progressive directionality in canonical Bantu nasal consonant harmony, like that of Kikongo, might be reducible to a system of harmony that is stem–controlled and that preserves the underlying oral/nasal quality of root–initial segments (e.g. using a faithfulness constraint specific to this position). However, this hypothesis has been questioned. Although the canonical Bantu root structure is CVC, [Rose and Walker \(2004\)](#)

cite evidence that [bilum] is lexically stored as a whole. For the similar pattern of nasal consonant harmony in Yaka, another Bantu language, they point to evidence of stored forms with the sequences /CVIVN-/ and /CVbVN-/ , which likewise do not show nasal harmony. Because the /l/ or /b/ is not root-initial in these cases, nor does it belong to a different cycle from the nasal, it would be expected to undergo nasal harmony that was not strictly progressive. Within a correspondence-based approach, Rose and Walker propose to analyze directional harmony in these patterns using a precedence-sensitive identity constraint for the feature nasal in corresponding segments.

In sum, there are systems of nasal vowel-consonant harmony and nasal consonant harmony that seem to display directionality effects that cannot be attributed to independent aspects of the system or structure. Differences in directionality in certain patterns of nasal vowel-consonant harmony with opaque segments present the strongest evidence for these effects. In some cases, certain researchers have suggested that morphological structure and/or prosodic position could obtain the effect of directional harmony, but there is not consensus on this explanation for the various patterns discussed above.

5 Conclusion

To conclude, at the heart of research on nasal harmony are patterns that fall into three descriptive categories: nasal vowel-consonant harmony with opaque segments, nasal vowel-consonant harmony with transparent segments, and nasal consonant harmony. Across languages, patterns belonging to the first category respect an implicational scale that governs favored targets. Whether nasal vowel-consonant harmony with transparent segments and systems with opaque segments share a common source remains in question. Studies bearing on this issue have generated diverse perspectives on the harmony imperatives, the levels of representation that are involved, and the nature of locality. Nasal consonant harmony presents differences from nasal vowel-consonant harmony in showing action-at-a-distance and in favoring harmony between segments that are phonologically similar. This has given rise to a correspondence-driven approach to nasal consonant harmony, situated in a general typology of consonant harmony. This approach is distinct from the treatment of nasal vowel-consonant harmony, which is most often assumed to involve spreading.

The study of nasal harmony can illuminate not only the nature of long-distance phonological assimilation but also themes in phonology that are more general in nature. Whereas in the last couple of decades the broad strokes of the typological characteristics of nasal harmony patterns have been reasonably well delineated, the details of many specific systems remain unknown. Future research could be fruitfully applied to developing more case studies. The resulting findings will doubtless in turn shed new light on the theoretical debates and the cross-linguistic characterization of nasal harmony, both alone and in the larger picture.

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Notes

1 The description of Harms (1985: 16) states that /s/ blocks progressive nasal harmony. The later description by Harms (1994: 8) seems to indicate that /s/ does not always block spreading, but includes the example [ˈmĩ̃su] ‘spear’, where it is opaque (1994: 6). Another example, [ˈsĩ̃sɔ̃] ‘sugarcane’ (1994: 5), could be regarded as showing that /s/ does not block spreading, since Harms’s phonemic transcription of this word posits only the first syllable as underlyingly nasal. However, it is also compatible with a treatment in which both the first and last syllables contain nasal vowels underlyingly.

2 Harms (1985: 16) describes “a minor degree” of nasalization on a vowel that precedes a nasal syllable, but he characterizes it as “so slight” that he does not represent it in transcription.

3 A fricative variant [β] of /w/ does not block harmony: [ˈnãwẽ] ~ [ˈnãβẽ].

4 This form is transcribed in Harms (1985) with a prenasalized [s], but later description in Harms (1994) indicates that [s] is not prenasalized following a nasal vowel.

5 Harms (1985: 16) transcribes this form without aspiration of [t]; however, given his description of voiceless stops before a nasal vowel (1985: 15), it is presumably aspirated.

- 6 I will use [nasal] to cover a privative nasal feature or a [+nasal] specification. Where an equipollent vs. privative distinction is relevant, I will disambiguate with \pm notation or in surrounding discussion.
- 7 For this example, the consonants' phonetic realization is based on the description provided by Morris and Bivin.
- 8 Rich does not distinguish degrees of stress in her transcription.
- 9 On the operation of nasal harmony from roots to certain suffixes in Tucano, see [Trigo \(1988\)](#) and [Noske \(1995\)](#).
- 10 An off-glide [h], realized predictably in word-final position, is not shown in these transcriptions.
- 11 [ɛ] is an allophone of [e] in Tucano.
- 12 Noske assumes an intermediate stage in this derivation that is not relevant to the issues under focus.
- 13 However, the locative suffix shows an alternation between [-pe] and [-mẽ]. See [Piggott and Humbert \(1997\)](#) for discussion.
- 14 [Kaiser \(2008\)](#) finds that word-initial vowels often do not undergo nasal harmony in words over two syllables long. She speculates that a morpheme boundary might be blocking harmony in these forms.
- 15 [Kaiser \(2008\)](#) observes that the data available do not confirm whether progressive harmony can affect more than one syllable. See also [Piggott and Humbert \(1997\)](#) on observed asymmetries in progressive vs. regressive harmony in Guaraní. If it were determined that progressive harmony does not advance beyond one syllable, then the second two examples in (13b) would be most relevant to establish blocking by a stressed syllable, for regressive harmony from the following nasal vowel or prenasalized stop.
- 16 The vowel sequence [ei] in this form is tautosyllabic ([Kaiser 2008](#)).
- 17 For other assumptions about the representation of sonorant stops in the context of nasal harmony systems, see [Botma \(2004, 2009\)](#) and [Botma and Smith \(2007\)](#).
- 18 Tucano has also been analyzed in this way by [Trigo \(1988\)](#), but it has come to light that a suffix beginning with a labial voiced stop alternates in nasal harmony in this language ([Piggott and van der Hulst 1997](#); [Botma 2004](#)), which indicates that voiced stops do not systematically block harmony from the stem to suffix in this language.
- 19 Whether laryngeals should be treated as sonorants is an open question.
- 20 Ganda also shows a dispreference for particular pairs of voiced stops and nasals in a root when the voiced stop and nasal have a different place of articulation and the voiced stop follows the nasal ([Katamba and Hyman 1991](#); [Hansson 2001](#)).
- 21 Some additional differences are that nasal consonant harmony never has opaque segments ([Hansson 2001](#); [Rose and Walker 2004](#)), whereas many nasal vowel-consonant harmony systems do. Also nasal consonant harmony does not appear to show sensitivity to metrical structure, such as stress and foot boundaries, and it does not extend across word boundaries ([Hansson 2001](#)), although these characteristics are attested in some patterns of nasal vowel-consonant harmony.
- 22 Vowel nasalization in this word is assigned according to Onn's description and harmony rule. Because vowel nasalization is predictable in Johore Malay, Onn only marks it when demonstrating rule applications.
- 23 Capanahua also manifests a bidirectional nasal harmony triggered by a nasal stop that is deleted preceding an oral continuant consonant. For discussion, see [Loos \(1969\)](#), [Safir \(1982\)](#), and [Trigo \(1988\)](#).
- 24 Vowel nasalization in this word and the next one is assigned according to Loos's description and rules.
- 25 [Bivin \(1986: 71\)](#) transcribes the suffix consonant here as [n], but in other transcriptions that he provides for flaps that have undergone nasal harmony in Siriano the consonant is a nasalized flap.
- 26 [Miller \(1999\)](#) treats the regressive nasal harmony in Desano as lexicalized.

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