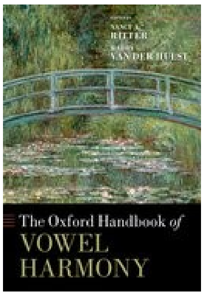

The Oxford Handbook of Vowel Harmony

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CHAPTER

3 Nasal Harmony

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Abstract

This chapter is concerned with nasal harmony, the cover term for processes involving long-distance assimilation of nasality. Nasal harmony is similar to vowel harmony in several respects. Languages may differ in the domain, the direction and the trigger of nasal harmony, and in the behavior of sounds that do not participate in the harmony; like vowel harmony, nasal harmony may involve opaque segments (which block nasalization) and transparent segments (which are skipped by nasalization). The focus of the chapter is on cross-linguistic variation in nasal harmony patterns, especially with regard to the nasalizability of segments and the issue of segmental transparency.

Keywords: nasal harmony, nasalization, (hierarchy of) segment nasalizability, opaque segment, transparent segment

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3.1 Introduction

The term ‘nasal harmony’ is applied to phenomena of long-distance assimilation whereby segments in some domain come to share the property of being nasalized. In practice, the term is applied rather loosely to a variety of nasalization processes. This is in keeping with the observation that harmony in phonology tends to be used as “a descriptor of a class of similar phenomena, rather than a technical term referring to phenomena with a clearly defined set of properties” (Archangeli and Pulleyblank 2007: 352).

A more restrictive characterization is provided by Clements and Osu (2003: 71), who contend that in order to qualify as nasal harmony, nasalization must cross syllable boundaries, nasality must be contrastive at the level of the morpheme, and there must be alternating oral and nasal forms. A language which meets these criteria is

Tuyuca (Tucanoan) (Barnes 1996). Tuyuca has oral words (1a) and nasal words (1b); in the latter, nasality surfaces as a property of all sounds except voiceless stops and fricatives. The words in (1c) show that some suffixes—for example, /-ri/ ‘imperative of warning’—have oral and nasal allomorphs. The suffixes in (1d) are consistently oral, and so block nasal harmony.[1]

(1)	a.	bipí	‘swollen’
		sigé	‘follow’
	b.	mĩpĩ́	‘badger’
		sĩã́	‘kill’
	c.	tutí-ri	‘watch out or you will get scolded!’
		h̃ĩĩ́-r̃ĩ	‘watch out or you will get burned!’
	d.	h̃õṍ-pɨ	‘at that place (over there)’
		j̃ũká-da	‘thread made of Tucum fiber’

p. 38 These data show that nasal harmony is similar to vowel harmony in several respects. Like vowel harmony, nasal harmony may function as a morpheme-level property.[2] And like vowel harmony, it may involve opaque segments (which block the harmony) and transparent segments (which are skipped by the harmony). Many issues that come up in the analysis of nasal harmony are therefore the same as in vowel harmony. What is the domain in which harmony operates? What are the triggers of harmony? What are the targets? And what are the properties of opaque and transparent segments?

While canonical cases of vowel harmony involve a relation between vowels, nasal harmony usually involves a relation between vowels and consonants. A notable exception is the pattern of nasal harmony found in Yaka (Niger-Congo) and some other Bantu languages, in which only nasal consonants participate. Hyman (1995) observes that the perfective suffix in Yaka is realized as [idi] (2a), but surfaces as [ini] when the preceding root ends in a nasal consonant (2b). The suffix also surfaces as [ini] when there is a nasal earlier on in the root, which is separated from the suffix by a transparent consonant (2c). Pre-nasalized stops do not condition a nasal consonant in the suffix (2d).

(2)	a.	tsúb-idi	‘wander-PERF’
		kík-idi	‘sweep-PERF’
	b.	tsúm-ini	‘sew-PERF’
		kún-ini	‘plant-PERF’
	c.	mák-ini	‘climb-PERF’
		fínúk-ini	‘sulk-PERF’
	d.	bíí^{m}b-idi	‘kiss-PERF’
		kúú^{n}d-idi	‘bury-PERF’

It has been argued that nasal consonant harmony involves a different formal mechanism than standard cases of nasal harmony (Hansson 2002, 2010a; Rose and Walker 2004; Walker 2011; see also Chapter 2, this volume). A major difference is that nasal consonant harmony is driven by a relation of feature identity (i.e., the trigger and target are phonologically similar), while in standard cases of nasal harmony the compatibility of harmonic targets is determined by an implicational scale, which is similar to the sonority hierarchy (see Section 3.3). The focus in the remainder of this chapter is on standard cases of nasal harmony.

The chapter is organized as follows: Section 3.2 considers how nasal harmony may develop diachronically from vowel nasalization; Section 3.3 summarizes the main points from typological work; and Section 3.4 examines the issue of transparent segments.

3.2 From nasalization to nasal harmony

A good starting point for approaching nasal harmony is the more common phenomenon of vowel nasalization. This section looks at how the two may be connected in diachronic terms.

p. 39 The most frequent type of nasalization is that of a vowel by a neighboring nasal consonant. A nasal consonant —for example, [m]—involves a combination of an oral gesture (closing the lips) and a nasal gesture (lowering the velum). Speakers may show variability in the phasing of these gestures. For example, given the 'sluggishness' of the velum (e.g., Bell-Berti 1993), the nasal gesture may be implemented slightly earlier than the oral gesture. As a result of this, part of the preceding vowel will be phonetically nasalized. Alternatively, the nasal gesture may persist after the oral gesture has been completed, resulting in some spill-over of nasalization on a following vowel.[3] Over time, such effects may become phonologized. In some languages this has resulted not just in nasalization of adjacent vowels, but in the creation of longer nasal spans. An example is Madurese (Austronesian) (Stevens 1968), where vowels and epenthetic glides are nasalized when following a nasal consonant, as in the singular forms in (3).

(3)	Singular	Plural	
	mõw̃ã	w̃ã-mõw̃ã	'face'
	nẽj̃ãt	j̃ãt-nẽj̃ãt	'intention'
	mãẽn-ãn	ẽn-mãẽn-ãn	'toy'

Evidence from reduplicative morphology shows that nasalization in Madurese is more than a phonetic effect. The plural forms show that vowels also surface as nasalized in reduplicants, despite the fact that the triggering nasal is present only in the base. For a theoretical treatment of this, see, for example, McCarthy and Prince (1995b).

In some languages with long-distance nasalization, the original nasal trigger is no longer present. This is the result of 'nasal effacement,' a development in which a nasal consonant triggers nasalization of a neighboring vowel and is itself lost (Foley 1975). Nasal effacement is the most common origin of contrastively nasal vowels. The process typically affects syllable-final nasals. The reason for this is probably that such nasals lack formant transitions into a following vowel, making them diachronically unstable (see, e.g., Silverman 2017 for discussion of the acoustic properties of nasals).

An example of a language with synchronic nasal effacement is Capanahua (Pano-Tacanan) (Loos 1969). In this language nasality spreads leftward from a nasal consonant; it targets vowels, laryngeals, and glides, and is blocked by other consonant types, including /r/ (4a). Nasals undergo effacement in final position (4b) and before continuants (4c); in the latter case, nasality also spreads rightward.

(4)	a.	/t͡ʃipoŋki /	[t͡ʃipõŋki]	'down river'
		/hama-wɨ/	[h̃ãmawɨ]	'step on it'
		/wɨran-ai/	[wɨrãnai]	'I pushed it'
	b.	/pojan/	[põj̃ã]	'arm'
	c.	/wɨran-wɨ/	[wɨrãw̃ɨ̃]	'push it over'
		/wɨran-jaʃaʔn-wɨ/	[wɨrãj̃ãʃãʔ̃w̃ɨ̃]	'push it over sometime'

p. 40 The Capanahua pattern is interesting because the triggering nasals alternate with zero; the forms in (4b,c) exhibit harmony in the absence of an overt trigger. From a diachronic perspective, this pattern may therefore show how, in the development of long-distance nasalization, the original nasal trigger is gradually lost.

The cross-linguistic frequency of nasal effacement has led some researchers to argue that certain types of nasal harmony involve an abstract trigger. This is what Piggott and Humbert (1997) propose for Guaraní (Tupian). Where earlier analyses posit two separate spreading processes, Piggott and Humbert provide a unified account in which harmony is triggered by a 'latent' syllable-final nasal consonant, represented as 'N' in example (5) below. Within stems, this latent consonant spreads nasality leftward, causing any prefix to harmonize. The trigger itself combines with a following stop to form a pre-nasalized stop (5a). A stem-final trigger undergoes effacement unless a suffix-initial stop follows, with which it forms a pre-nasalized stop (5b). A further complication is that some unstressed suffixes are harmonic only when they can be grouped in the same foot as the stem-final syllable.[4] When this is the case, as in (5c), the trigger fuses with the suffix-initial stop, giving a nasal (rather than a pre-nasalized) stop. If the suffix cannot be grouped in the same foot as the preceding syllable, it remains oral, as in (5d). (Foot structure is represented between parentheses.)

(5)	a.	/kumaNda/	[kũmã^{n}da]	'bean'
		/ore-kaNbɨ/	[õr̃ẽkã^{m}bɨ]	'our milk'
	b.	/petɨN/	[pẽtɨ̃]	'tobacco'
		/petɨN-tɨ/	[pẽtɨ̃^{n}dɨ]	'tobacco field'
		/iruN/	[ĩr̃ũ]	'friend'
		/iruN-k^{w}era/	[ĩr̃ũ^{ŋ}g^{w}era]	'friends'
	c.	/akaN/	[ãkã]	'head'
		/akaN-pe/	[ã('kãmẽ)]	'in the head'
	d.	/menaN/	[mẽnã]	'husband'
		/menaN-pe/	[('mẽnã)pe]	'at the husband'

With the exception of the restricted pattern in (5c), voiceless stops in Guaraní are transparent to nasal harmony. The effect of this is that regressive nasalization is unbounded, so that the left edge of a nasal span coincides with the left edge of the word (barring word-initial voiceless stops).

It seems plausible to assume that at least some nasal harmony patterns with transparent sounds have developed from patterns in which these sounds were formerly opaque—that is, blocked nasal spread. A possible example of this development is found in Mọ̀bà Yoruba (Niger-Congo) (Ajíbóyè and Pulleyblank 2008). Where other Yoruba dialects restrict nasalization to single syllables, Mọ̀bà Yoruba has extended the domain to preceding vowels (6a), including in those cases where an intervening consonant cannot be nasalized (6b). (The forms in (6b) are given with their Standard Yoruba cognates, so as to show the difference in harmonic domain.) The forms in (6c) show that mid vowels resist nasalization.

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(6)	a.	/iw̃ĩ/	[ĩw̃ĩ]	'spirit'	
		/urĩ/	[ũr̃ĩ]	'walk'	
		/lã̌/	[nã̌]	'spend'	
		/jũ̌/	[ɲũ̌]	'go'	
	b.	/idã̌/	[ĩdã̌]	'magic'	(Standard Yoruba [idã̌])
		/ikĩ/	[ĩkĩ]	'mucus'	(Standard Yoruba [ikũ])
		/ì-sĩ̀/	[ĩ̀sĩ̀]	'worship'	(Standard Yoruba [jɔ-sĩ̀])
		/ìfũ/	[ĩ̀fũ]	'intestine'	(Standard Yoruba [ìfũ])
	c.	/erĩ/	[er̃ĩ]	'elephant'	
		/ɛrã/	[ɛr̃ã]	'meat'	
		/ogũ/	[ogũ]	'war'	
		/ɔdũ̌/	[ɔdũ̌]	'festival'	

In the Mọ̀bà forms in (6b), the nasal span is not a contiguous string of sounds. The edges of the harmonic domain are aligned with the edges of words, as in Tuyuca and Guaraní. Kaye (1989: 51) observes that alignment of harmonic nasality with word edges serves a functional purpose:

> Detection of morpheme or word boundaries is facilitated by the harmony process. A boundary may be placed at a change from nasal to oral or from oral to nasal. This is not 100% effective, because sometimes two oral or nasal words occur in succession. Failure to find a change of nasalization does not always imply that we are in the same domain. On the other hand, changes in nasalization are fairly reliable indicators that we are also at a boundary.

Suomi et al. (1997) provide a similar functional interpretation of vowel harmony in Finnish (Uralic). For more discussion of this perspective, see Chapter 40, this volume.

The data examined in this section suggest that patterns of nasal harmony have their origin in the gradual extension and phonologization of low-level phonetic nasalization. This development may involve the loss of the original nasal trigger. This trigger may alternate with zero, as in Capanahua, or it may manifest itself as pre-nasalization, as in Guaraní. In languages where some segments are transparent, such as Mọ̀bà Yoruba, the harmonic domain no longer involves a single nasal gesture, because the velum raises whenever a nasal span is broken up by an oral sound. This type of harmony could be said to be perceptually motivated, since nasality spreads even when this requires additional articulatory effort (Boersma 2003).[5] In languages of this type, nasality tends to be a property of entire morphemes or words; as such, it may provide listeners with a cue for detecting morpho-syntactic boundaries.

3.3 Cross-linguistic patterns of nasal harmony

Typological work shows that nasal harmony patterns may differ from each other in a number of ways. Cohn
p. 42 (1993) is the first large-scale survey of the patterning of nasals and nasalization ↳ processes. The later survey in Walker (1998) specifically covers the typology of nasal harmony patterns. These are classified primarily on the basis of the segmental targets of the harmony. Additional variables include the trigger, the domain, and the direction of harmony. The focus here is on the segmental targets; other variables are discussed in connection with this.

One insight that has emerged from typological work is that there is an implicational scale of segment nasalizability (see Walker 1998, 2011). A simplified version of this scale is given in (7).

(7) *Implicational scale of segment nasalizability*
vowels › laryngeals › glides › liquids › fricatives › stops

The scale in (7) is implicational in the sense that if, say, a language displays harmonic nasalization of liquids, then nasalization will also target glides, laryngeals, and vowels. We therefore find the patterns in Table 3.1, exemplified by Sundanese (Austronesian), Johore Malay (Austronesian), Kolokuma Ịjọ̣ (Ijoid), Applecross Gaelic (Indo-European), and Tuyuca (languages taken from Walker's database). Table 3.1 also lists, for each of the patterns, the number of languages in the database.

Table 3.1 Cross-linguistic typology of segment nasalizability (Walker 1998)

	Language	*n*	vowels	laryngeals	glides	liquids	fricatives	stops
a.	Sundanese	9	✓	✓	*	*	*	*
b.	Johore Malay	28	✓	✓	✓	*	*	*
c.	Kolokuma Ịjọ	15	✓	✓	✓	✓	*	*
d.	Applecross Gaelic	4	✓	✓	✓	✓	✓	*
e.	Tuyuca	28	✓	✓	✓	✓	✓	✓

The table lists the number of languages (*n*) for each of the five types of segment nasalizability (a)–(e), with a representative example for each type.

In Walker's Optimality Theory analysis, the scale is formalized in terms of a hierarchy of phonetically grounded markedness constraints: *NAS/STOP » *NAS/FRIC » *NAS/LIQ, etc. For a similar approach, see Piggott (2003).

The scale in (7) is similar to the sonority hierarchy, with the exception of the position of laryngeals. The status of laryngeals in nasal harmony has been the subject of debate (e.g., Cohn 1990; Piggott 1992; Ní Chiosáin and Padgett 1997; Walker and Pullum 1999; Boersma 2003). Piggott argues that nasal harmony in languages like Tuyuca is restricted to sonorants, and that obstruents, including laryngeals, are transparent. The problem with this is that it fails to account for the fact that /h/ in such languages is invariably nasalized in nasal spans. Glottal stops pose a different problem. In nasal spans these are produced with a lowered velum, but glottal stops lack nasal airflow due to their glottal closure. The patterning of glottal stops in nasal harmony has led some researchers to adopt a strictly articulatory definition of the feature [nasal] (see, e.g., Durvasula 2009). Boersma (2003) distinguishes between an articulatory and a perceptual feature, so that [ʔ̃] is articulatorily
p. 43 nasal and perceptually non-nasal. Ní Chiosáin and Padgett (1997) note that the frequent occurrence ↳ of [ʔ̃] in nasal spans is due to it being both articulatorily and perceptually unmarked; it is articulatorily unmarked because it has a lowered velum inside a nasal span, and it is perceptually unmarked because the lowered velum has no auditory effect, and so does not create a perceptual contrast with oral [ʔ].

The remainder of this section is devoted to a discussion of types (a)–(d) in Table 3.1. These involve languages with nasal harmony in which segments are opaque. Languages belonging to type (e) involve transparent segments—that is, segments that occur in nasal spans without being nasalized themselves. These languages are considered in Section 3.4.

Inspection of Walker's database reveals some interesting correlations between targets, triggers, and the direction of nasal harmony. Languages with a restricted target range tend to have progressive harmony, triggered by nasal consonants. This is the case for 6 of the 9 languages of type (a), and for 17 of the 28 languages of type (b). In languages of type (c), progressive and regressive harmony are roughly equally frequent. Walker's database contains only four languages of type (d), which is not enough to assess any potential correlations between variables.

The overview in (8) provides sample data from the languages representing each of the types in Table 3.1, taken from Walker (1998: 30–33) and Piggott (2003: 377).

(8) a.	*Sundanese* (Robins 1957)	
	ɲãĩ̃ãn	'wet'
	mĩʔ̃ãsih	'love'
	mãwur	'spread'
	mõlohok	'stare'
	ŋãtur	'arrange'
b.	*Johore Malay* (Onn 1976)	
	mãj̃ãn	'stalk'
	mẽw̃ãh̃	'be luxurious'
	mãʔ̃ãp	'pardon'
	mə̃laran	'forbid'
	mãkan	'eat'
c.	*Kolokuma Ịjọ* (Williamson 1965)	
	w̃ãĩ	'prepare sugarcane'
	tɔ̃nĩ	'light (a lamp)'
	j̃ãr̃ĩ	'shake'
	kɔ̃r̃ɔ̃ŋ͡mɔː	'thin'
	izõŋgo	'jug'
d.	*Applecross Gaelic* (Ternes 1973)	
	f̃r̃ĩãːṽ	'stalk'
	kʰɔ̃ĩs̃paxk	'wasp'
	ʃ̃ɛ̃nɛ̃ːṽãr̃	'grandmother'
	str̃ãĩːɣ̃	'string'
	mãːh̃ãr̃	'mother'

Types (a)–(c) are robustly attested, although inspection of individual languages frequently reveals complicating
p. 44 factors. Sundanese is a well-documented example: The data in ↳ (8a) show that harmony is blocked by all consonants except laryngeals. However, while /l/ blocks nasal spread in stems, it is harmonic in infixes—for example, [ŋãl̃ĩãr] 'seek-PL' (from /ŋ-al-iar/). This overapplication has received considerable attention in the theoretical literature: see, for example, Benua (2003).

Type (d), in which nasal harmony produces nasalized fricatives, is represented by just four languages in the database: Isekiri (Niger-Congo), Inor (Afro-Asiatic), Umbundu (Niger-Congo), and Applecross Gaelic. The question is whether the sounds concerned are truly fricatives and, if so, whether they are truly nasalized. Ohala and Ohala (1993) observe that nasalized fricatives are rare, given that velum lowering inhibits air pressure build-up behind the oral constriction, making it hard to produce friction.

Of the four languages, only Scottish Gaelic has been the subject of phonetic research. Warner et al. (2015) present aerodynamic data showing that speakers very rarely produce nasalized fricatives.[6] Most of the fricative tokens in their experiment are produced without nasalization and, when nasalization is present, it hardly ever creates an aerodynamic conflict with oral friction. Nasal airflow data from other languages present much the same picture. Demolin (2009) shows that Guaraní /v ɣ/ are realized as approximants in nasal spans, and /x/ as [ɦ̃] (i.e., as a fricative, but without oral friction); however, he also finds that /ʃ/ in nasal spans has peaks in both oral and nasal airflow during the initial portion of the fricative, suggesting that it is at least partly nasalized. Gerfen (2001) presents airflow data showing nasalized fricatives in Coatzospan Mixtec (Oto-Manguean). Shosted (2006) questions some aspects of Gerfen's methodology; he is also skeptical of the claim, made by Schadeberg (1982), that Umbundu has a nasalized fricative /ṽ/.

Phonologically, sounds which are transcribed as voiced fricatives sometimes pattern as sonorants rather than obstruents (see, e.g., Botma and van 't Veer 2013). This may be the case for /ɣ/ in Isekiri, which is realized as [ɣ̃] or [ŋ] before nasal vowels (Opubor 1969). Since the other sounds that alternate in this context are /w j r/, it is tempting to analyze /ɣ/ as an approximant, as this would limit targets to the class of continuant sonorants (/l/ in Isekiri can apparently precede nasal vowels). A similar pattern is found in other African languages. In Kpelle (Mande) there is a complementary distribution between nasals and a series of voiced oral consonants, including a sound that Welmers (1962) transcribes as /ɣ/. The former occur before nasal vowels (9a), the latter before oral vowels (9b).

(9)	a.	mĩ́	'where'	(*mí)
		nĩnã	'new'	(*nina)
		ɲɛ̃ɛ̃	'fish'	(*ɲɛ́ɛ)
		ŋĩ́nã	'rat'	(*ŋína)
		ŋʷã́nã	'bitter'	(*ŋʷána)
	b.	ɓɔ́ɔ	'magic'	(*ɓɔ̃́ɔ̃)
		lúu	'fog, mist'	(*lṹũ)
		já	'water'	(*jã́)
		ɣíla	'dog'	(*ɣĩ́la)
		wée	'white clay'	(*wẽ́ẽ)

p. 45 The oral variants in (9b) are phonetically heterogeneous but share the property of being voiced. The simplest analysis is one in which they are treated as sonorants, as is proposed in Botma (2004). This is consistent with the observation that implosive stops (e.g., /ɓ/) in African languages do not pattern as obstruents (Clements 2000).

There are also good grounds to treat the voiced nasalized fricative in Inor as a sonorant. According to the description in Chamora and Hetzron (2000), this sound is the lenited outcome of /m/, and occurs root-initially after the imperfective prefix /jɨ-/, as in (10a).[7] In the same context /n/ lenites to [r̃] (10b). Nasal lenition triggers nasalization of surrounding vowels, glides, and glottal stops.

(10)		Perfective	Imperfective	
	a.	məsər	j̃ɨ̃-β̃ə̃sɨr	'resemble'
		məkər	j̃ɨ̃-β̃ə̃gɨr	'come out'
	b.	nəʔər	j̃ɨ̃-r̃ə̃ʔ̃ɨ̃r̃	'uproot'
		nətər	j̃ɨ̃-r̃ə̃dɨr	'bore a hole'

Chamora and Hetzron's description is short on details, but their data suggest that lenition targets nasal consonants (which are sonorants to begin with) and removes their oral occlusion, making them even more sonorous. This suggests that [β̃] is not a fricative but an approximant.

This section has discussed the implicational scale of segment nasalization as proposed in Walker (1998). The scale predicts a number of different types of nasal harmony, which differ from each other in terms of the range of segments that are harmonic and opaque. Nasal harmony processes in which fricatives are nasalized are rare. Few of the nasalized fricatives that have been reported in the literature stand up to phonetic scrutiny. Voiced nasalized fricatives are typically realized as approximants, which suggests that they are more appropriately treated as sonorants.

3.4 Transparency in nasal harmony

A key issue in nasal harmony is the status of neutral segments—that is, segments that do not participate in the harmony process. The preceding section considered cases in which segments are opaque. This section considers cases in which segments are transparent. The issue of segmental transparency is controversial. Some researchers reject the possibility of transparent segments and contend that such segments are in fact harmonic. In what follows, I will proceed on the assumption that transparency is a ‘real’ phenomenon. The last part of this section considers briefly how the issue of transparency is treated in different approaches.

Cross-linguistic evidence shows that the only segments that can be transparent in nasal harmony are obstruents. Languages with transparent voiced obstruents are very rare. An example is Mọ̀bà Yoruba, where
p. 46 nasalization skips both voiceless and voiced stops (see Section 3.2 ↳). A more common pattern is that only voiceless obstruents are transparent, which is the case in a number of Tucanoan and Tupian languages.[8] We have encountered two of these languages already: Tuyuca (in Section 3.1) and Guaraní (in Section 3.2). Languages of this type display a complementary distribution between voiced oral stops (which may be phonetically pre-nasalized) and nasals. The following data from Southern Barasano (Smith and Smith 1971) show that voiced pre-nasalized stops occur before oral vowels (11a) and nasals before nasal vowels (11b).[9] Voiceless obstruents occur in both oral and nasal spans.

(11)	a.	ta^{m}boti	‘grass’
		^{m}ba^{ŋ}go	‘eater’
		juka	‘vulture’
		hikori	‘tail’
	b.	ŋãmõnõnĩ	‘ear’
		mãsã	‘people’
		kãmõkã	‘rattle’
		w̃ãtĩ	‘demon’

In a standard autosegmental analysis, forms of the kind in (11b) are analyzed as having a morpheme-level feature [nasal] that links to all nasalizable segments in the harmonic domain. This analysis implies that Southern Barasano lacks underlying nasals; these emerge instead as the result of linking [nasal] to voiced oral stops. Support for this comes from alternating suffixes, such as those in (12). The alternation between voiced pre-nasalized stops and nasals in (12a) parallels that between oral and nasal(ized) sonorants in (12b); in both cases, the nasal allomorphs are derived by rightward nasal spread.

(12)		Oral forms		Nasal forms	
	a.	wa-^{m}ba	‘come!’	mãhã-mã	‘go up!’
		wa-^{m}bɨ	‘I came’	ĩã-mɨ̃	‘I saw’
	b.	ji-re	‘to say’	h̃ũnẽ-nẽ	‘to hurt’
		ʔoha-wɨ	‘I wrote’	mãsɨ̃-w̃ɨ̃	‘I knew’

According to one view, the type of nasal harmony found in Southern Barasano targets all voiced segments in a word (e.g., Pulleyblank 1989; Noske 1995). Alternatively, it has been proposed that the voiced stops are sonorants (e.g., Piggott 1992; Piggott and van der Hulst 1997; Botma 2004; Smith 2018) or non-obstruents (Clements and Osu 2003).

The class of non-obstruents is proposed by Clements and Osu (2003), who argue that the distinction between obstruents and sonorants in terms of the feature [±sonorant] is not sufficiently fine-grained. Their evidence comes from Ikwere (Niger-Congo), which contrasts four labial stops, /p b ḅ ʼḅ/. Of these, /p b/ are the familiar explosive stops; /ḅ ʼḅ/ are non-explosives, a much rarer type of stop. Non-explosives lack two properties that are
p. 47 associated ↳ with obstruents, namely a rise in intra-oral air pressure during the closure and a turbulent noise

at the release. Explosive stops are found before oral and nasal vowels (13a). Non-explosive stops occur before oral vowels only; they are in complementary distribution with nasals, which occur before nasal vowels (13b). This parallels the distribution of sonorants, which are oral before oral vowels and nasalized before nasal vowels (13c).

(13)	Oral words			Nasal words	
	a.	ákà	'hand, arm'	ákã̀	'sickness of hens'
		ìdó	'peace'	ìdõ̀	'shade of sun'
	b.	áḅá	'paint'	ámã̀	'matchet'
		á'ḅá	'companionship'	à'mã̀	'path, road'
	c.	é-wé	'to be spicy hot'	è-w̃ẽ̀	'to breathe'
		érú	'mushroom'	ɛ́r̃ṍ	'work'

The data in (13) show that non-explosive stops pattern with sonorants in respect of their nasalizability. However, Clements and Osu note that non-explosives pattern as obstruents in other respects, which leads them to analyze these segments as [–obstruent, –sonorant]. The former feature refers to the lack of air pressure build-up, the latter to the lack of a well-defined formant structure. The patterning of non-explosives with sonorants (which are [–obstruent, +sonorant]) in nasal harmony would then follow from the fact that both are [-obstruent].

It is unclear whether alternating voiced stops have non-obstruent properties in other languages. As we saw in (11), voiced oral stops in Southern Barasano are realized as pre-nasalized. Nevins and Wetzels (2018) refer to this pre-nasalization as 'nasal venting,' a phonetic strategy which enhances the voicing of these sounds.[10] They observe that nasal venting is frequent in languages that lack an underlying contrast between voiced stops and nasals (as is the case in Southern Barasano). However, they also note that venting occurs in languages like French (Indo-European) and Spanish (Indo-European), where voiced stops and nasals are contrastive and the former pattern as obstruents. Pre-nasalization can therefore not be taken as evidence for the non-obstruent status of voiced stops. This may suggest that the patterning of these stops is determined solely by their phonological representation—for example, by whether they have a Spontaneous Voicing node, as in Piggott (1992), or lack a velum closure gesture, as in Smith (2018).

The existence of transparent segments implies that nasal harmony can be non-local at the segmental level. This is a contentious issue, since strict segmental locality has been claimed to be an inviolable principle of the grammar (e.g., Ní Chiosáin and Padgett 1997; Walker 1998). Approaches that reject the possibility of transparent segments treat such segments as being harmonic instead.[11] For example, Ní Chiosáin and Padgett (1997) and Smith (2018) assume that nasality in harmonic spans is articulatorily contiguous (see Chapter 32, this volume, for the same approach to vowel harmony). Walker (1998) assumes that strict segmental locality holds at the phonological level (i.e., the grammar never produces gapped configurations), and that surface transparency is the result of a derivational opacity effect.

p. 48 Some approaches that allow for transparent segments account for the Southern Barasano pattern in terms of relativized locality. For example, Piggott (1992) assumes that [nasal] in these languages spreads only to segments specified for a Spontaneous Voicing node; this ensures that obstruents, which lack this node, are skipped. Piggott and van der Hulst (1997) define locality at the level of nuclei. If a nucleus is specified for nasality, then all segments within the syllable must be specified for nasality, provided [nasal] occupies the same structural position as in the nucleus; this also ensures that obstruents, which cannot be syllable heads, are skipped. In this approach, nasal harmony with transparent segments therefore receives a fundamentally different interpretation than nasal harmony with opaque segments; only the latter involves spreading on the segmental level and respects strict segmental locality. The same can be said about the approach in Boersma

(2003), where harmony with opaque segments involves spreading of articulatory nasality, while harmony with transparent segments involves spreading of perceptual nasality.

Rejecting segmental transparency leads to a more parsimonious typology of harmony systems, but it requires an accompanying theory of how the harmonic feature is phonetically implemented. Ní Chiosáin and Padgett (1997) describe the outlines of a model in which harmonic nasality (formalized in terms of a velum-lowering gesture) is superimposed on consonant and vowel articulations. This approach is fleshed out in more detail in the gestural model of Smith (2018), where the difference between opaque and transparent segments results from inter-gestural competition (see also Chapter 32, this volume). Opacity results when a segment's velum-raising gesture is stronger than the harmonic velum-lowering gesture; transparency results when the harmonic gesture is stronger than the segmental gesture.

A general question that is raised by approaches that reject segmental transparency is to what extent obstruents in nasal spans can be said to be phonetically nasalized. We saw in Section 3.3 that voiceless fricatives are sometimes realized with nasal airflow, at least for part of their duration. Is nasal airflow also compatible with voiceless stops? The nasal leak that results from a lowered velum counteracts the build-up of intra-oral air pressure, thereby inhibiting the most salient property of voiceless stops, namely their release burst. Phonetic work shows that voiceless stops are not necessarily completely unaffected by nasalization, however. While Walker (1999) finds no acoustic evidence for nasalization of oral stops in Guaraní, the aerodynamic data in Demolin (2009) show that these stops have a nasalized approach stage, with some degree of voicing during the initial portion of the closure. More generally, Durvasula (2009), citing Warren et al. (1993), observes that the velum is not necessarily fully raised during the production of oral stops, so that some nasal airflow is apparently tolerated. Further work on the phonetics of nasal harmony should provide a better insight into the nasalizability of obstruents, and thereby into the status of segmental transparency.

3.5 Conclusion

The overview in this chapter shows that nasal harmony is subject to considerable cross-linguistic variation with respect to the harmonic trigger, the harmonic targets, and the behavior of non-targets. Like vowel harmony, the phenomenon continues to be a fruitful testing ground for phonological theories.

Notes

1 Barnes (1996: 34) notes that Tuyuca lacks alternating suffixes with initial stops or fricatives, suggesting that these sounds block nasalization from stems to suffixes.

2 Like vowel harmony, nasal harmony can also be root-controlled or affix-controlled. For discussion and illustration, see, e.g., Piggott (1997) and Walker (1998).

3 The timing of the velic gesture relative to oral gestures is influenced by a range of factors. One finding is that nasal consonants have a greater degree of velic lowering in a syllable-final position than in a syllable-initial one, suggesting that nasalization is more likely to affect preceding vowels than following ones (Krakow 1993). It is interesting that this does not appear to be reflected by the typology of nasal harmony systems, where nasals more often trigger progressive rather than regressive harmony (see Section 3.3).

4 The relevance of metrical structure is also acknowledged in earlier analyses of Guaraní nasal harmony. See, e.g., van der Hulst and Smith (1982b).

5 Boersma (2003: 6) gives an analogy from the domain of visual perception: A car which is partly blocked from view by a lamppost is still perceived as a single car. In the same way, a nasal word is perceived as a single unit, even when the nasal span is broken up by an intervening oral sound.

6 The speakers in Warner et al.'s experiment did not speak the variety described by Ternes (1973), of which there are very few (if any) speakers left; most of the speakers were instead from the nearby Isle of Skye.

7 Chamora and Hetzron (2000) transcribe the sound as [ɱ]. Their description makes clear that what is intended is a

nasalized bilabial continuant.

8 The languages in Walker's database are Southern Barasano, Desano, Guanano, Orejon, Siriano, Tatuyo, Tucano, and Tuyuca (Tucanoan), and Guaraní, Icua Tupí, Kaiwa, and Parintintin (Tupian).

9 Smith and Smith (1971) note that pre-nasalization is consistently present in word-initial positions and variable in word-medial positions.

10 Iverson and Salmons (1996) refer to this phenomenon as "hypervoicing."

11 Ní Chiosáin and Padgett (1997) use the term "permeable."