UNDERSTANDING NASALITY

by

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partial fulfillments of the requirements for the degree of the Doctor of Philosophy in
Linguistics

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In my time as a graduate student, I have read, at least, a few dissertations. The first two things I always did and will probably always do with a dissertation are read the abstract and then the acknowledgements. Somehow knowing the influential people in the author's life was as important as the research itself. And I always dreamt that when it was time for me to write my acknowledgements page, I would sincerely acknowledge everyone that ever helped. However, as all before me did surely, I have come to realize that no amount of thanks actually does justice to all the help and support one has received in my life. My family, my friends, especially those in Delaware, and my academic mentors are really the reason I am at this final step of my graduate life – the writing of the acknowledgements page.

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there whenever I looked back for help; and they were there to share my happiest moments. I just could not have done it without their love and support.

DEDICATION

I dedicate this dissertation to the four most important beings in my life:

My father, Durvasula Sitarama Murthy;

My mother, Durvasula Seshavalli Murthy;

My brother, Kameshwar Durvasula;

My dog, Teddy Durvasula.

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ABSTRACT

The central aim of this dissertation is to further our understanding of the phonological feature underlying nasality, and thereby improve our understanding of phonological representations and the phonology-phonetics interface, in general. Specifically, I show that given appropriate abstraction and appropriate phonology-phonetics mapping principles, we can most insightfully account for both categorical featural behaviour and variable feature manifestations of nasal segments.

The bulk of the dissertation is devoted to a careful study of segments that have been lumped together under the cover term "prenasalised stops" (or partially-nasal stops (PNS), in this dissertation). I show that, contrary to the standard view in the phonological literature, there are at least two distinct types of PNS: 1) Nasal-based partially-nasal stops (N-PNS), and 2) Voice-based partially-nasal stops (V-PNS). N-PNS are featurally identical to simple nasal stops that surface as PNS, and are found in languages with no separate nasal series; V-PNS are segments featurally identical to fully-voiced stops that surface as PNS. I argue that their behaviours are best accounted for by re-conceptualising the phonological feature [nasal], as the *dimension Soft Palate (SP)*, which is sensitive to a set of (universal) phonology-phonetics mapping principles. Crucially, the gestural/phonetic manifestation of the discrete representation 'SP' is shown to be sensitive to the nature of laryngeal contrast in the *specific* syllable position.

I further argue that 'post-stopped nasal' segments, which have previously been grouped with PNS, do not constitute a genuine variety of PNS. From their phonological and phonetic properties, it is clear that they are neither N-PNS, nor V-PNS. In fact, I show that all their phonetic and phonological properties are accounted for by reclassifying them as *obstruent nasals.* However, the existence of *obstruent nasals* creates a problem for all recent accounts of nasal harmony, as obstruent opacity in nasal harmony is usually accounted for through the claim that obstruent nasals are phonetically impossible. I show that the phonological representation of nasality and feature-gesture mapping principles developed for PNS in this dissertation, along with other general principles discussed in the phonological literature can be used to give a straight-forward analysis for the problematic data.

The dissertation also shows that the phonological feature representing nasality must have an articulatory definition. Specifically, I show that aspirate segments have acoustic effects (perceived as nasalization) nearly identical to nasal segments on adjacent segments. Despite this phonetic precursor, aspirate segments, unlike nasal segments, never trigger nasal harmony processes. I use this bias in nasal harmony processes to compare different distinctive feature theories, and conclude that *unconstrained emergentist approaches,* and *auditory feature theories* have serious problems in accounting for the data, while distinctive feature theories that necessitate an articulatory definition like *articulatory feature theories*, *translational feature theories*, and *articulatorily-bootstrapped emergentist feature theories* can insightfully account for the data.

Chapter 1

INTRODUCTION

1.1 Goals of the thesis

In this thesis, I argue for the following descriptive and theoretical conclusions:

(1) Descriptive conclusions

a. There are at least two kinds of *partially-nasal stops*[1] in the world's languages, one being phonologically identical to simple nasal stops, and the other being phonologically identical to fully/truly voiced stops.

b. Another set of segments that are usually described as partially-nasal stops are argued to be best classified as *obstruent nasals*.

(2) Theoretical conclusions

a. An articulatory definition of the feature [nasal] is *a must* to account for the asymmetries observed in nasal-harmony processes.

b. The featural representation for nasality is more abstract than previously considered. Furthermore, despite enormous surface (phonetic) variation, abstract representations are *absolutely* necessary.

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[1] These have previously been called *pre-/ post-nasalised stops*, pre-/post-stopped nasals, *pre-/post-occluded nasals* amongst others in the literature, and are essentially segments with both a nasal portion and an oral portion, e.g., ^{n}d, ^{m}b, $^{\eta}$g. As discussed in more detail in Chapter 3, I will use the term 'partially-nasal stops' to abstract away from the ordering of the nasal and oral portions of these segments.

c. The phonetic manifestation of phonological nasality is *always* crucially mediated by the nature of laryngeal contrast.

d. Some opaque nasal-harmony processes are due to principles at the phonology-phonetics interface (feature-gesture interface, to be precise), and not because of (featural) phonological processes.

In understanding the typology of partially-nasal stops, I pay special attention to understudied languages like Jambi Malay dialects (data for which is from my own field-work amongst other sources), Mundurukú and Mamaindé. A close look at the typology and behaviour of partially-nasal stops reveals interesting sub-patterns which force us to reconsider the conception of the phonological feature [nasal], and facilitates the development of a more intricate model of the phonology-phonetics interface than was previously recognized.

The theoretical conclusions regarding phonological features (especially, for nasality) are arrived at by studying the behaviour of nasal segments with respect to harmony processes, and the cross-linguistic behaviour of partially-nasal stops.

This dissertation deals primarily with representational issues, and the results are compatible with both parallel-computation theories of phonology (Optimality theory, Declarative Phonology) and serial-computation theories of phonology (Rule-based theories). Under either view of phonological computation, the representations proposed simplify the computational machinery needed to account for the relevant patterns. So issues related to the specific computational aspects are largely ignored except in cases where it is essential to introduce them to discuss competing analyses of the data at hand.

1.2 Theoretical preliminaries – the nature of representations in Phonology

An important preliminary question that is relevant to this dissertation is: what is the nature of phonological representations? There appear to be three answers to this question in the literature, as shown in (3). For reasons discussed in the subsequent sections, I adopt (3c) as the framework for this dissertation.

(3) a. Discrete representations - trivial interface (Chomsky and Halle 1968; Goldsmith 1976a, 1976b; McCarthy 1979a; Kenstowicz 1994, inter alia)

Phonological representations are discrete (atemporal). The translation to concrete physical representations is trivial (in some sense, as explained below).

b. No discrete representations – no interface (Browman & Goldstein 1986 et seq; Ohala 1990; Port 2007, inter alia)

There is no need for discrete (atemporal) representations. Phonological computation is over non-discrete representations.

c. Multiple representations - Feature-gesture interface (Zsiga 1997)

There is a need for both atemporal and temporal (abstract) representations that phonology computes over.

1.2.1 Discrete representations - trivial interface

In the classic generative phonology tradition, the sound patterns of a language were captured by computations, in the phonological module of the grammar over *discrete* (atemporal) representations (Chomsky and Halle 1968).

(4) “that utterances are sequences of discrete segments, that segments are complexes of a particular set of phonetic features, and the simultaneous and sequential combination of these features are subject to a set of specific constraints’ (Chomsky & Halle 1968,pg. 5)

The phonological representation for a word like ‘mat’ as per this view would be something like in (5). The word is represented as a sequence of discrete features[2] connected to segmental slots. Below I represented each segment with a set of features in matrix form; however, essentially, the same view of phonological representations can be maintained if features and segments were multiply linked, as in non-linear representational models (Goldsmith 1976a, 1976b; McCarthy 1979a; Kenstowicz 1994 inter alia) because the units of representation are still discrete.

(5) ‘mat’ /mæt/

X	X	X
+consonantal	-consonantal	+consonantal
+nasal	-nasal	-nasal
+labial	+front	+alveolar
…	…	…

The model of phonology and phonetics that develops as a result of this perspective is shown in (6). The phonological component deals with discrete features (putative

[2] For the sake of expository simplicity, I shall assume that features are articulatorily defined. However, I shall discuss this issue in more detail in Chapter 2 of this dissertation.

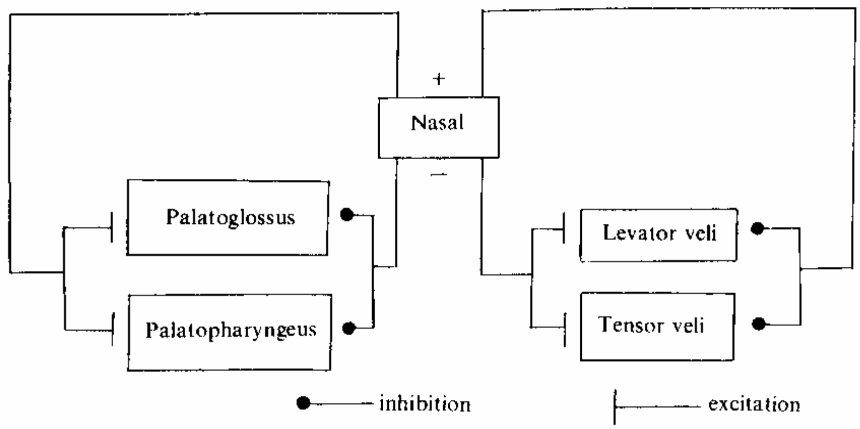
abstractions over phonetic (articulatory/auditory) dimensions), and the phonetic component deals with 'implementing' the fully specified surface representations (in the original Chomsky & Halle (1968) conception, *phonetic detail rules* convert surface representations to scalar/gradient values, but the rest of the details were a matter of *universal phonetics*).

(6) Trivial Interface - SPE-view

Lexical Representations:	Discrete (atemporal) UR
	↓
Phonology:	Discrete (atemporal) Underlying Representations
	Computations over representations
	Surface representations
	↓
Phonetics:	Continuous representation

In a particularly strong implementation of this view, Halle (1983) argues that features (presumably extended to phonological surface forms, in general) are *direct* neuro-muscular commands. So, a feature like [nasal] would have the neuro-muscular command shown in (7). A segment specified [+nasal] would activate ('excite') the muscles *palatoglossus* and *palatopharyngeus* (to lower the velum/soft palate), but a segment specified for [-nasal] would cause the inhibition of the above muscles and the activation (excitation) of the muscles levator veli palatini and tensor veli palatini (to raise the velum/soft palate).

(7) Neuro-muscular command for the feature nasal (Halle 1983)



The model of phonology in (6), without further assumptions, tacitly implies that *all* language-specific sound-patterns can be captured in the discrete phonology.

However, there is clearly a need to account for language-specific phonetic variation. Language-specific variation in temporal detail is a well-observed phenomenon (Chen 1970; Cohn 1993; Flemming 2005 inter alia). For example, it is well known that vowels, in many languages, are longer before voiced stops than before voiceless stops (Chen 1970; Keating 1985; Fowler 1992). For example, in English, the [ɛ] that precedes voiceless obstruents is on an average is 20% shorter than the same vowel before voiced obstruents and sonorants (8).

(8) a. /bɛt/ ⟶ [bɛt] 'bet'

b. /bɛd/ ⟶ [bɛˑd] 'bɛd'

Crucially, not all languages show this variation. Some languages like Polish, Czech and Saudi Arabic show no effect of voicing on the preceding vowel (Keating 1985; Flemming 2005).

More language specific phonetic variation is observed by Cohn (1995), Cohn observes that the same featural representations can have small (but consistent) differences in phonetic manifestations. The onset of nasalization of nasal vowels is earlier in European French than in Canadian French (Fig. 1.1).

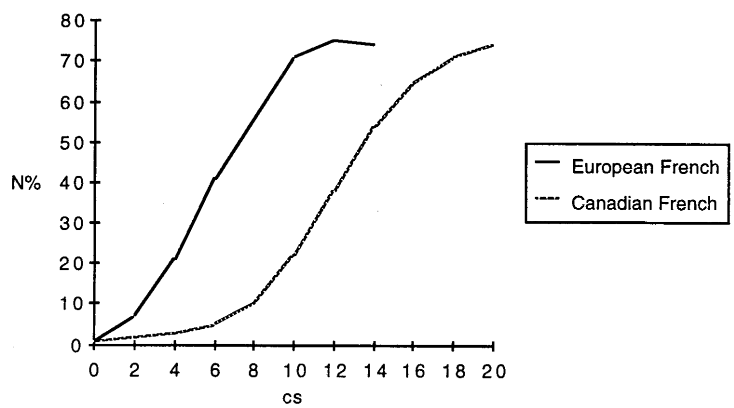


Fig. 1.1. Time course of nasal vowels of European & Canadian French (van Reenen 1982, quoted in Cohn 1995). Time in centi-seconds along the X-axis; and N% is the Nasalance ratio.

The language-specific nature of the shortening of vowels observed before voiceless consonants (in English and other languages), and the onset of nasalization, cannot (by definition) be reduced to *universal* phonetics. Therefore, we need a grammatical module that can manipulate temporal information to accounts for the facts.

1.2.2 No discrete representations – no interface

Contrary to the discrete model described above, some have argued that the very idea of an interface between discrete (atemporal) representations and concrete temporal representations is ill-conceived, instead arguing for a conception of temporal phonological representations (9), i.e., phonological representations are either 'dynamic' representations with gradient qualitative distinctions (Benus & Gafos 2006; Kirov & Gafos 2007), or articulatory gestural representations[3] (Browman & Goldstein 1986, et seq; Ohala 1990; Gafos 2002 inter alia), or exemplar representations that have fine grained phonetic detail in lexical representations (Pierrehumbert 2001; Jansen 2004; Port 2007; VanDam 2007)[4].

(9) No Interface view

Lexical Representations:	Continuous representations
	↓
Phonology/Phonetics:	Computations over continuous representations

I exemplify this view, in Fig. 1.2, with proposed phonological representations from Articulatory Phonology (Browman & Goldstein 1986, et seq; Gafos 2002 inter alia).

[3] In at least one conception of Articulatory phonology (Browman & Goldstein 1989), discrete representations and temporal gestural representations are not necessarily incompatible. However, this view was pursued only later by Zsiga (1993, 1997).
[4] Unlike the others, Articulatory (gestural) phonology argues for abstract, but temporal, representations.

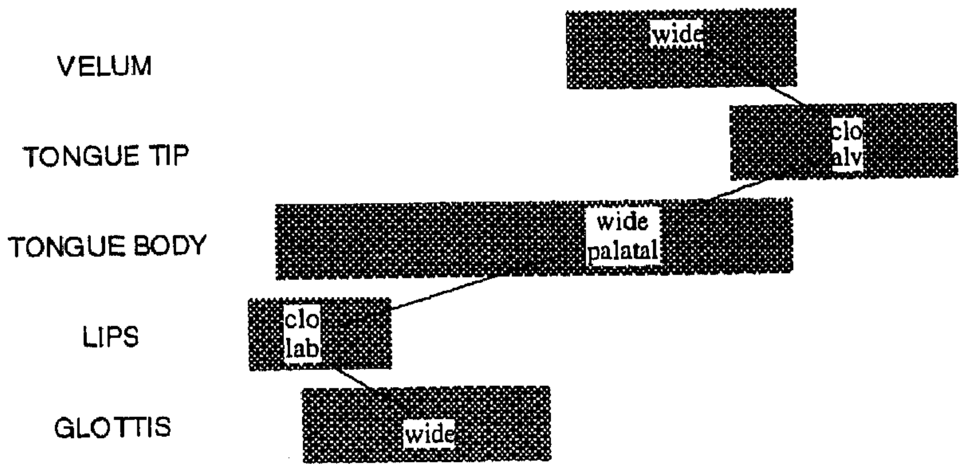


Fig. 1.2. Gestural score for ‘pen’. Lines connect gestures whose co-ordination is specified lexically in the computational model (Browman & Goldstein 2000).

As can be seen, different gestures have different amounts of temporal information associated with them in the phonological representations.

It is important to note that theories that espouse continuous phonological representations as in Fig. 1.2 do not have the concept of a discrete segment. Therefore, processes that describe categorical manipulation of segments are problematic for them. For example, processes of metathesis and reduplication that involve the ‘movement’ or ‘copy’ of entire segments are difficult to model in these theories (10). In Kwara’ae, metathesis involves the flip of the last two segments[5] (10a), and in Semai, reduplication involves the copy of the first and last segments of the word (10b). Such processes that target entire segments are relatively common across the world’s languages. In theories without recourse to the notion of a (discrete) segment, such patterns would have to be

[5] The domain of application of this rule is more complicated than what I show it to be. However, this does not affect the thrust of the argument being presented here. I refer readers to (Heinz 2005) for further details.

described by brute force mechanisms that change the temporal order of a whole range of phonetic parameters with no obvious connection.

(10) a. Kwara'ae Metathesis (Heinz 2005)

	citation	normal	
i.	ˈsɪ.na	ˈs̯ɪ̯ɛn	'sun'
ii.	bo.ˈbe.ʔa	ˈbo.ˌbe̯aʔ	'fat'

b. Semai Reduplication (Raimy 1999)

	normal	continuative	
i.	dŋɔh	dhdŋɔh	'appearance of nodding'
ii.	payan	pnpayan	'appearance of being disheveled'

Such theories also have trouble accounting for cases of (positionally-conditioned) complete neutralizations observed in languages. Further problems for such models are identified in Chapter 5 of this dissertation.

1.2.3 Multiple representations - Feature-gesture interface

It was seen in the preceding sub-sections that neither a *trivial-interface* phonological model, nor a *no-interface* phonological model can by itself account for language specific sound patterns. Zsiga (1997) arrives at the same conclusion, and argues, in an acoustic study of the nature of vowel harmony in Igbo, that either gestural representations (involving articulatory targets with temporal quality) or featural representations (involving abstract articulatory/acoustic targets with no temporal quality) alone cannot account for the phenomena observed in Igbo vowel related processes. Instead, she advocates the position that both are essential to account for the data.

Vowel harmony within the domain of the (phonological) word in Igbo as in (11) is argued to be absolute. Simplifying the process, all the vowels in the word harmonise to the feature [+/-ATR]. Zsiga (1997) shows that there is no difference between a [+ATR] or [-ATR] vowel derived through vowel harmony and one that is underlyingly [+ATR] or [-ATR], respectively.

(11) a. i̙-zu̙-ta̙ INF-buy-DIREC 'to-buy for'

b. i-zu-te INF-meet-DIREC 'to meet with'

However, vowel assimilation across (phonological) word contexts as in (12a) has a gradient output contrary to many phonological descriptions that have transcribed it as a categorical process (12b). Zsiga shows acoustic evidence that the first [a] in many cases starts off as an [e], but finishes up as an [a], i.e., the [e] gradually morphs into an [a]. She argues that a gestural overlap account is best.

(12) a. nwoke a → nwoka a
man DEF
'this man'

b. V1 V2→ V2 V2

The model of phonology she develops includes both abstract (atemporal) featural representations and gestural (temporal) representations in sequence (13).

(13) Representations in the phonology

Lexical Representations:	Discrete (atemporal) representations
	↓
(Featural) Phonology:	Discrete (atemporal) Representations
	Computations over representations
	Surface discrete representations
	↓
(Gestural) Phonology:	Gestural (temporal) Representations
	Computations over temporal representations
	Surface gestural (temporal) representations
	↓
Phonetics:	Concrete Phonetic Representations

An important point that is not usually discussed (but is naturally assumed) in the mapping of phonological *features* to *gestures* is the constraint on temporal alignment of different gestures related to features of a single segment. More specifically, there needs to be at least some overlap between the gestural manifestations of different features connected to the same x-slot[6] (14) - the gestures do not necessarily have to be simultaneous as this would not account for the fact that 'aspirated stops' can surface as either pre-aspirated stops, or post-aspirated stops, where clearly the gestures are not simultaneously

[6] X-slots are abstract "empty" timing units to which features attach to make phonological segments (Kaye & Lowenstamm 1984; Levin 1985 inter alia).

implemented. A variant of this constraint on gestural mapping is discussed by Sagey (1988) and Hammond (1989).

(14) Temporal constraint on feature-gesture mapping[7]

There is (at least) some overlap between gestural manifestations of different features linked to the same x-slot.

As per the mapping constraint, if a segment is specified for feature F (15a), then the gestural mapping of the feature should (at least partly) coincide with other features of the segments (15b). Therefore, the gestural mapping in (15c), where the F-gesture does not overlap at all with the other gestures (namely, G-gesture) related to X-slot$_1$, is impossible.

(15) a. Featural Representation

x_1 x_2 x_3
/ \
F G

b. Attested gestural mapping

x_1 x_2 x_3
gesture F ______
gesture G   ______

c. Unattested gestural mapping

x_1 x_2 x_3
gesture F ______
gesture G   ______

The view of phonological representations discussed in this sub-section forms the basis for the analyses developed in this dissertation to account for the behaviour of partially-nasal

[7] Sagey's (1988) version of this principle is the following: 'For a feature and an x-slot to overlap means that some part of the feature and some part of the x-slot are simulataneous.' However, since x-slots have no gestural correlate, I have restated this constraint as in (6).

stops (Chapter 3), and the opacity of obstruents in nasal harmony (Chapter 4). Henceforth, I shall refer to the level accessing featural (atemporal) representations as *featural phonology*, and the level accessing gestural (temporal) representations as *gestural phonology.*

1.3 Outline of the dissertation

In chapter 2, I argue that the phonological feature [nasal] necessarily has an articulatory definition. Specifically, I show that aspirate segments have acoustic effects (perceived as nasalization) nearly identical to the effects of nasal segments (on adjacent segments). Despite this phonetic precursor, aspirate segments never trigger nasal harmony processes like nasal segments. I use this bias in nasal harmony processes to compare different distinctive feature theories, and conclude that *unconstrained emergentist approaches,* and *auditory feature theories* have serious problems in accounting for the data, while distinctive feature theories that necessitate an articulatory definition like *articulatory feature theories*, *translational feature theories*, and *articulatorily-bootstrapped emergentist feature theories* can insightfully account for the data.

In chapter 3, I first discuss the descriptive fact that, contrary to the standard view in the phonological literature, there are at least two distinct types of partially-nasal stops (PNS): Nasal-based partially-nasal stops (N-PNS) - segments featurally identical to simple nasal stops that surface as PNS, and Voice-based partially-nasal stops (V-PNS) – segments featurally identical to fully-voiced stops that surface as PNS. I, then, argue that their behaviours are most insightfully accounted for by re-conceptualising the phonological feature [nasal], as the *dimension Soft Palate (SP)* that is sensitive to a set of (universal) feature-gesture principles. Crucially, the gestural manifestation of the discrete representation 'SP' is shown to be sensitive to the nature of laryngeal contrast in the specific syllable position.

In chapter 4, I argue that another variety of segments called 'pre-nalised stops' or 'post-stopped nasals' is not a genuine variety of partially-nasal stop. From their phonological and phonetic properties, it is clear that they are neither N-PNS, nor V-PNS. In fact, I argue all their phonetic and phonological properties are accounted for by reclassifying them as *obstruent nasals.* The existence of *obstruent nasals* creates a problem for all recent accounts of nasal harmony. However, I show that the phonological representation of nasality and feature-gesture mapping principles developed in chapter 3, along with other general principles discussed in the phonological literature provide a straight-forward analysis of the problematic data.

In chapter 5, I make two theoretical claims based on the results of the previous chapters. First, the surface manifestation of phonological representations depends on the nature of both *underlying contrast* and *surface contrast.* Therefore, there is a need for an improved model of phonology-phonetics that captures this. Second, I show that partially-nasal stops, despite showing a fantastic variation in surface manifestations, trigger nasal harmony-rules *categorically,* and never variably. I argue that this absolute bias can only be accounted for in theories that necessarily involve abstract, distinct and categorical features.

Chapter 2

[nasal] IS ARTICULATORILY DEFINED

2.1 Introduction

The theory of *distinctive features* is one of the most note-worthy phonological achievements of the past century. Distinctive features have traditionally been seen as innate entities that are bearers of phonological contrast in linguistic systems (Jacobson 1928/1971; Trubetzkoy 1939).

However, some recent studies on phonological features have questioned the traditional generative phonology claim that features are innate. Mielke (2004, 2005, 2008) argues that traditional *natural classes* account for at most 75% of the observed cross-linguistic phonological phenomena. He further argues that phonological phenomena are all explicable through classes formed through interactions with 'external' factors. He argues that an *Emergentist* feature theory, as per which, features are *just* classificatory abstractions that are influenced by a variety of phonetic, cognitive and social factors, can lead to a better understanding of cross-linguistic patterns. Lin (2005), Hall et al (2006), Vallabha et al (2007) reach a similar conclusion based on modern computational and statistical techniques of clustering, whereby they claim that broad phonetic (acoustic) classes can be learnt through unsupervised learning algorithms without any predefined knowledge about phonological features.

However, Dillon et al (2008) argue that such algorithms are successful only with unrealistic assumptions about the frequency of classes/categories, and more realistic frequency distributions of classes/categories present “major challenges to acoustically-driven models”. They also show that the presence of allophonic variation leads to additional problems of categorization for such models. Furthermore, they, along with Peperkamp et al (2006), argue that there is a need for some sort of linguistic constraints to block spurious generalizations. One such constraint suggested by both Peperkamp et al (2006) and Dillon et al (2008) is that phonological features have articulatory definitions (possibly alongside acoustic definitions).

In this chapter, I argue that it is essential that the definition of the phonological feature [nasal] include the articulatorily correlate of a lowering of the velum or opening of the velopharyngeal port. I specifically show that nasal harmony and long distance nasal consonant harmony patterns show a strong articulatory bias in that aspirated segments despite having acoustic/perceptual effects remarkably similar to typical nasal segments *never* trigger nasal harmony. Based on this, I argue that, some innatist approaches to phonological features have a simple account for this bias, while (at the very least) *unconstrained emergentist* approaches are incapable of accounting for it.

In what follows, I shall first briefly discuss the theories of distinctive features that evolved in the last 5 decades or so of phonological research (section 2.2). I shall then discuss the phonetic definition and phonological behaviour of the feature [nasal] as discussed in the literature (section 2.3). I shall then proceed to argue that [nasal] is indeed articulatorily defined (section 2.4). Finally, I shall argue that the behaviour of nasals, as opposed to aspirate segments, in the phonology is a problem for *unconstrained emergentist* theories of distinctive features, and is better captured by the traditional understanding of these entities as innate concepts (section 2.5).

2.2 Review of Distinctive Features

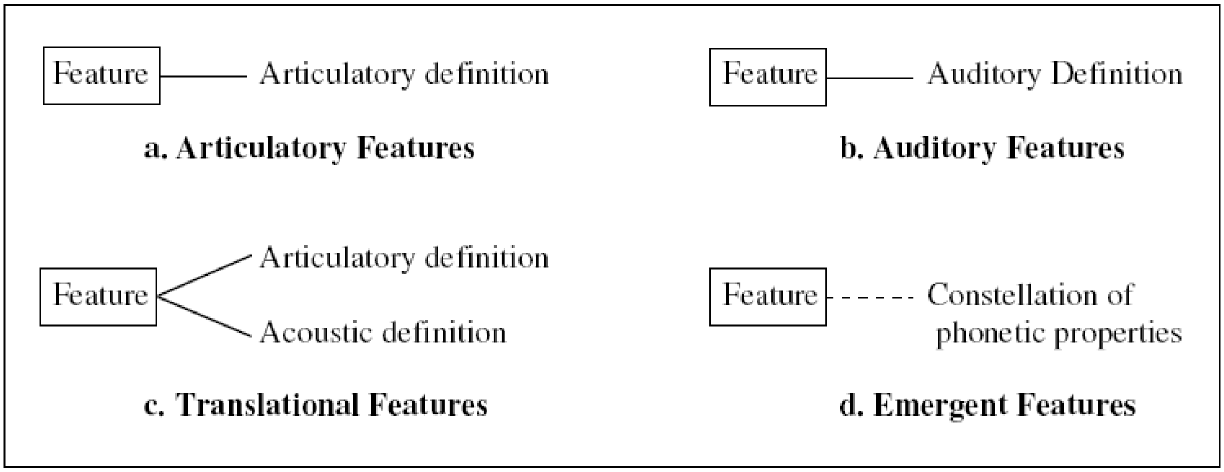
The debate on distinctive features has concentrated around two major issues: the dimensions of featural definitions – whether features are to be defined in terms of articulatory parameters or acoustic/auditory parameters (1a); and whether or not the proposed features are innate (1b)

(1)a. What is the physical dimension in which features are best defined – articulatory or acoustic/auditory or both?

b. Are features innate or learned cognitive categories?

With the above two questions as backdrop, theories of distinctive features usually fall into one of four classes: (i) Articulatory Feature Theories – features are innate articulatory categories (2a); (ii) Auditory Feature Theories– features are innate auditory/perceptual categories (2b); (iii) Translational Feature Theories – features are innate cognitive categories with both articulatory and auditory definitions (2c); (iv) Emergent Features Theories– features are non-innate emergent cognitive categories (2d).

(2) Theories of Distinctive Features



Articulatory feature theories (2a) have emphasized the primacy of articulation over audition in the definition of innate features (Browman and Goldstein 1986, 1995; Halle and Stevens 1991 amongst others). Speech production is seen as a direct implementation of these distinctive features, while speech perception is argued to be achieved by the analysis-by-synthesis model of speech perception (Halle and Stevens 1962). These theories have received inspiration from the work of Liberman and Mattingly (1985, 1989) on the *Motor Theory of Speech Perception* – according to which speech perception is perceiving vocal-tract gestures. Support for this view comes from the experiments that show that perception follows articulation when “articulation and sound wave go their separate ways” (Liberman 1957) – it has been shown that identical stop-bursts can trigger the perception of different consonants (/p/ or /k/) in different vowels (Liberman et al 1952); and the same segment (/d/) can be identified from two different CV (second-formant) transitions (Liberman et al 1956). Further evidence comes from the celebrated *McGurk Effect* (McGurk and MacDonald 1976) which shows that speech perception is also affected by visual information, which carries articulatory *not* auditory information[1]. Other sensory information, namely, haptic feedback, that carry articulatory information have also been observed to affect speech perception (Fowler & Dekle 1991). Lastly, the recent discovery of *mirror neurons* has also been argued to support the view that "speech perception and speech production processes use a common repertoire of motor primitives" (Fadiga et al 2001 – quoted in Halle 2003). However, the claim of motor neurons possibly supporting neurobiological structures for the "motor primitives" of the *Motor Theory of Speech Perception* has been argued to be dubious and lacking in empirical support, by Hickok (2009) and Lotto et al (2009).

Auditory feature theories (2b) have emphasized the primacy of audition over articulation in the definition of innate features (Kingston and Diehl 1994; Kingston 2006 amongst others). While speech perception is, at least in theory, easily achieved as the features are auditorily defined, the actual mechanisms related to speech production in these theories have not been discussed explicitly. Auditory feature theories receive support from experiments which show that slightly perturbed auditory-feedback affects the articulatory target of the speaker. In an experiment that asks listeners to pronounce /pɛp/, Houde and Jordan (2002) perturbed the auditory feedback to the subjects so that the vowel sounded more like the high vowel /i/, in response subjects tended to change the articulation of the intended mid vowel /ɛ/ so that it sounded more like low vowel /æ/. This experimental result has been argued to be the result of the subjects trying to achieve

[1] However, Bill Idsardi points out that this is not so straightforward, especially, if there is a forward model for speech, as in analysis-by-synthesis (Halle & Stevens 1962).

an auditory target. Further evidence for these theories derives from the variation in the pronunciation of the American English rhotic between bunched and retroflexed variants that appear to maintain the consistent 'lowered F3' value in spite of their different articulations (Guenther et al 1999). Furthermore, Mielke, Baker & Archangeli (2006) show through ultrasound imaging that the actual articulatory variation for rhotics, in different segmental contexts, is a lot more complex than is typically acknowledged, while all the variants share the acoustic correlate of a low F3. Finally, bite-block experiments (Lindblom et al 1979) have been argued to show the auditory/acoustic intent is more important than articulatory intent. These experiments show that speakers compensate for articulatory perturbations by articulatory adjustments that produce near-normal acoustic outputs. However, the results from the bite-block experiments have been argued to be compatible with articulatory features theories, too (Kingston 2006).

Translational feature theories (2c) have argued that "distinctive features correspond to controls in the central nervous system which are connected to the human motor and auditory systems" (Halle 1983), and so there is a necessity for both an articulatory and an auditory/acoustic definition for features (Jacobson et al 1952; Halle 1983 amongst other). Both speech perception and production are readily explained as the direct interpretation of the features. While explicit experimental evidence in support of *translational feature theories* specifically, as opposed to *articulatory* and *auditory feature theories*, is lacking, they receive support to the extent that neither *articulatory* nor *auditory feature theories* can account for the all data by themselves.

Emergent feature theories (2d) claim that features are non-innate emergent cognitive categories that evolve during language acquisition (Lindblom 1999; Mielke 2004 *inter alia*). On the one hand, Lindblom (1999) argues that the definitions that these learned features get, while language specific, are nonetheless articulatory; therefore, the accounts for speech production and speech perception are similar to those in innatist articulatory feature theories. I shall call these theories *articulatorily-bootstrapped emergentist feature theories*. On the other-hand, Mielke (2004), while arguing that many factors (auditory, articulatory, social…) affect sound patterns, is less clear on what goes into featural definitions – I shall call these theories *unconstrained emergentist feature theories*. Proponents of emergent feature theories have argued that existing innatist theories of features account for at best about 70-75% of the observable phonological phenomena is the world's languages, and a 'large' 25-30% is not accounted for by any 'natural classes', and have thereby questioned the efficacy of innatist feature theories in accounting for natural phonological phenomenon (Mielke 2004, 2005, 2008). Furthermore, experiments exist wherein some species of birds have learned what appears to be featural information - Japanese quail were trained to peck in response to syllables beginning with /d/, but not those beginning with /b/ or /g/. The quail were successful in identifying /d/'s in novel syllabic contexts after the training period (Kluender, Diehl & Killeen 1987 – as referred to in Lindblom 1999). In the face of such evidence, Lindblom argues that it is "premature" to explain human phonological and phonetic knowledge in terms of "our genetic endowment for language".

2.3 Linguistic Theory and the feature [nasal]

The following sub-section will briefly present the discussion regarding the feature [nasal] in the linguistic literature. Research has raised two basic questions with respect to the feature nasal that centre around the phonetic definition of the feature [nasal] (3a), and its phonological representational structure (3b).

(3) a. What is the (phonetic) definition of nasality?

b. What is the phonological representation of the feature nasal?

2.3.1 The phonetics of nasality

The quest for a phonetic definition of nasality (3a) has been fraught with difficulties. Two main approaches can be outlined in this sphere of research – (i) an acoustic definition of nasality; (ii) articulatory definition of nasality (the two definitions are not necessarily mutually exclusive in the various phonological feature theories).

2.3.1.1 The Acoustics of Nasality

The acoustic definition of nasality consists of a number of acoustic correlates – an increased number of formants (poles); a decrease in the first formant amplitude; an increase in the first formant bandwidth; the spectral flattening at low frequencies; the existence of anti-formants (zeroes) (Jacobson et al 1952; Entenman 1976; Stevens 1998; Pruthi & Espy-Wilson 2007).

However, the definition is plagued with two major problems. First, some of these acoustic correlates have been shown not to be consistent cross-linguistically (Dickson

1962; Delattre 1968). A second and more important problem is that the acoustic correlates of nasality in consonants and vowels are vastly different, a fact noted at least as far back as Jacobson et al (1952). In simple nasal consonants, along with the presence of formants and anti-formants, there is a consistent low-frequency 'nasal-murmur' in the F1 region around 300 Hz (Fujimura 1962, Pruthi & Espy-Wilson 2004). Pruthi & Espy-Wilson (2004) identify 4 acoustic correlates of nasal segments that can be used to develop Acoustic Parameters (AP) that could be used in the automatic detection of nasal consonants (they achieve very high classification rates of around 90% in different syllabic contexts). They use the four acoustic correlates graphically presented in Fig. 2.1 and listed in (4).

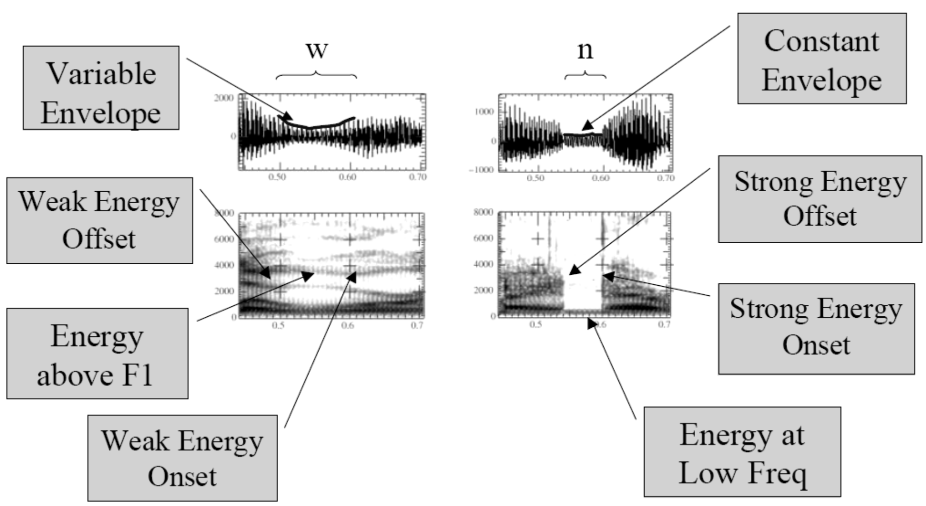


Fig. 2.1. A comparison of the Acoustic Parameters between the semivowel [w] and the nasal [n] (from Pruthi & Espy-Wilson 2004b)

(4) Acoustic Correlates of (simple) nasal stops

a. Energy onset/offset

The change in energy at the boundary between a nasal and following/preceding vowel. It is sharp for nasal consonants as compared to non-nasal (sonorant) consonants.

b. Energy Ratio

The ratio of the energies between 0-320 and 320-5360 Hz is higher for nasal consonants than non-nasal (sonorant) consonants.

c. Spectral Peak Frequency

The spectral peak frequency in the 0-800 Hz range is lower for nasal consonants than for other (sonorant) consonants.

d. Envelope Variance

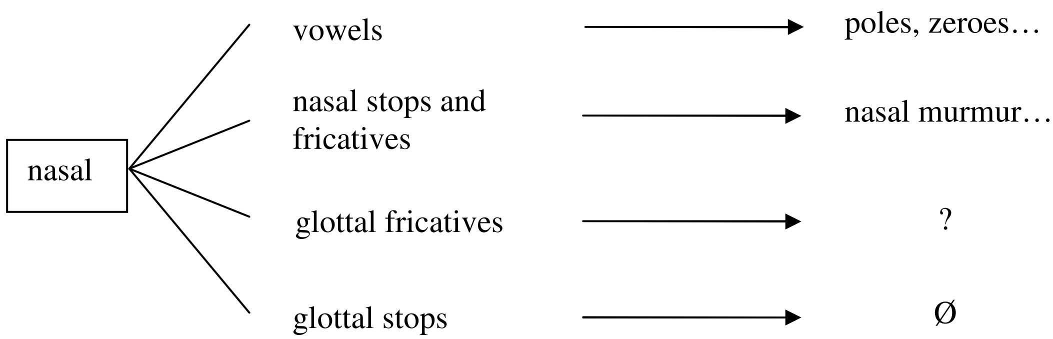
Nasal consonants show lower envelope (of the signal waveform) variance than non-nasal (sonorant) consonants.

What is especially noteworthy about the acoustic correlates in (4) is that almost none of them can be immediately used as correlates of vowel nasality. Energy onset/offset for nasalized vowels (and for vowels, in general) would have a pattern that is the opposite of nasal consonants, as vowels generally have rising energy offsets, and falling energy onsets. Envelope variance too would not be a useful acoustic correlate to identify nasal vowels as nasal vowels are not known to show any flat or near-flat envelopes – a fact that should become obvious in the face of nasalized diphthongs. Similarly, the acoustic correlates Energy ratio and Spectral peak energy, as defined, would have significant overlap with the acoustic correlates of high vowels to be strong predictors of vowel nasality in general.

Adding to the complexity are the acoustics of nasalization in glottal stops and glottal aspirates. In glottal stops, there is no air flow past the glottis; therefore there is no acoustic correlate of nasality in these segments. In glottal fricatives, the problem is the inverse, glottal fricatives already seem to have most of the acoustic characteristics that nasal consonants do, so isolating the acoustic correlates of nasality in nasal(ized) glottal fricatives is difficult (Ohala 1975). The cues for glottal fricatives are ‘largely the same whether produced nasalized or oral’ (Ohala 1990). This has led some to conclude that nasalized glottal stops are phonemically impossible (Ohala 1990). However, a clear phonemic distinction between nasal and oral glottal fricatives has been claimed for at least two languages: Kwangali, a Bantu language (Ladefoged & Maddieson 1996) and Semiat (Blust 1997, 1998).

The above discussion necessitates a multiply disjunctive acoustic definition of nasality for consonants and vowels as shown below in (5).

(5) Acoustic correlates of nasality



2.3.1.2 The articulation of Nasality

The articulatory definition of nasality is, simply, the lowering of the soft palate (6) (Jacobson et al 1952; Chomsky and Halle 1968; Huffman 1989; Cohn 1990).

(6) Articulatory correlate of nasality

nasal → lower soft-palate (or) open velopharyngeal port

This definition of nasality has been far more popular in the linguistics literature as it is consistent across both vowels and consonants. However, even this definition is not beyond problems. It has been observed that even oral vowels exhibit a certain amount of soft-palate lowering (which is substantially less than that of nasal vowels); furthermore, different vowels (both nasal and oral) show different amounts of soft-palate lowering – there is an increase in soft-palate lowering with a decrease in vowel height, i.e., low vowels are more nasal (Bell-Berti 1993, and references therein). So, while soft-palate lowering is a consistent correlate of phonologically nasal segments, it is not a correlate that is exclusive to nasal segments. However, what is absolutely clear is that phonologically nasal segments have *more* soft-palate lowering than corresponding phonologically oral segments. Following up on this fact, Huffman (1989) defines an 'orality threshold' – the degree of soft-palate lowering beyond which the segment is considered nasal. However, given the tremendous inter-speaker variation in the degree of nasalization, some have claimed that it is almost impossible to come up with a 'universal orality threshold' (Ploch 1999). However, it is possible to argue that a single articulatory definition of nasality is viable if we could somehow *normalize* away the interspeaker and intraspeaker (and intersegmental) variability since there is a clear difference in the *degree* of nasalization of nasal and oral counterparts.

2.3.2 The phonology of nasality

The views regarding the phonological representation of nasals (3b), can again be seen in the light of two competing hypotheses[2] – (i) [nasal] is binary feature, i.e., [±nasal]; (ii) nasal is a unary feature, i.e., [nasal].

The first hypothesis is that [nasal] is a binary feature with [+nasal] defining nasal segments, and [-nasal] defining oral segments (Jacobson et al 1952; Chomsky and Halle 1968; Cohn 1990 amongst others). Evidence in support of the [+nasal] value derives from the various rules of nasalization that are well-attested cross-linguistically. Evidence in support of the [-nasal] value is derived from the existence of segments in many language that block nasal harmony. The difference between the harmony-undergoers and harmony-blockers has been argued to be a difference between segments that are phonologically unspecified for nasality and segments that are phonologically specified for the feature [-nasal]. Furthermore, the existence of segments that are variably nasalized (argued to phonetically unspecified for nasality) and those that are invariably oral (argued to be phonetically specified for [-nasal] value) in Sundanese has been viewed as further evidence for the binarity of the feature (Cohn 1990).

[2] I am, for the present purposes, ignoring the possibility of gradient distinctions, a possibility in Exemplar Theories of phonology. Exemplar Theories are more generally argued against in Chapter 5 of this dissertation.

The second hypothesis that [nasal] is a unary feature, with oral segments remaining unspecified for any feature related to nasality in the phonology is a more recent view (Rice 1993; Steriade 1995; Botma 2004). While the nasal features proposed by Rice (1993), Steriade (1995), Botma (2004) differ on the exact representation of the feature in their feature system, they agree on the fact that only nasal segments need be specified for nasality, and they, therefore, constitute proponents of the unarist hypothesis of the feature [nasal]. Evidence for the unarist view of the feature [nasal] comes from the fact that orality ([-nasal]) rarely, if ever, acts as the *trigger* of phonological phenomena – while, [+nasal] harmony is a well-attested phenomenon, there appear to be no clearly demonstrable cases of [-nasal] harmony.

2.4 [nasal] is articulatorily defined

In the following sections, I shall argue that despite the tremendous amount of observable surface variation, there is reason to believe that the feature nasal has an articulatory definition. I shall first present, in section 2.4.1, an older (arguably, incomplete) argument in favour of an articulatory definition of the feature [nasal] discussed by Walker & Pullum (1999). I shall then provide, in section 2.4.2, a new argument based on a bias in nasal harmony rules.

2.4.1 An Old Argument

In a set of papers, arguing against the impossibility of nasal(ised) glottal segments like a nasal(ised) glottal fricative, [h̃], and nasal(ised) glottal stop [ʔ̃], Walker & Pullum (1996,

1999) put forth an argument in favour of the view that the phonetic definition of the feature [nasal] is the lowering of the velum, or the presence of a velopharyngeal opening.

In Sundanese, an Austronesian language spoken in Java, there is a process of nasal harmony that proceeds from a nasal consonant onto all adjacent vowels (7a). The harmony is blocked by all surface consonants in the language (7d), except glottal segments [h, ʔ] (7b) and glides derived through a process of epenthesis to break up hiatus situations (7c).

(7) Nasal Harmony in Sundanese (Robins 1957; Anderson 1972; Cohn 1990; Walker & Pullum 1999)

a. Harmony through vowels

ɲĩ ʲ̃ ã r 'to seek'

b. Harmony through glottal segments

i. mĩʔãsih 'to love'

ii. mãhãl 'expensive'

c. Harmony through derived glides

i. /ɲiar/ → [ɲĩ ʲ̃ ã r] 'to seek'

ii. /ɲaur/ → [ɲã ʷ̃ ũ r] 'to say'

d. Harmony blocked by other consonants

i. mõlohok 'to stare'

ii. mãro 'to halve'

iii.. ŋãjak 'to sift'

iv. mãwur 'to spread'

v. ŋã̃tur ‘to arrange’

vi. ŋũ̃dag ‘to pursue’

The most relevant data for Walker & Pullum’s argument is the nasalization through the glottal stop. Walker & Pullum argue that though the glottal stop shows no signs of nasal airflow or nasal resonances (because airflow is blocked at the glottis), it is phonologically specified for the feature nasal, thereby, implying the phonological structure in (8).

```
(8)  mĩʔã̃sih   ‘to love’    →    m     i        ʔ        a      s  i  h
                                      |        |        |
                                  [+nasal] [+nasal] [+nasal]
```

They argue that the glottal stop has a velum lowering gesture or velopharyngeal opening gesture associated with it triggered by the feature [nasal][3]. They adduce support for their position by citing other phoneticians and phonologists who have worked on the issue who see this position as a reasonable one. I show below, in (9-10), the relevant passages from the literature that they refer to (Ohala 1990; Cohn 1993).

(9) ‘There is no reason to assume that the velum changes its position during the glottal stop. Following the view that velum position, or more precisely velopharyngeal opening, is the primary phonetic correlate of [nasal], a glottal stop in such a case is phonetically nasal; yet perceptually, there would be no cue to this nasalization.’ (Cohn 1993a, pg. 347)

[3] Walker & Pullum follow Ní Chiosáin & Padgett (1997) in analyzing (nasal) hamorny as a process that does not ‘skip’ any segments, i.e, harmony is always to an adjacent segment.

(10)‘In all likelihood, the [ʔ] in Sundanese is also nasalized in the environment of adjacent nasal vowels, but the nasal airflow traces provided by Robins would not give a reliable indication of it since, obviously, if airflow is blocked at the glottis it will not show up in a nasal airflow trace.’ (Ohala 1990, pg. 165, note 10)

Based on these excerpts, they conclude that the feature [nasal] *must be* articulatorily defined as neither an acoustic definition (based on nasal resonances), nor an aerodynamic definition (based on nasal airflow) is either sufficient or necessary for the phonetic manifestation for the feature [nasal][4].

While the logic of their argument is sound, and their assumption of a velopharyngeal opening (or velum lowering) during a glottal stop is reasonable, it is still clear that they have not produced actual evidence showing that there is a velopharyngeal opening (or velum lowering) during the glottal stop. Therefore, this argument is technically incomplete and is in need of experimental verification (possibly via fMRI or x-ray microbeam or ultrasound studies).

2.4.2 A New Argument

In this section I will, briefly, present a new argument that supports the hypothesis that the phonological feature [nasal] is articulatorily defined. I will first argue that there is a strong articulatory bias in nasal harmony rules, and then argue that nasal harmony rules

[4] Bill Idsardi raises the interesting possibility of defining features in terms of their effects on neighbouring segments, for example, vowel length cues for voicing. However, this would only transfer the problem from estimating the phonetic effects ‘during’ the segments to estimating the phonetic effects that occur on adjacent segments. Therefore, in some sense, the question of what dimension of phonetic effects (acoustic, articulatory, both…) is the correct one for the feature remains.

are necessarily abstract; hence, they are phonological. The above arguments taken together force one to the conclusion that the phonological feature [nasal] must have an articulatory definition.

2.4.2.1 There is an articulatory bias in nasal harmony rules

There appears to be a close (acoustic and diachronic) connection between aspirated segments and nasals. Aspiration and nasalisation have similar acoustic correlates in that they have decreased first formant (F1) amplitudes and increased F1 bandwidth (Ohala & Amador 1981; Ohala 1983; Ohala & Ohala 1993).

Ohala & Amador (1981) also showed that the phonetic effects of aspirates (or high airflow segments) and nasals on adjacent vowels are very similar, and that the co-articulations of both types of segments are prone to be perceived as nasalized. They conducted an experiment wherein listeners were made to judge vowel stimuli made by iterating single pitch-periods from the middle of the first vowel (left vertical line for each word in Fig. 2.2) and the end of the first vowel (right vertical bar in Fig. 2.2) for the three words [bala], [bana], and [bafa]. Their results showed that listeners judged stimuli consisting of single pitch-period iterations of vowel portions immediately next to voiceless fricatives (high-airflow segments produced with greater-than-normal glottal opening) to be about as nasalized as comparable periods made from vowel margins near nasal consonants.

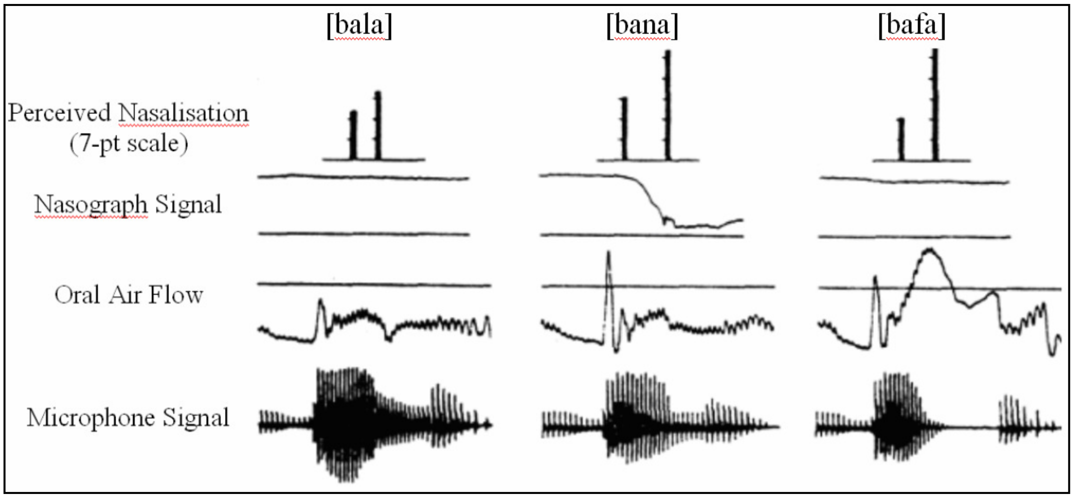


Fig. 2.2. Listeners' judgements of degree of nasality of iterated vowel (left bar of each pair from middle of vowel; right bar from the end); Ohala 1983)

Arai (2006) showed in an experiment using synthesized speech that even experienced speech pathologists can be tricked into believing nasality is present in synthesized segments with high open quotient (OQ) (a measure of the openness of the glottis during vibration), and high amplitude of aspiration (AH). In fact, the perception of nasality appeared to increase with increased OQ and higher AH.

Phonetic studies have also noted that aspiration and nasalization in vowels share many acoustic similarities (Stevens & Keyser 2001, Arai 2006); they both flatten the spectrum at low frequencies, and increase the bandwidth of the 1st formant; they both also enhance the 1st or 2nd harmonic in the spectrum of a vowel; and finally, they both introduces pole-zero pairs (formants and anti-formants).

Furthermore, similar to nasal consonants, aspirate segments (including high-airflow segments like fricatives and affricates) have (diachronically) been observed to induce nasality next to themselves (11) – this has been termed *spontaneous nasalization* or *rhinoglottophilia* (Turner 1921; Bloch 1920,1965; Grierson 1922 – as cited in Ohala 2001; Matisoff 1975; Ohala & Ohala 1993).

(11) a. Rhinoglottophilia in modern Hindi (from Ohala and Ohala 1993)

Sanskrit	Old Hindi	Modern Hindi	
pakʂa	pa:k^{h}	pə̃ŋk^{h}a	'a side'
uččaka-		ũ:ča	'high'

b. Rhinoglottophilia in modern Breton (from Jackson 1967 – in Ohala and Ohala 1993)

French	Middle Breton	Modern Breton	
rosse	roncet/ronceet	rounet/rouneet	'horses'
vis	vicc	bins	'screw'

However, Botma (2004, pg. 294) notes that most processes of spontaneous nasalization are 'too erratic to leave, or to have left, a firm imprint on the language concerned.'

Finally, there are also observed cases of aspiration emerging on (voiceless) consonants adjacent to nasal consonants in Swahili (12) (Botma 2004). When the nominal class 9/10 marker /N-/ is prefixed to a voiced-stop initial root, a 'pre-nasalised stop' surfaces (12a-b), but when it is prefixed to a voiceless-stop initial root, an aspirated stop surfaces (12c-d)[5].

[5] The diachronic chain of events that led to this alternation is unclear. It has been argued that the original prefix is from the Proto-Bantu prefix *ni/li- (Meinhof 1932, Goyvaerts 1972). Based on this, Botma (2004) hypothesizes that the chain of events that led to the alternation was: ni+t > ni̥+ t > n̥+t > t^{h}, i.e., first, the intervening /i/ was devoiced, then, the vowel was lost and the devoicing spreading to the preceding nasal, and finally, the nasal was lost with the aspiration spreading onto the following voiceless consonant. Hinnebusch (1975), based on the variation observed in some neighbouring dialects/languages, proposed a different chain of events: n+t > nn̥+ t^{h} > n̥+t^{h} > t^{h}
However, it is unclear that either was the actual chain of events; Wald (1990) notes that the cognate variants of N+t sequences in some other closely related Bantu languages (unconsidered in the historical reconstructions) usually are [nd] and [n] as in Proto-Bantu *bantò > [wat^{h}u] in Swahili, [andu] in Thagicu

(12) Aspiration in Swahili (Botma 2004)

a. /N+buzi/ ^{m}buzi 'goat'

b /N+dege/ ^{n}dege 'bird'

c. /N+pepo/ p^{h}epo 'spirits'

d. /N+tembo/ t^{h}embo 'elephant'

Despite the strong phonetic similarity and diachronic relationship between nasals and aspirate segments, there are no observed cases of aspirate segments partaking in nasal harmony/dissimilation rules or long-distant nasal harmony rules (13a-b).

(13)a. Attested: naya → nãỹã

b. Unattested: haya → h̃ãỹã

There are two apparent counter-examples to this generalization, which however, do not stand-up to scrutiny. These are from the Peruvian languages Aguaruna (from the Jivaroan language family), and Arabela (from the Zaparoan language family).

Aguaruna, a Jivaroan language spoken in Peru, appears to have a glottal fricative that spreads nasality bidirectionally (14) (Payne 1974 – cited in Walker & Pullum 1999).

(14)a. [ãh̃ũm] 'later'

b. [sũh̃ĩk] 'beads'

c. [kũh̃ũ] 'porcupine'

d. [isãh̃ĩ] 'later'

---

languages of interior Kenya, and [wanu] in Luguru (among other central coastal Tanzanian languages). Interestingly,, what appears to be a generalization in the languages discussed, is that the loss of the nasal segment is somehow related to the appearance of aspiration, possibly through the phenomenon of rhinoglottophilia.

However, three pieces of evidence make it highly unlikely that the relevant segment is an *oral* glottal fricative, underlyingly. First, there is another oral glottal fricative that never triggers nasalization next to tense high vowels (15) (Trigo 1988, pg. 112, note 4).

(15)a. [humaŋ] no gloss

b. [t͡sihiŋ] no gloss

Second, the relevant glottal fricative in (14) is always nasalized, at least impressionistically[6] (when it surfaces next to vowels, it itself is not oral.). Third, the glottal fricative is in complementary distribution with a velar nasal [ŋ] that occurs syllable-finally. In fact, we can see alternations for the same morpheme: the possessive-aspectual morpheme in Aguaruna alternates between [ɦ̃ũ] and [ŋ], as shown in (16), which are 'conditioned by a vowel deletion whose environment is not well understood' (Trigo 1988).

(16)a. duha-ɦ̃ũ-t 'rise-asp-inf'

b. duha-ŋ-tinu 'rise-asp-fut'

Based on these three facts, others who have analysed the language have claimed that the (nasalized) glottal fricative is a surface allophone of the velar nasal (Payne 1974 – cited in Walker & Pullum 1999; Trigo 1988). At the very minimum, one needs to say that the segment that surfaces as the glottal fricative that spreads nasality in (14) is actually

[6] Therefore, it is in need of experimental verification.

underlyingly specified for nasality. One cannot maintain that the segment in question is an oral glottal fricative that spreads nasality.

Arabela, a Zaparoan language spoken in Peru, also appears to have a glottal fricative that spreads nasality right-wards[7] (17) (Rich 1963; Walker & Pullum 1999). However, based on the (impressionistic) fact that the glottal fricative is nasalized in all environments (Rich 1963), Walker & Pullum (1999), analyse the segment as underlyingly (a placeless) nasal (à la Trigo 1988). Given that the phonemic consonant inventory includes /p, t, k, s, ʃ, m, n, h̃, r, w, y/ in Arabela (Rich 1963), the proposed analysis of [h̃] being a placeless nasal (or even a velar nasal /ŋ/ just as in Aguaruna above) is made more plausible in light of the fact that the feature [nasal] is already a necessary distinctive feature of Arabela, while aspiration has no distinctive role.

(17)a. h̃ũw̃ãʔ

b. h̃ẽẽg̃ĩʔ

As I have shown, neither of the languages needs to be analysed as having phonemic (oral) glottal fricatives that spread nasality (without also being specified for the feature [nasal]) as might be expected from the phonetic characteristics of aspirated (or high-airflow) segments.

Therefore, aspirated segments, in spite of having similar acoustic correlates and to some extent similar diachronic effects as nasal segments, do not synchronically behave

[7] The nasalization on the vowels is very unlikely to be a result of phonemic vowel nasality, as vowel nasality is completely predictable, and surfaces only next to nasal segments (Rich 1963).

like ‘regular’ nasal segments. These observations lead to the conclusion that nasal harmony rules and long-distance assimilation rules are triggered only by segments which are *articulatorily* nasal (18).

(18) **Result A**

There is an articulatory bias in nasal harmony rules.

2.4.2.2 Nasal harmony is abstract

In many languages, nasal harmony ‘skips’ obstruent segments that are within the nasal harmony domain; in Mòbà Yoruba (19a), a Benue-Congo languages (Welmers 1973; Piggott 2003a,b); in Barasano (19b), a Tucanoan languages (Piggott 2003a,b); and in Guaraní̃ (19c), a Tupi language (Rivas 1975, Walker 1999).

(19) Nasal Harmony is abstract

a. Mòbà Yoruba

(i) /ur̃ĩ/ → [ũr̃ĩ] ‘iron’

(iii)/itã/ → [ĩtã] ‘story’

b. Barasana

(i) /w̃ãre + re/ → [w̃ãr̃ẽr̃ẽ] ‘to watch’

(ii) /mini + aka/ → [m̃ĩñĩãkã] ‘small bird’

c. Guaraní̃

(i) tupã́ → tũpã́ ‘god’ (Rivas 1975)

(ii) popĩ́ → põpĩ́ ‘to peel, strip’ (Walker 1998)

The harmony process could not be the result of phonetic spreading of a single velum-lowering articulatory gesture, as this would predict that the intervening obstruents would be nasalized[8]. Walker (1998) showed that the intervening obstruent stops for Guaraní were clearly oral with no nasal airflow, i.e., the velum was not lowered, and the velo-pharyngeal port was more-or-less closed. Therefore, the harmony process cannot be the phonetic spreading of nasality to adjacent segments, and is necessarily at a more abstract representational level.

Further evidence that nasal harmony is an abstract process that is not amenable to a purely phonetic analysis comes from Sundanese. As described above in section 2.4.1, Sundanese has a nasal harmony rule that is blocked by a set of segments (a sub-set of the consonant inventory) that includes those that have been, convincingly, argued to be phonetically underspecified for nasality (Cohn 1993a).

The relevant data for our present purpose involves the forms where there is an infixation of the plural infix /-ar- (or) -al-/ (there is a regular dissimilation alternation between the two that is not important for the present purposes).

Nasality in mono-morphemic words is blocked by the liquids [l] and [r] (20a). However, nasal harmony appears to overapply when infixation happens, as vowels of both the root and the infix are nasalized in spite of the intervening liquids (20b). Cohn

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[8] The data, as it stands, also weakens Walker & Pullum's (1999) argument that harmony is to adjacent segments, as the intervening obstruent stop is non-nasal. However, in Chapter 4, I show that it is possible to maintain that, in the phonology, nasal harmony is to adjacent segments even in the case of intervening 'non-nasal' obstruents.

(1990) argues that it is a case of a lexical nasalization rule interacting with the morphology, i.e., the nasalisation rule applies before and after infixation[9].

(20) Nasal harmony in Sundanese

a. Nasal harmony before liquids

i. ŋũliat ‘stretch (sg. active)’

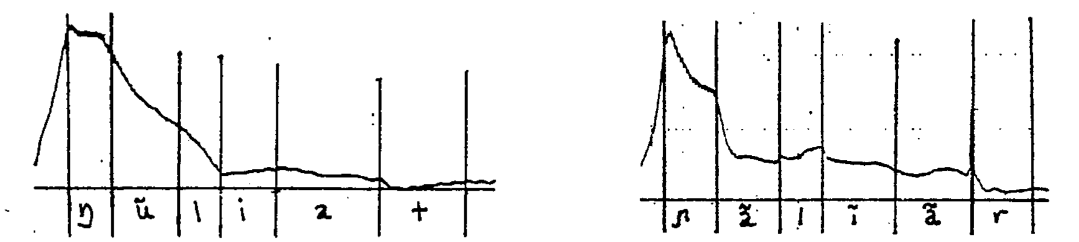
ii. mãro ‘to halve’

b. Nasal harmony after infixation (Cohn 1993)

i. /ɲ-ar-aian/ → [ɲãrã ʲ̃ ĩ ʲ̃ ãn][10] ‘wet (pl. active)’

ii. /ɲ-al-iar/ → [ɲãl̃ĩ ʲ̃ ãr] ‘seek (pl. active)’

Cohn shows that though [l] appears to block nasal spreading, it is phonological and phonetically underspecified for the [nasal] feature. The same [l] has different phonetic manifestations based on what the adjacent segments are; when it is next oral vowels, it is oral; when it is between a nasal vowel and an oral vowel, it has a nasal cline (Fig. 2.3a); and when it is between two adjacent nasal vowels, it is fully nasalized (Fig. 2.3b)



(a) (b)

Fig. 2.3. Nasal flow tracings for words with [l] in different phonetic contexts

[9] See (Raimy 1999) for an improved analysis of morphophonological interaction that does not involve multiple applications of the same nasalization process.

[10] The vowel immediately following an infixal [r] in nasalization contexts has been argued to be de-nasalised (Cohn 1990, Robins 1957). The issue does not affect the point at hand.

Cohn (1990, 1993) argues that the phonetic behaviour of [l] is most insightfully captured if it is analysed as phonetically unspecified for nasality, and any nasality that surfaces is a result of adjacent nasal segments. This means that the segment [l] is phonologically unspecified for nasality too.

As can be seen, the set of harmony blockers in Sundanese includes both necessarily oral segments and segments that are phonetically/phonologically unspecified for nasality. It is thus an abstract set of segments with no obvious phonetic motivation for blocking the spread of nasality. The Sundanese data reinforces the fact that the nasal harmony must be an abstract, i.e., *phonological*, phenomenon.

(21) **Result B**

Nasal harmony is abstract; it is phonological

2.4.2.3 Deriving the phonetic definition of [nasal]

Given the results in the previous two sections, we are now in a position to derive the result that the definition of the feature [nasal] must include an articulatory dimension. Sections 3.2.1 and 3.2.2 gave us two important results (22).

(22) a. Result A

There is an articulatory bias in nasal harmony rules.

b. Result B

Nasal harmony is abstract; it is phonological

The observations in (22a-b) force us to conclude that the articulatorily bias with regard to nasal harmony is in the phonology – more specifically, in the representational system, i.e., in the feature system. Therefore, the feature [nasal] is *articulatorily* defined (23).

(23) The feature [nasal] has an *articulatory* definition - in terms of velum lowering or velo-pharyngeal port opening.

2.5 Implication for feature theories

In this section, I shall use the characteristics of nasal segments discussed or derived in the preceding sections to assess the different theories of distinctive features outlined in section 3.2. I shall specifically show that not all theories can account for the results, insightfully. The theories that stand out as explanatory are those that include articulatory relations in their featural definitions.

The characteristics relevant to the present purposes are listed below in (24).

(24) a. Nasals have a unified articulatory definition, but not a unified acoustic definition.

b. There is an articulatory bias in nasal harmony rules (Result A)

c. Phonologically, the feature [nasal] has to have an articulatory definition (Result C).

It is immediately clear that feature theories that necessitate articulatory featural definitions, namely, *articulatory feature theories, translational feature theories,* and *articulatorily-bootstrapped emergentist feature theories,* can account for the characteristics of nasal segments in (24). As per these theories, a segment is specified for nasality only if they have a soft-palate lowering gesture. This explains why nasal segments appear to have a consistent articulatory definition (24a). Result A (24b) & Result C (24c) are similarly easily accounted for – only segments that are specified for the articulatory effect of lowered soft-palate can partake in phonological processes sensitive to the feature [nasal] (25a). Glottal aspirates (and other aspirate segments), in the absence of a lowered soft-palate, are not [nasal] segments (25b), and therefore do not trigger nasal harmony processes in spite of having similar acoustic effects as nasal segments.

(25) Specification for nasality in the phonology – articulation-based theories

a. Segments with a lowered soft-palate

n, m, ŋ, ã, ĩ, ẽ, õ, ũ, ɦ̃, … → X
|
[nasal]

b. Segments without a lowered soft-palate

s, h, ʃ, ʦ, ʧ, (d, b, ɡ, a, …) → X
|
Ø

Contrastingly, theories that do not necessitate articulatory featural definitions, namely, *auditory feature theories,* which claim that distinctive features have auditory phonetic targets, and *unconstrained emergentist feature theories,* which claim that phonological features can be formed over any phonetic (or even non-phonetic) dimension, are incapable of accounting for the characteristics of nasal segments highlighted in (24). Such theories would lead one to expect that aspirate segments and nasal segments, despite having different articulatory manifestations with respect to the soft-palate, could in at least some languages be classified as 'nasal' because they share many acoustic characteristics (26). However, as was discussed above (13a-b), there is no support for this prediction. In fact, nasal-harmony rules, as was pointed out, are absolutely biased in favour of what are only articulatorily-nasal segments.

(26) Specification for nasality in the phonology – non-articulation-based theories

a. Segments with (acoustic) phonetic characteristics similar to nasal segments

n, m, ŋ, s, h, ʃ, ʦ, ʧ → X
|
[nasal]

b. Segments without (acoustic) characteristics similar to nasal segments

d, b, ɡ, a, … → X
|
Ø

Furthermore, *auditory feature theories*, also suffer from a need for a multiply disjunctive definition of the feature [nasal] (24a). Such theories are at a loss to explain why segments with such disparate acoustic characteristics are ever treated as 'the same' in the phonology.

2.6 Conclusion

As was mentioned in (1) and repeated below in (27), the debate on distinctive feature theories has revolved around two major themes:

(27) a. What is the physical dimension in which features are best defined – articulatory or acoustic/auditory or both?

b. Are features innate or learned cognitive categories?

In this chapter, I have shown that at least the question in (27a) can be answered in the light of evidence from nasal segments. I have provided a new argument in favour of the view that the feature [nasal] has an articulatory definition, in terms or a lowered soft-palate – despite acoustic properties that are similar to some nasal segments, aspirates never participate in nasal harmony processes like true nasals; furthermore, different nasal segments themselves participate in nasal harmony processes despite having disparate acoustic properties; the one hypothesis that explains both these observations is that nasals necessarily have a lowered soft-palate gesture that aspirates do not. This argument along with other factors, such as, the different phonetic manifestation of nasal segments, are shown to support distinctive feature theories that necessitate articulatory definitions, namely, *articulatory feature theories, translational feature theories,* and *articulatorily-bootstrapped emergentist feature theories.*[11]

The chapter has not necessarily contributed to our understanding of distinctive features in light of the issue of innateness raised in (27b). Based on the data, it could be argued that the feature [nasal] is not innate, but it is the *expectation* that features are to be defined, at least partly, articulatorily that is innate. On this view, features are still language specific and 'emergentist', but in a clearly delineated way.

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[11] Note, however, that I haven't even raised the prospect of *mixed feature theories,* i.e., feature theories according to which some features are defined auditorily, and others articulatorily (Thanks to Jeff Heinz for pointing to this possibility). While this is definitely possible, especially when one considers rhotics which might be better defined acoustically, it needs to be shown (in contrast to the feature [nasal] in this chapter) that segments bearing the feature never pattern with other segments that have similar articulatory properties as the feature in question in active phonological processes. Note, also that such an exposition would then be a strong argument in favour of innatist views of features, as both *unconstrained* and *bootstrapped emergentist feature theories* would be at pains to explain the observed asymmetries.

The data and analyses in the following chapters argue against such an emergentist view. Chapter 3 shows that the phonetic manifestation of nasals is *always* mediated by the nature of laryngeal contrast in the specific syllabic position – if there is a laryngeal contrast, simple nasal stops surface as simple nasal stops; if there is no laryngeal contrast, simple nasal stops could surface as pre-nasalised stops (or partially-nasal stops, as labeled in the following chapters). Given, such universal phonology-phonetics mapping principles, it is difficult to maintain emergentist approaches (even if they are articulatorily-bootstrapped). Contrarily, innatist feature approaches can be developed further to model such principles.

Chapter 3

PARTIALLY-NASAL STOPS

3.1 Introduction

The focus of this chapter is the typology and phonological representation of segments that have been called pre-/post-nasalised stops in the literature. These are segments that have both a nasal portion and an oral portion (1). Pre-nasalised segments are those that have a nasal portion before the oral portion (1a), and post-nasalised stops are segments that have a nasal portion after the oral portion (1b).

(1) Post/pre-nasalised stops

a. Pre-PNS (^{n}d, ^{m}b, ^{ŋ}k) - in onsets.

(i) Barasano (Rice 1993; Piggott & Hulst 1997)

^{m}baŋgo ‘eater’ ^{n}diro ‘fly’

(ii) Apinaye (Salanova 2002)

^{m}botʃ ‘ox’

b. Post- nasalised stops (d^{n}, b^{m}, k^{ŋ}) – in codas.

(i) Jambi Malay (Tadmor & Yanti 2004; Yanti (in prep); personal field work)

[m̃ãlá^{b}m] ‘night’ tɔlɔ^{g}ŋ ‘please’

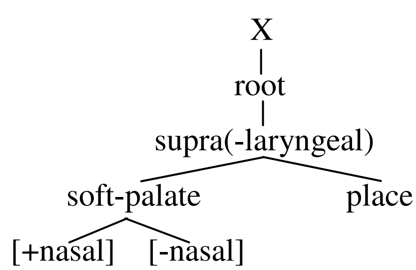
(ii) Mẽbengokre (Salanova 2002)

[to^{d}n] ‘armadillo’

It has been argued, since at least (Sagey 1986), that these two types of segments do not contrast in any language, and that the ordering of the nasal and oral gestures is phonologically irrelevant. I follow this conventional view, and shall call these segments 'partially-nasal stops' (PNS).

The phonological structure of partially-nasal stops has been debated in the phonological literature at least since Chomsky and Halle (1968). Sagey (1986) proposes the representation in (2) for these segments[1]. Sagey proposes that partially-nasal stops are specified for both values of the feature [nasal], namely, [+nasal] and [-nasal]. This results in the intuitively unappealing situation of a segment being specified for both values of a feature; and just as with a description of anything that includes contradictory statements, we should pursue a representational theory that prohibits such possibilities. Furthermore, this analysis uses the value, [-nasal], which never acts as the *trigger* of harmony phenomena – while, [+nasal] harmony is a well-attested phenomenon, there appear to be no clearly demonstrable cases of [-nasal] harmony.

(2) Representation of partially-nasal stops (Sagey 1986)



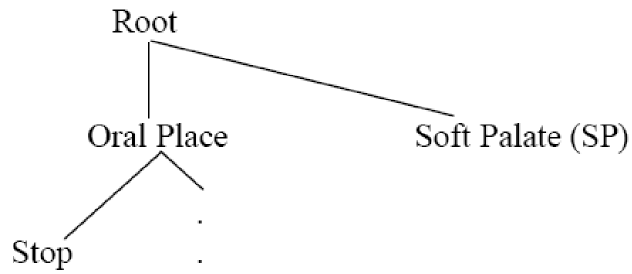
[1] For this view, there is a need for a phonetic implementational theory that does achieve the surface ordering.

More recent analyses have concentrated on showing that at least one of the two (nasal or oral) portions is phonologically irrelevant (Anderson 1976; Piggott 1992; Rice 1993; van de Weijer and Hinskens 2004 amongst others) – typically arguing that the nasal portion of the segment is a by-product of phonetic (interpretation) rules. This chapter aims to counter this claim by bringing into the debate languages with similar phenomena that have received scant attention like Yuhup, Jambi Malay, Mamaindé.

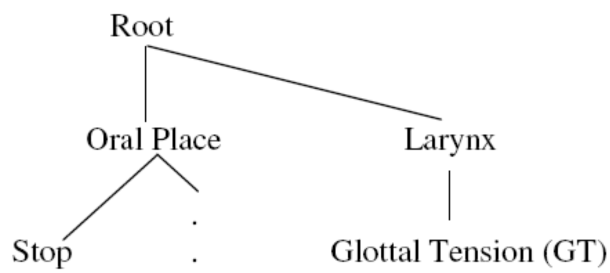
An important claim in this chapter is that "partially-nasal stops"[2] (PNS) actually come in (at least) two flavours – *Nasal-based partially-nasal stops* (N-PNS), and *Voice-based partially-nasal stops* (V-PNS). Nasal-based partially-nasal stops are best understood as having the same phonological structure as simple nasals and surface in languages with a 2-way stop contrast that does not include a laryngeal contrast (with the structure in (3a)); while voice-based partially-nasal stops (3b) are truly voiced stops that are enhanced with a phonetic nasal gesture, and surface in languages where there is already another series of simple nasals (Stevens and Keyser 2006). There are a few other cases of what have been called 'pre-nasalised stops', or 'funny nasals' or 'post-occluded stops' amongst others that I discuss in Chapter 4. As I show in Chapter 4, these cases are best analysed as 'Obstruent Nasals' because they exhibit a distinct set of phonetic and phonological properties.

[2] I use this term to refer to both PNS (oral stops with a small nasal portion) and occluded nasals (nasals with a small oral stop portion) - Maddieson and Ladefoged (1993).

(3) a. Nasal-based partially-nasal stop (N-PNS)



b. Voice-based partially-nasal stop (V-PNS)



More generally, I claim that the appearance of simple nasals in languages is through a principle of feature-gesture mapping or completion for the sake of enhancement of contrast (Stevens and Keyser 2006) for the node/dimension Soft Palate (SP). In languages without this completion, there is variation of the phonetic implementation of the node – it surfaces as a partially-nasal stop, or a simple nasal stop or as a simple oral stop.

Section 3.2 introduces the basic phonological and phonetic facts regarding the two types of PNS. Section 3.3 discusses recent analyses that have been proposed to account for PNS and argues that they are flawed. Section 3.4 motivates and develops a new analysis for these segments. Section 3.5 discusses some open questions. Section 3.6 concludes the chapter. There is also an Appendix at the end of this dissertation that briefly presents the phonological grammar of Tanjung Raden Jambi Malay.

3.2 The many flavours of partially-nasal stops

In this section, I shall show that, contrary to conventional wisdom, there are two varieties of partially-nasal stops, with starkly different characteristics. *Nasal-based partially-nasal stops* (N-PNS) surface in inventories where there is no laryngeal contrast in the obstruents, while *voice-based partially-nasal stops* (V-PNS) surface in languages which have a laryngeal contrast in the obstruents, and a phonemically-distinct simple-nasal series. In Section 3.2.1, I present the phonological and phonetic characteristics of N-PNS. In section 3.2.2, I discuss the phonological and phonetic characteristics of V-PNS. In Section 3.2.3, I present a brief summary and contrast the facts regarding N-PNS and V-PNS which forms the basis of the new analysis that I propose later in the chapter (section 3.4).

3.2.1 Nasal-based Partially-nasal stop (N-PNS)

Languages such as Barasano, Kaingang (Rice 1993; Piggott & Hulst 1997), Jambi Malay (Tadmor & Yanti 2004; Yanti in prep.; personal field-work), Guaraní (Rivas 1975; Walker 1998), Apinayé and Mẽ̆bengokre (Salanova 2002) amongst others, have segments described in the literature as partially-nasal stops. In these languages, there is no laryngeal contrast in obstruents[3]. I classify the segments as nasal-based partially nasal stops (N-PNS), and argue in a later section (section 3.2.3) that these segments are best analysed as featurally identical to simple nasals in the (featural) phonology.

[3] In Jambi Malay dialects, Apinayé and Mẽ̆bengokre , the absence of a laryngeal contrast in obstruents is confined to the coda position. This fact, as will be shown later (in section 3.3), leads to a very important observation regarding N-PNS.

In the following sub-sections, I show the characteristic phonological and phonetic behaviours of these segments. The first three sub-sections include the typical phenomena discussed (in the phonological literature) – they surface in languages with laryngeal contrast (section 3.2.1.1); they consistently surface as simple nasal stops next to a tauto-syllabic nasal (section 3.2.1.2); and, they sometimes have oral stop counterparts in related dialects (section 3.2.1.3). The next few sub-sections discuss phenomena regarding the voicing characteristics of these stops (section 3.2.1.4), the possibility of N-PNS spreading nasality (section 3.2.1.5), and, finally, that they are more likely to surface in prosodically-strong positions (3.2.1.6).

3.2.1.1 Nasal-based partially-nasal stops and 2-way stop contrast

Nasal-based partially-nasal stops appear only in languages with a 2-way stop contrast (4a), i.e., in languages (for example, Barasano, Kaingang, Guaraní) with no laryngeal contrast in stops, and where there are only two series of stops: simple voiceless stops, and partially-nasal stops. In contrast, languages with a laryngeal contrast, and a 3-way stop contrast (for example, English) usually have a series of simple nasals and no nasalised stop series (4b).

(4)a. 2-way stop contrast

Oral Stops	p	t	k
Nasal Stops	ᵐb	ⁿd	ᵑg

b. 3-way stop contrast

Oral stop(vl./asp.)	p	t	k
Oral stop(vd.)	b	d	g
Simple nasal stops	m	n	ŋ

Although, this fact has been noted by many researchers (Anderson 1976; Rice 1993; van de Weijer and Hinskens 2004 inter alia), it has always remained an observation in passing without ever being used to strongly motivate an analysis of these segments. As was discussed in the introduction and as will be elaborated in the following sections, this fact has a direct bearing on the phonetic manifestation of the nasal feature.

3.2.1.2 The Nasal/Oral Alternation

In languages with N-PNS and nasal(ised) vowels[4], there is an interesting alternation with N-PNS and simple nasals – only simple nasals appear adjacent to tauto-syllabic nasal vowels, while N-PNS (in free-variation with simple nasal stops and/or oral stops) appear next to tautosyllabic oral vowels. Typical data is as in (5) from Barasano.

(5) Barasano (Data from Piggott and Hulst 1997)

a. mãsã	'people'	c. ^{m}baŋgo	'eater'
b. mãnõ	'none'	d. ^{n}diro	'fly'

In (5a-b), the nasal segments are directly adjacent to a tauto-syllabic nasal vowel, and they surface as simple nasal segments. In (5c-d), the relevant segments are directly adjacent to tauto-syllabic oral vowels, and they surface as PNS.

3.2.1.3 N-PNS have (voiced) oral stop counterparts in related dialects

Languages with N-PNS sometimes have voiced/oral-stop segments appearing in place of PNS both intra-dialectally and inter-dialectally (Slave (Rice 1993), Southern Barasano (Botma 2005))

[4] It does not matter if the nasalization on the vowel is contrastive or derived.

(6) Southern Barasano[5] - data from Botma (2005)

a. wa^{m}ba ~ waba ‘come!’

b. wa^{m}boti ~ taboti ‘grass’

The appearance of simple (voiced) oral stops has motivated the above-mentioned researchers to conclude that voicing is a part of the representation of these segments. In particular, Rice (1993) claims that these segments are sonorants specified for the organizational node Sonorant Voicing (SV) – hence, voicing is automatic; and van de Weijer and Hinskens (2004) claim that the segments are actually specified for the feature [+voice][6]. However, it is not clear from the data cited whether the PNS just surfaces as non-nasal (hence, oral), or it is really the case that the PNS is somehow phonologically specified for some sort of voicing feature – which would then be a consistent phonetic correlate in all contexts.

Previously undescribed data from Jambi Malay dialects has a bearing on this issue. Jambi Malay dialects have N-PNS in word-final position. As can be seen in (7), the reflexes of N-PNS in the Sarolangun (my field work) and Seling (Anderbeck 2003) dialects of Jambi Malay are in fact *voiceless* oral stops (7). In Sarolangun Jambi Malay, the relevant segments show the same invariance adjacent to tauto-syllabic nasal vowels (7d-e), where a simple nasal stop surfaces.

[5] This free alternation is limited to non-word-initial positions. Word-initially, the nasalisation is obligatory.
(i)a. ^{n}diro (*diro) ‘grasshopper’ b. ^{m}ba^{n}go ~ ^{m}bago (*bago) ‘eater’

[6] It is not clear if they intend to mean [+slack vocal folds] in particular.

(7) **Tanjung Raden**	**Sarolangung**	
a. maka^{d}n	makat	‘eat’
b. tula^{g}ng	tulak	‘bone’
c. jaru^{b}m	jarup	‘needle’
d. tangãn	tangãn	‘hand’
e. kanãn	kanãn	‘right’

The data from Jambi Malay clarifies the situation with the N-PNS. The intra-/inter-dialectal variants, if any, are consistently, *non-nasal* (or) *oral*, and not voiced as claimed previously in the literature. What is claimed, specifically, is when dialectal variants lack phonetic nasality, voicing is not a consistent correlate of the variants. It would be more accurate, but a truism, to say that such variants are consistenly oral or non-nasal.

3.2.1.4 Voicing in N-PNS

Voicing has been claimed to be an important phonetic correlate of PNS in general. The oral portion of all PNS is clearly oral as per all descriptions, and is, further claimed to be voiced by some researchers; however, the latter claim is rarely, if ever, substantiated through phonetic measurements. Stevens and Keyser (2006) and van de Weijer and Hinskens (2004) (inter alia) attribute the voicing to the phonemic representation of these segments – claiming in particular that they are specified for voicing, and are only phonetically enhanced with (partial) nasality. However, contrary to the common folk-lore of these segments, N-PNS do not show consistent voicing in their oral portion. A rather extreme case of voicelessness during the oral portion of the N-PNS in the word [gəNGá^{b}m] ‘grasp’ from Jambi Malay is presented below in Fig. 3.1. As can be seen, these segments need not necessarily have voicing during the oral portion (the circled portion is the oral part of the PNS).

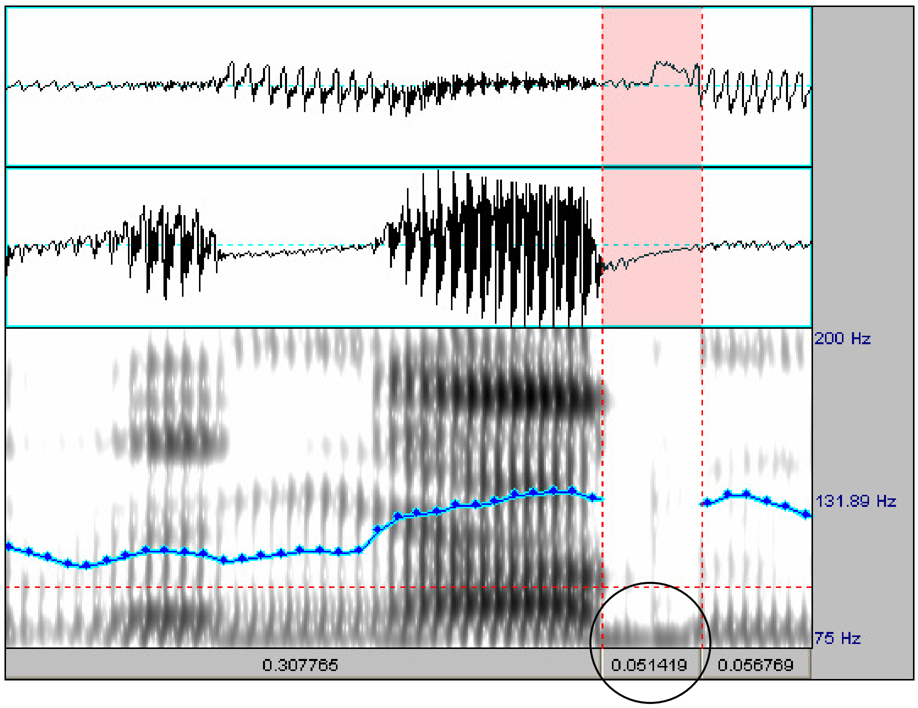


Fig. 3.1. A nasometer recording of the word [gəNGá^{b}m] ‘grasp’ in Jambi Malay[7]

More usual manifestations of these segments, in Jambi Malay are as in Fig. 3.2 & 3.3. As can be seen, there is some weak voicing during the oral portion of the N-PNS. Such alternation between weak voicing and almost voicing is indicative of passive voicing (Jessen 1998, Jessen & Ringen 2002 inter alia). In other data one can see stronger voicing bars during the oral section. However, note, the argument is not about the impossibility of strong voicing, but is about the lack of consistent voicing.

[7] The higher waveform represents the nasal pressure waveform; the lower waveform represents the oral pressure waveform; the blue dotted-line through the spectrogram in the pitch track. X-axis represents time in seconds

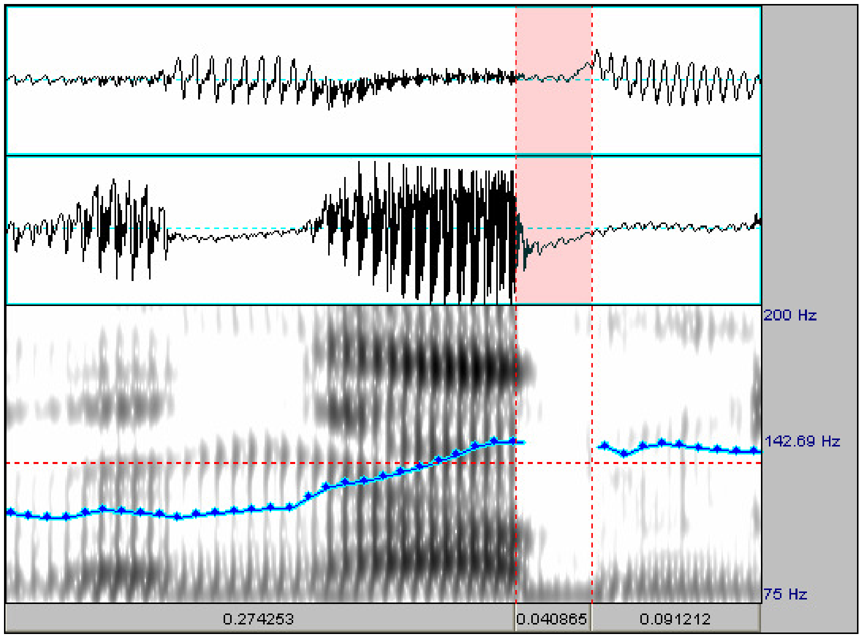


Fig. 3.2. A second nasometer recording of the word /gəNGa^{b}m/ ‘grasp’ in Jambi Malay

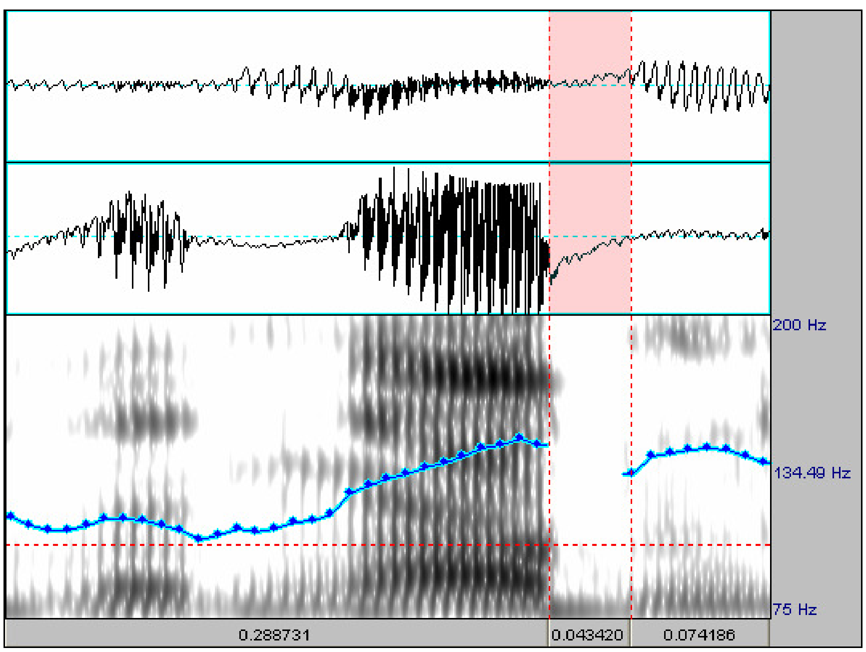


Fig. 3.3. A third nasometer recording of the word /gəNGa^{b}m/ ‘grasp’ in Jambi Malay[8]

[8] One might argue that there are ‘pitch perturbations’ effects immediately after the oral closure in Fig. 3, possibly associated with voicing. However, it is clear from the other spectrograms displayed (Fig.1 & 2), that even this is not a consistent phonetic correlate of the segment.

More evidence that the voicing in the oral portion is variable and not a consistent phonetic fact comes from Bonggi, a western Malayo-Polynesian language spoken in Sabah, Malaysia. N-PNS appear in word-final position in Bonggi just as in many other Malayo-Polynesian languages. In transcriptions of Bonggi words, not all N-PNS are transcribed with 'voiced' oral portions (Boutin 2000). In fact, the velar N.PNS is consistently transcribed with a voiceless oral portion (8).

(8) N-PNS in Bonggi (Boutin 2000)

a. ˈagwʊ^{b}m	'type of shellfish'
b. sənˈdahə^{d}n	'Sandakan' (city)
c. ˈadə^{k}ŋ	'charcoal'

If these segments were underlyingly specified for voicing[9], then it is unclear why they would not show a consistent voicing throughout. The voicing of the nasal portion - the only portion in which the voicing consistently appears – can be independently arrived at if segments are specified for nasality, as voicing is usually seen as an automatic correlate of nasal consonants (in the absence of contradictory specifications like aspiration).

The observation that emerges from the phonetic data is that the only 'invariant' phonetic correlate of these PNS is that there are two portions/phases in them– a nasal portion and an oral portion.

[9] Iverson & Salmons (1995) argue that language French, Japanese, Spanish, … have phonologically specified voiced stops that show a consistent (pre-)voicing bar, while languages like the Germanic languages (except Dutch) where the voiceless stops are aspirated, usually have 'voiced' stops that are only phonetically voiced through mechanisms of passive voicing, and are not phonologically specified for voicing.

3.2.1.5 N-PNS do spread nasality

Some researchers (Rice 1993; Botma 2004) have argued that PNS (in most languages) are phonologically not specified for the feature [nasal] and are different from simple nasals – thereby implying that they cannot spread nasality[10]. However, PNS have been observed to spread nasality in at least three languages – Guaraní (Rivas 1975; Walker 1998, and references within), Yuhup (Lopes & Parker 1999; Botma 2005 and references within), Tinrin (Osumi 1995; Botma 2004 and references within).

Typical examples of nasality spreading from PNS are shown below in (9) – from Guaraní (9a), Yuhup (9b), Tinrin (9c).

(9) PNS (regressively) spreading nasality[11]

a. Guaraní - Rivas (1975), Walker (1998)

/ro + ^{m}bo +γ^{w}atá/ ———> [r̃õ^{m}bo γ^{w}atá] ‘I made you walk’

b. Yuhup – Lopes & Parker (1999), Botma (2005)

/tə:d^{n} + ih/ ———> [tə:d^{n}ĩh̃] ‘beating’

c. Tinrin – Osumi (1995), Botma (2004)

/fa + ^{n}de/ ———> [fã^{n}de] ‘hang something up’

What is easily observable is that nasality can spread irrespective of the ordering of the nasal and oral portions – in Yuhup, it is a post-nasalised stop; in Tinrin and Guaraní, it is a pre-nasalised stop.

---

[10] Botma (2004) specifically claims that PNS (in most cases) are ‘phonologically inert nasals’, as opposed to simple nasals which spread nasality which he calls ‘phonologically active nasals’. The testability of his theory nearly vanishes when he claims that PNS which appear in conditions similar to other languages having them but spread nasality are ‘phonologically active nasals’.

[11] The nasal spreading in Guaraní is unlikely to be the ‘phonetic’ spreading of a single nasal gesture because the obstruent stops in nasal harmony spans are oral, as shown by Walker (1998).

3.2.1.6 N-PNS and phonetic variability

In section (3.2.1.3), it was shown that N-PNS have oral stop reflexes in related dialects. Such variation is also possible within the same dialect (10).

(10) Southern Barasano (data from Botma (2005))

a. wa^{m}ba ~ waba 'come!'

b. wa^{m}boti ~ taboti 'grass'

A related observation that is missing from the previous literature on the issue is the locus of the variability. As can be observed in some languages, N-PNS are more likely in prosodically-strong positions.

In Southern Barasano, in word-medial (or intervocalic) positions, the PNS freely varies with an oral stop (11ii-iii); however, in word-initial position, there appears to be no free-variation, with the surface PNS as the only occurring variant (11i & 11iii).

(11) Southern Barasano (Rice 1993 - data Smith & Smith 1971:82-83, Botma 2005)

(i) ^{n}diro 'grasshopper'

(ii) wa^{m}ba/waba 'come!'

(iii)^{m}ba^{ŋ}go/^{m}bago 'eater'

Similarly, in Jambi Malay, while in phrase-final contexts the relevant (word-final) segments can surface as PNS and freely vary with simple nasal stops and oral stops (12i-ii), in phrase-medial position, the same segments never surface as PNS (Tadmor & Yanti 2004). My own field-work confirms this observation.

(12) Jambi Malay (Tadmor & Yanti 2004, personal field work)

(i) /mimpi/ → [mĩ̃mpi̊] 'dream'

(ii) /malam/ → [mã̃lá$^{(b)}$m] 'night'

In both Southern Barasano and Jambi Malay, PNS are more likely to surface in, putative, prosodically-strong positions.

3.2.2 Voice-based Partially-nasal Stops (V-PNS)

There are PNS in some languages such as Mixtec (Gerfen 1999; Iverson & Salmons 1996), Northern Tohoku Japanese (Nasukawa 2005), Auca (Pike & Saint 1962; Ploch 2003) that do not share most of the properties of N-PNS outlined in section (3.2.1). I shall call these PNS, voice-based partially-nasal stops (V-PNS). In these languages, there is a distinct series of simple-nasal stops

In the following sub-sections, I will show that V-PNS contrast with N-PNS in most of their phonological (and phonetic) behaviour. Unlike N-PNS, they appear in inventories with a phonemically-distinct nasal series (3.2.2.1). V-PNS appear to be truly voiced (section 3.2.2.2); they do not surface as simple-nasal stops adjacent to tauto-syllabic nasal vowels, and, in general, do interact with phonological nasality on adjacent segments (section 3.2.2.3); finally, they more likely to surface in prosodically-weak positions (3.2.2.5).

3.2.2.1 V-PNS contrast with simple nasal stops

V-PNS, in contrast to N-PNS, appear in inventories where there is a phonemically-distinct simple-nasal stop series (13). The other stops in the inventory, along with PNS, typically include simple nasal stops, and voiceless unaspirated stops.

(13) 3-way stop contrast

Oral stop(vl./asp.)	p	t	k	
Oral stop(vd.)	^{m}b	^{n}d	^{ŋ}g	(vary with: b d g)
Simple nasal stops	m	n	ŋ	

3.2.2.2 V-PNS alternate with truly voiced

It was shown in sections 3.2.1.3 – 3.2.1.4, the true generalization with N-PNS was that they alternate with oral stops, whose voicing is not consistent. Contrastingly, V-PNS alternate with segments that are clearly truly and fully voiced. I shall use the term fully-voiced stops or truly-voiced stops to identify voiced stops with pre-voicing as, typically, in the Romance languages, and to contrast them with 'voiced' stops that are argued to be voiced through passive voicing as in English.

The PNS, in Mixtec, alternate with fully-voiced stops in word-initial position (14) (Gerfen 1999; Iverson & Salmons 1996).

(14) Mixtec

(i) /bà?à/	→	[^{m}bà?à] (or) [bà?à]	'good'
(ii) /bá?ù/	→	[^{m}bá?ù] (or) [bá?ù]	'coyote'

Similarly, the PNS in Northern Tohoku Japanese are diachronic reflexes of voiced stops in intervocalic positions (15i-ii) (Nasukawa 2005). These stops are in complementary distribution with voiced stops, which are found in all other positions (15iii-iv).

(15) Northern Tohoku Japanese (Nasukawa 2005)

(i) *hada	→	ha^{n}da	'skin'
(ii) *sabi	→	sa^{m}bi	'rust'

(iii)*daruma → darɯma 'Dharma'

(iv) *baku → baɣɯ 'tapir'

With respect to Northern Tohoku Japanese, it is clear that the PNS pattern has fully voiced stops reflexes in related dialects from work by Shimizu (1989), who has shown that Japanese voiced stops are fully voiced stops with prevoicing. Furthermore, Japanese, famously, has a general 'voicing' alternation of *Rendaku* that affects only truly voiced segments[12].

3.2.2.3 V-PNS do not interact with phonological nasality

V-PNS, unlike N-PNS, are not subject to the nasal/oral alternation mentioned in section (3.2.1.2), according to which N-PNS always surface as simple nasal stops next to tauto-syllabic nasal vowels.

In Coatzospan Mixtec, the second person (familiar) morpheme is a floating [+nasal] feature that links to the final vowel in a word and spreads leftwards until blocked by a voiceless segment (16ai-ii) (Gerfen 1999). Under such morphological conditions, it is possible for a PNS to surface adjacent to a tauto-syllabic nasal vowel without becoming a simple nasal stop (16aiii-iv). The facts in Auca, an Ecuadorian language, are essentially the same (Pike & Saint 1962; Ploch 2003) – utterance initial voiced-stops can optionally surface as PNS, and this optionality persists despite an adjacent tauto-syllabic nasal vowel (16b), in contrast to N-PNS (section 3.2.1.2) .

[12] Vance (2005) suggests that the process originated from the reduction of a genitive particle /-no/, involved in noun phrases.

(16) a. Mixtec (Gerfen 1999)

i. kau 'cough' ii. kã̃ũ̃ 'you (familiar) will cough'

iii. ^{n}dii 'to go down' iv. ^{n}d̃ĩĩ 'you (familiar) will go down'

b. Auca (Pike & Saint 1962; Ploch 2003)

i. $^{(m)}$b́ékã 'he drinks' ii. $^{(m)}$b̃́ãmõ 'whole seed'

Another significant fact related to interaction with phonological nasality is that V-PNS do not spread nasality in any language.

3.2.2.4 V-PNS are more likely to surface in prosodically-weak positions

It was shown in section 3.2.1.6, that N-PNS are, consistently, more likely to occur in prosodically-strong positions than prosodically-weak positions. In contrast, V-PNS are more likely to occur in prosodically-weak positions.

In Coatzospan Mixtec, the PNS freely vary with fully-voiced stops in word-initial position, but word-medially or intervocalically, PNS show no variation (17).

(17) Mixtec

(i) /bàʔà/	→	[^{m}bàʔà] (or) [bàʔà]	'good'
(ii) /báʔù/	→	[^{m}báʔù] (or) [báʔù]	'coyote'
(iii) /tiĺígɨ́/	→	[tiĺí^{ŋ}gɨ́]	'skinny'
(iv) /ode/	→	[o^{n}de]	'up to'

Similarly, in Northern Tohoku Japanese, as shown above in (15) and repeated below, PNS appear word-medially or inter-vocalically, but never word-initially (18).

(18) Northern Tohoku Japanese (Nasukawa 2005)

(i) *hada → ha^{n}da 'skin'

(ii) *daruma → darɯma 'Dharma'

The generalization regarding V-PNS being most-likely in prosodically-weak positions is perhaps not absolute, because in Auca, (19i-ii), PNS show up (though, optionally) only in utterance-initial position, but never elsewhere. However, it is possible that there are other factors present, in Auca, that are confounding the generalization, for the word-initial voiced stops are also the locus of optional 'implosive glottal action' (19iii) (Pike & Saint 1962) – it may, in fact, be that the utterance-initial position is, counter-intuitively, a prosodically-weak position in this language. It is also possible that further phonetic work on Auca might reveal that PNS (in non-nasal contexts) are not restricted to the word-initial position.

(19) Auca (Pike & Saint 1962; Ploch 2003)

i. $^{(m)}$békã 'he drinks' ii. $^{(m)}$b̃ámõ 'whole seed'

iii. bábæ (or) ɓábæ 'wild'

3.2.3 Summary of facts about PNS

In the preceding sections (3.2.1-3.2.2), I have described the phonological and phonetic characteristics of two distinct types of partially-nasal stops. I have labeled the first of these types as Nasal-based partially nasal stops: as will become evident in section 3.4, these stops are best analysed as simple nasal stops in the (featural) phonology. I have labeled the latter of the two types of PNS, voiced-based partially nasal stops: in sections

3.3-3.4, I will argue that these segments are phonetic manifestations of what are fully-voiced stops in the (featural) phonology.

In what follows, I will briefly summarise the characteristics of the two types of PNS. N-PNS appear in inventories where they do not contrast with a phonemically-distinct simple nasal stop series; these inventories also lack a laryngeal-constrast in stops (20a). In contrast, V-PNS surface in inventories where there is a phonemically-distinct simple nasal stops series (20b).

(20) **Inventories and Surface Manifestations**

	a. Nasal-based PNS	**b. Voice-based PNS**
Stop Inventory	/p/ /m/	/p/ /b/ /m/
Phonetic Forms	[p] [^{m}b]	[p] [^{m}b] [m]

Contrary to common claims, voicing does not seem to be a relevant feature in describing the intra-dialectal and inter-dialectal variation of N-PNS (21a). In contrast, V-PNS clearly alternate with truly/fully voiced stops (21b).

(21) **Are oral stop alternants consistently voiced?**

	a. N-PNS	**b. V-PNS**
Is voicing a relevant feature?	No	Yes

N-PNS show a variation between oral stops, simple nasal stops and PNS adjacent to tauto-syllabic oral vowels (22ai), but these segments surface only as simple nasals next to tauto-syllabic nasal vowels (22aii). V-PNS on the other hand show the same variation between PNS and fully-voiced stops in both situations (22bi-ii).

(22) **Adjacent to tauto-syllabic oral/nasal vowels**

	a. N-PNS	**b. V-PNS**
Tauto-syllabic oral vowel	(i) /am/→[ab^{m}], or [ab], or [am]	(i) /ab/→[ab^{m}] , or [ab]
Tauto-syllabic nasal vowel	(ii)/ãm/→[ãm], but *[ãb^{m}],and *[ãb]	(ii)/ãb/→ [ãb] , or [ãb^{m}]

N-PNS have been observed to spread nasality in a variety of languages (23a), however, V-PNS have not been observed to spread nasality in any language (23b).

(23) **Spreading nasality**

	a. N-PNS	**b. V-PNS**
Can they spread nasality?	YES	NO

Finally, there appears to be more of a likelihood for N-PNS to appear in prosodically-strong positions (24a), while V-PNS appear to have a preference prosodically-weak positions (24b).

(24) **Prosodic strength and PNS**

	a. N-PNS	**b. V-PNS**
Where are they more likely to appear?	In prosodically-strong positions	In prosodically-weak positions

3.2.4 Are there other kinds of PNS?

The preceding subsections identified two different types of PNS, namely, N-PNS and V-PNS. There are, however, many languages with segments that could be claimed to be PNS that do not fall into either category of PNS. One might conclude that there are yet other types of PNS. However, concluding so, while not detrimental to the present results, might be premature in the face of the fact that the languages that are problematic for this dichotomy have alternative analyses that could account for the data more succinctly. I shall discuss four major cases identified in the literature: Jambi Malay, Bantu languages, Sinhalese, and Fijian.

Some Jambi Malay dialects, along with the regular N-PNS described above, have another series of partially-nasal stops[13]. Phrase-final stops in Tanjung Raden Jambi Malay[14] surface optionally as partially nasalized as shown in (25). I refer the reader to the Appendix at the end of this dissertation for a short phonological sketch of Tanjung Raden Jambi Malay.

(25) a. /sakɪt/ → [sakɪ́t] (or) [sakɪ́^{n}t] 'sick'

b. /asap/ → [ʔasáp] (or) [ʔasá^{m}p] 'smoke'

c. /ojek/ → [ʔojék] (or) [ʔojé^{ŋ}k] 'motorcycle taxi'

An important fact about these segments is that they appear to be phonologically specified for nasality as they can spread nasality when a vowel-initial suffix is added (26). In (26a-b), a root-final nasal spreads nasality to the following suffixal vowel. Similarly, the root-final oral stop spreads nasality to the following suffixal vowel (26c-d)[15].

[13] In Durvasula (2008c), I classified these as 'unnatural partially-nasal stops' because they are underlyingly oral obstruent stops that surface as partially-nasalised for no immediately apparent phonetic reason. However, as I shortly suggest these might be better classified as 'Obstruent Nasals'

[14] There is some question over whether these final stops also surface as fully nasal, as in [sakɪ́n], [ʔasám], and [ʔojéŋ]. The final oral portion is sometimes very faint, and it is unclear if it is there at all sometimes.

[15] Note, the root-final stop appears not to be resyllabified as the following onset in (26d), and the glottal stop is most probably the reflex of a more general process of glottal stop insertion in empty-onset positions in Tanjung Raden Malay. Refer to Appendix and Yanti (in prep.) for more details.

(26) a. /ayam/ → [ayá$^{(b)}$m] ‘chicken’

b. /ayam+e/ → [ayámẽ] ‘his chicken’

c. /siap/ → [siá$^{(m)}$p] ‘ready’

d. /siap+i/ → [siá$^{(m)}$pʔẽ] ‘ready APPL’ [= ‘to prepare’]

These consonants appear to have almost all the features that regular N-PNS do, as shown in (27).

(27) Features of final prenasalised oral stops in Jambi Malay

a. Like N-PNS, they appear in environments where there is no laryngeal-contrast.

b. Like N-PNS, they can spread nasality.

c. Like N-PNS, the oral portion is not voiced.

d. Like the N-PNS in Jambi Malay, they show surface variation in exactly the same place as other N-PNS in Tanjung Raden Jambi Malay.

The one characteristic of these segments that differentiates them from regular N-PNS is that they seem to surface as partially-nasalised next to both tauto-syllabic oral vowels (28a) and tauto-syllabic nasal vowels (28b).

(28) a. [sakɪ^{n}t] ‘sick’

b. [sə.ŋã́^{n}t] ‘sting’

However, it is possible that what is heard as an oral portion is because of the obstruent burst of these segments, just as in the case of regular ‘obstruent nasals’ or ‘funny nasal’ discussed in Chapter 4. If this is in fact the right analysis, and final oral stops do surface as obstruent nasals, we are in a position to explain all their properties: Their patterning with N-PNS (27) is because of the behaviour of the feature [nasal] in this position, and their final oral portion is in fact a result of the feature [obstruent].

I submit that these segments deserve better phonological and phonetic scrutiny, and what is especially needed is the measurement of intra-oral pressure in these segments[16], to see if they differ from the measurements of the regular N-PNS in the language.

Bantu languages have been claimed to have PNS by some researchers (Rosenthal 1988a; Steriade 1993 amongst others), while others have debated this characterization and have preferred to analyse them as consonant sequences (Herbert 1986; Downing 2005 amongst others). Typical examples of such segments are taken from Kikuyu where voicing is arguably contrastively present (29). These so-called unitary segments contrast with both simple nasals and voiced stops in onset positions, so cannot be either N-PNS or V-PNS, and thereby stand as another type of PNS if they can be shown to be so.

(29) PNS in Kikuyu (Armstrong 1940, cited in Rosenthal 1988)

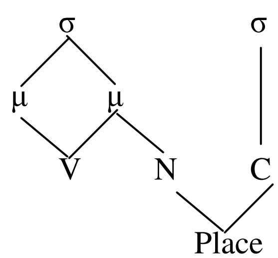
a. ^{n}demeete	'cut 1p. perf. ind.'
b. ^{ŋ}gomeete	'sleep'

However, recently, Downing (2005) has argued that the ^{N}C in Bantu languages are best analysed as a sequence of two segments. Her evidence for this (citing Herbert (1986)) is that the ^{N}C in Bantu almost never occur stem-intially, although other consonants can be

[16] I was not able to collect intra-oral pressure measurements during my fieldwork, and am therefore unable to provide the reader with the requisite data.

in this position[17]. Furthermore, most of the ^{N}C occur in intervocalic positions, and the few those that occur word-initially are all split by a morpheme boundary. In order to account for their phonological and phonetic effects, she proposes the structure in (30) – essentially arguing that the nasal part is not only a separate segment, but also that it bears a mora.

(30)



Sinhalese is another language claimed to have PNS (Rosenthal 1988a, 1988b). Sinhalese, like Kikuyu, has a contrast between truly voiced stops, simple nasal stops and apparent PNS in onset position. Again, it should be clear that the, putative, PNS cannot be accounted for under N-PNS or V-PNS. Typical examples include data in (31a-b). However based on consistent alternations between NC and ^{N}C in singulars and plurals as in (31c-d), one can conclude that, at the very least, the ^{N}C are derived from a sequence of two separate underlying segments (NC).

(31) Sinhalese NC clusters (Feinstein 1979)

a. ka^{n}du	‘hill, pl.’
b. ho^{m}bu	‘chin, pl.’
c. kandə	‘hill, sg.’
d. hombə	‘chin, sg.’

[17] She cites Hyman & Ngunga (1997) in referring to Ciyao, an eastern Bantu language, as a rare exception to this generalization.

Based on other systematic evidence from Sinhalese, Feinstein (1979), and Feinstein & Cairns (1982) argue that the difference is one of syllabification – in (31a-b), the nasal consonant and the C are both syllabified in the onset, and in (31c-d), the nasal consonant is syllabified in the preceding syllable. Based on phonetic durational evidence, Maddieson & Ladefoged (1993) argue that what is transcribed as ^{N}C (31a-b) is actually an NC cluster syllabified in the onset, while what is transcribed as NC (31c-d) is actually a geminate nasal followed by a consonant. As can be seen, the analyses, though different, agree on the surface realization of the ^{N}C as two separate segments.

A final interesting case worth observing is Fijian. Fijian has a contrast between simple voiceless stops, simple nasal stops, and, what have been called, PNS, in onset positions (Maddieson 1989; Geraghty 1983). At first sight, the claimed PNS appear to be consistent with V-PNS (as they appear in languages with a phonemically-contrasting simple nasal stop series). However, delving a little deeper into the phonetic manifestations of these segments reveals that they are not, necessarily, that straight-forwardly accounted for.

V-PNS, as will be shown later, are best accounted for as nasally-enhanced voiced stops. If this is so, then they should consistently surface as fully voiced irrespective of the presence/absence of nasality on the segments. A broadband spectrogram of the Fijian word (^{n}da^{n}da ‘soft’) taken from Maddieson (1989) shown below in Fig. 3.4 shows that while voicing is a consistent phonetic correlate of the nasal portion (A & C) of the nasalised segment, it is not a consistent feature of the oral portion (B & D) – the voicing bar is far less distinct in the portion marked ‘B’ than in the portion marked ‘D’ in Fig. 4 below.

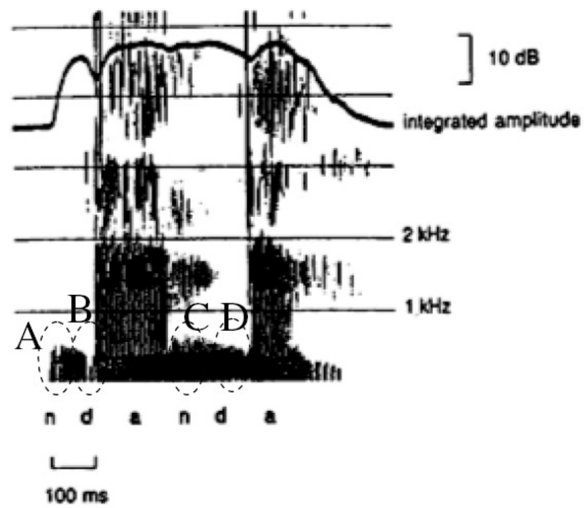


Fig. 3.4. Broadband spectrogram of the Fijian word - ^{n}da^{n}da ‘soft’ (from Maddieson (1989))

It is possible that the spectrographic data shown is aberrant, as it is the only such figure available in the paper (Maddieson 1989). Therefore, more data on the variability of voicing in these PNS is needed to get a better picture of what’s really happening. However, given the possibility that the data is representative, we need to see if there are possible re-analyses.

The strongest, and only, empirical evidence in favour of a single-segment analysis of Fijian PNS is that no other consonant clusters appear in the onset position. Therefore, for the sake of theoretical simplicity, the segments have been called singleton segments. Theoretical concerns like the Sonority Sequencing Principle (SSP) (Kenstowicz 1994), which bans decreasing-sonority onsets, also motivate the analysis. However, both these arguments are tenuous, as these are arguments of simplicity, and are not data driven[18].

Another possible analysis of Fijian PNS that maintains a simple(r) phonemic analysis and explains the variable voicing phenomenon in Fig.4, is that the PNS in Fijian are NC clusters. Simple nasals followed by (voiceless) stops. The variable voicing on the stops could then be seen as variable passive voicing, after voicing is initiated by the preceding nasal segment.

In this section, I have shown that PNS come in two distinct varieties – N-PNS and V-PNS. While a few other languages have been argued to have PNS with characteristics incompatible with either N-PNS or V-PNS, these languages have re-analyses that are consistent with the available data.

3.3 Recent Analyses

PNS have been observed in many languages and have received many competing analyses. However, as was indicated in the previous sections, some characteristics of PNS (sections 3.2.1.1-3.2.1.3) have received a lot more attention than some others (sections 3.2.1.4 -3.2.2). It is with reference to the characteristics mentioned in sections (3.2.1.4-3.2.2) of irregular voicing in the oral portion of PNS and of their capacity to spread nasality, phonologically, that I argue, in the following sub-section, that previous accounts are inadequate to account for PNS.

---

[18] Furthermore, violations of the SSP are starkly evident in sC clusters in words like *spin, stamp…* in English. However, it is not clear that sC-clusters are to be analysed as singleton segments.

Recent literature on phonological theory has debated the formal account of these segments. However, the analyses can be broken down into two basic accounts. First, PNS are voiced stops that are enhanced by nasality (32a) (Iverson & Salmons 1996; van de Weijer & Hinskens 2004; Stevens & Keyser 2006 inter alia); second, PNS are just sonorant stops, and the nasality is phonologically irrelevant (32b) (Piggott 1992; Rice 1993; and in an Element Theory framework, Botma 2004).

(32) a. PNS are nasally-enhanced voiced stops

Phonological representation	Phonetic Representation
PNS	PNS
[+voice]	[+nasal] [+voice]

b. PNS are sonorant stops

Phonological representation	Phonetic Representation
PNS	PNS
[+son]	[+nasal] [+son]

Both these accounts suffer from the fundamental problem that they predict that all PNS have the same characteristics – as was shown in the previous sections, this is not true. However, it is possible that they might actually be able to account for at least one of the identified types. This is in fact the case. As will be shown below, the 'PNS are enhanced voiced-stop account' can account for the characteristics of V-PNS, but not N-PNS (section 3.3.1). On the other hand, the 'PNS are sonorant stops' account can account for neither type of PNS (section 3.3.2).

3.3.1 Against all PNS being enhanced voiced stops

According to this account, PNS are simply enhanced voiced stops. That means, PNS are segments which are voiced stops in the phonology, and are later enhanced by the feature/gesture [+nasal] for the sake of improved auditory salience of the [+voice] feature as schematised above in (28a) (Iverson & Salmons 1996; van de Weijer & Hinskens 2004; Stevens & Keyser 2006 inter alia).

One specific prediction that this analysis makes is that PNS should not show properties of nasal segments in the phonology, i.e., they can never spread nasality, phonologically. This prediction is true of V-PNS as they neither spread nasality, nor do they (necessarily) interact with tauto-syllabic nasal vowels (section 3.2.2.3). In contrast, N-PNS have been observed to spread nasality in a wide variety of languages (section 3.2.1.5), so the segments could not possibly be accounted for by this analysis.

Another prediction made by this analysis is that [+voicing] would be a consistent phonetic feature of PNS. However, it was shown for N-PNS that both inter-/intra-dialectally and synchronically (section 3.2.1.3-3.2.1.4), the variation is better captured as one between PNS and oral stops. However, V-PNS have been argued to be both consistently voiced and in alternation with truly/fully voiced stops (section 3.2.2.2). Therefore, the analysis as it stands can, again, account only for V-PNS, but not N-PNS.

Finally, with respect to the likelihood of the appearance of PNS, N-PNS have been shown to be more likely in prosodically-strong positions, while V-PNS appear to be likely in prosodically-weak positions. The analysis can possibly account for only one of these tendencies. It is a reasonable extension of the enhancement theory that enhancement of a feature for improved auditory saliency is more likely in prosodically-weak positions, as opposed to prosodically-strong positions. Again, it appears as though the analysis is capable of handling V-PNS but not N-PNS.

Overall, in this section, I have shown that the 'PNS are enhanced voiced stops' account handles the V-PNS cases in the literature very well, but consistently fails in accounting for N-PNS.

3.3.2 Against all PNS being Sonorant stops

In this section, I show that analyzing PNS as just sonorant stops in the phonology is incorrect for both N-PNS and V-PNS.

The fundamental representation claim that analyses that adhere to this viewpoint make is that PNS are representationally distinct from simple nasal stops in being just sonorant stops with their nasality being phonologically irrelevant, i.e., they are not phonologically specified for nasality, and the surface appearance of nasality is a phonetic fact (Piggott 1992; Rice 1993; Botma 2004).

This claim makes the specific prediction PNS can not spread nasality in the phonology. As was shown earlier, this is true of V-PNS (section 3.2.2.3), but not of N-PNS (section 3.2.1.5).

A second prediction a sonorant stop analysis makes is that in the absence of nasality, the relevant segments surface at least as 'voiced', but not pre-voiced (or truly/fully voiced) - as this is the preferred realization of sonorants, in the absence of counter-acting forces. As was shown earlier, voicing is not a consistent characteristic of N-PNS (section

3.2.1.3-3.2.1.4). It was also shown that V-PNS alternate with truly/fully voiced stops (section 3.2.2.2). With respect to the nature of phonetic voicing, the analysis fails in accounting for both N-PNS and V-PNS

On the issue of likelihood of appearance of PNS in different prosodic contexts, as was discussed in the previous section, it is not a stretch for the enhancement theory to say that segments in prosodically-weak positions are (more) enhanced than others as it results in better acoustic salience of those segments. Since partial-nasalisation is seen as enhancement in this analysis, it can account for the V-PNS cases, where PNS is more likely in prosodically-weak positions, but it can not account for the N-PNS cases, where PNS are more likely in prosodically-strong positions.

It is clear that the ‘PNS are sonorant stops’ analysis fails completely in accounting for the N-PNS cases.

It appears as if the analysis fares a little better with the V-PNS cases. The analysis cannot account for the nature of phonetic voicing in V-PNS, but it is able to account for other characteristics of V-PNS. Theoretical considerations make the analysis even more unconvincing for the V-PNS. As was noticed in section 3.2.2.1, V-PNS surface only in languages where there is already a phonemically-distinct series of simple nasal stops. If one were to consider the standard phonological representations of simple nasal stops and sonorant stops schematised in (33), one could see that sonorant stops (33a) are representationally simpler than simple nasal stops (33b). In fact, simple nasal stops have a superset of the features that sonorant stops do.

(33) a. Sonorant Stops

```
        X
        |
     [+son]
```

b. Simple Nasal Stops

```
          X
        /   \
   [+son]   [+nasal]
```

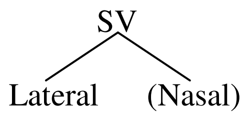
The standard representational assumption in phonology is that more complex representations imply simpler representations. However, in this case, it appears as though, the simpler sonorant stops appear only in inventories with more complex simple-nasal stops, i.e., the simpler phonological representation implies the existence of a more complex phonological representation. Therefore, the analysis of V-PNS as sonorant stops contradicts standard representational assumptions in phonology. As it stands, the 'PNS are sonorant stops' analysis accounts for neither N-PNS nor V-PNS.

In what follows, I will argue against a specific instantiation of the sonorant-stop analysis of PNS, called the Sonorant-Voicing Node (SV-node) analysis, proposed by Rice (1993), which was essentially echoed by Piggott (1992, 1996), and Botma (2004,2005)[19]. This is important as this variant of the 'PNS are sonorant stops' analysis proposes a specific representational view of nasals and the feature sonorant in general. The SV-node analysis suffers from a few more specific problems, along with those already mentioned for the general category of 'PNS are sonorant stops' analyses.

The organising node that is relevant for the SV –node of pre-occluded nasals[20] is (34).

[19] Though, Botma (2004, 2005) was in an Element-based Dependency framework.
[20] Rice (1993) calls them 'sonorant obstruents', but uses the descriptive term 'PNS' to discuss some alternations.

(34) Sonorant Voicing



(where, 'nasal' is the unmarked sonorant, hence in parentheses)

The organising node SV is claimed in Rice (1993) to be a part of the representation for all sonorants. The two content nodes under SV are 'lateral' and 'nasal'. As per her analysis, the representation (35a) always surfaces as a simple nasal, and that (35b) surfaces as a simple nasal stop, or a PNS, or a (voiced) oral stop.

(35)a. Simple Nasal Stop

```
Root
 |
 SV
 |
[nasal]
```

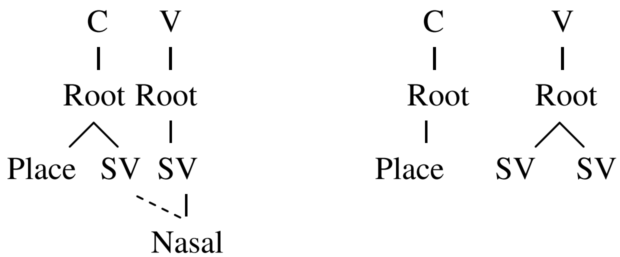
b. Simple nasal/Nasalised stop/(voiced)oral stop

```
Root
 |
 SV
```

According to the analysis, the structure in (35b) becomes a simple nasal or a PNS[21] depending on the vowel adjacent to it. In (36a), when the nasal is next to a nasal vowel, the [nasal] feature on the vowel spreads to the preceding segment and the phonetic output is a simple nasal. However, when the following vowel is an oral vowel (36b), there is no spread of the feature [nasal], and this segmental structure is claimed to surface as either a simple nasal stop, a PNS or a simple oral stop (depending on the language).

[21] In some dialects/languages she claims the same structure in (35b) can surface as a simple voiced stop.

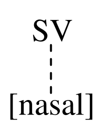
(36)a. Simple Nasal b. Partially-nasal stop



The analysis, however, faces a few problems. First, why is the phonetic variation of an empty SV node limited to simple nasal / PNS / (voiced) oral stop? The content node ‘lateral’ figures under SV, too (34). However, to my knowledge, there are no languages where some dialects have PNS, and others have laterals in place of them. The absence of such dialectal variants is surprising in the SV-node analysis.

A second problem with such an account is that Rice (1993) claims in her paper that there is a default rule (37) that inserts the feature [nasal] on to empty SV nodes. If this were the case, then it is difficult to imagine what prevents the representations of PNS in (35b, 36b) from getting the feature through default insertion, and hence surfacing as a simple nasal stop.

(37) Default Insertion



3.4 A New Analysis

In this section, I shall propose a new analysis to account for PNS. My analysis for V-PNS maintains that they are enhanced voiced stops; as I have shown in the section 3.3.1, this analysis is adequate in accounting for all the characteristics of V-PNS. Apart from a formal representation with the Dimensional Theory framework (Avery & Idsardi 2001), discussed later, I have nothing more to say about these segments.

N-PNS, however, need a new analysis, as the existing ones are incapable of accounting for their behaviour. In the section 3.4.1, I will argue that both N-PNS and simple nasals have the same phonological representations, and the different surface manifestations are because of the nature of laryngeal contrast in the syllabic position the segment appears in.

A natural starting point is the observation made in the previous sections that N-PNS appear in positions with 2-way stop contrasts. In languages like (Barasano, Kaingang, Guaraní), where N-PNS have been identified, a 2-way stop contrast exists, i.e., a laryngeal contrast is absent, in all phonological environments. The languages that are crucial for our understanding of N-PNS are those with syllabically-asymmetrical laryngeal contrast systems, i.e., languages where onsets and codas have different laryngeal contrasts – onset have a laryngeal contrast, but codas do not. Section 3.4.1 includes case studies in Jambi Malay (section 3.4.1.1), Mamaindé (section 3.4.1.2), and Mundurukú (section 3.4.1.3) that each show that N-PNS are phonologically the same as simple nasal stops, and it is the nature of laryngeal contrast that causes the phonetic output of the same phonological representation to be different.

3.4.1 Case-studies in syllabically-asymmetrical laryngeal contrast systems

3.4.1.1 Jambi Malay

In this section, I will discuss the relevant phonological data from the Tanjung Raden dialect of Jambi Malay (a Malay dialect spoken in the province of Jambi, Sumatra). I refer the reader to the Appendix at the end of this dissertation for a short phonological sketch of Tanjung Raden Jambi Malay.

Tadmor and Yanti (2005), Yanti (in prep.) list four series of phonemic stops for Jambi Malay – truly voiced stops, voiceless stops, simple nasal stop, and post-occluded nasals[22]. However, the contrast does not appear in all positions. In onset position, there is a contrast between all the different kinds of stops. Near-minimal pairs as in (38) have been taken to show their contrastive status.

(38)a. la.**b**a-la.**b**a 'spider'
    b. ba.**p**a? 'father'
    c. ka.**m**ãr 'room'
    d. ta.**M**at 'to tie' (ja**M**i 'Jambi')

In coda, or word-final, position however there is only a 2-way stop contrast between voiceless stops and N-PNS (39).

(39) a. čəpa**t** 'fast'
    b. kappa$^{(d)}$**n** 'when'

[22] Although these segments are symbolically represented as PNS in (Yanti & Tadmor 2004), they are more accurately categorized as obstruent nasals as argued in the next chapter. I shall use uppercase letters to represent these sounds.

The N-PNS in Tanjung Raden Jambi Malay like other N-PNS varies freely with nasals, and rarely with oral stops (and just as in a variety of Malayic languages as noted by Blust (1997)). The N-PNS surface when the words are in phrase-final position; otherwise, the simple-nasal stop variant surfaces. The one systematic exception to this generalization is when the word-final syllable has a nasalised vowel – in this case, simple nasals surface no matter what the phrasal context (40b). As can be seen, these segments show the characteristics that are typical of N-PNS.

(40) Word-final pre-occluded nasals.[23]

a. After oral vowels

it(t)a**$^{(b)}$m**	'black'
kappa**$^{(d)}$n**	'when'
sia**$^{(g)}$ŋ**	'early morning'

b. Adjacent to nasal(ized) vowels

minũ**m**	'drink'
dəŋã**n**	'and'
bərənã**ŋ**	'swim'

Another relevant fact has to do with nasal-spreading. In Jambi Malay, nasality spreads from a nasal onset to a following vowel (41) - this has been called 'onset-driven nasal harmony' for other Malay dialects by Blust (1997).

(41) Nasal spreading / Onset-driven harmony

lamõ	'a very long time'
binĩ	'wife'
pəlaŋĩ	'rainbow'

[23] Tadmor and Yanti (2005) argue that pre-occlusion with these nasal sounds is 'word-final' only in citation form, and is actually phrase final. See note 24 for more on this possibility.

The PNS appear only where there is no laryngeal contrast in the stops, similar to N-PNS (section 3.2.1.1). However, it is to be noted that the absence of a laryngeal contrast is not within the entire phonological system, it is local to the coda-position or the word-final environment, i.e., while the onset has laryngeal contrast in the language, the coda or the word-final position does not.

The important alternation appears when a vowel-initial suffix is added to words with final N-PNS (38). The N-PNS re-syllabifies as the onset of the following syllable and behaves like a simple-nasal stop. It surfaces as a simple nasal and it spreads nasality to the following vowel as all onset nasals do (42b) (from my field-work, and Yanti (in prep.)).

(42) a. ayam → a.ya$^{(b)}$m ‘chicken’
b. ayam-e → a.ya.mẽ ‘his chicken’

The relevant generalization appears to be that the same segment surfaces as an N-PNS in coda-positions, but behaves like a regular simple-nasal stop in onset positions.

3.3.1.2 Mamaindé

Mamaindé is a northern Nambiquara language spoken along the northwestern border of Mato Grosso state in Brazil. It is another language with N-PNS (Eberhard 2004). Like Jambi Malay, Mamaindé has a laryngeal-contrast in stops in the onset position, but no laryngeal contrast in stops in the coda position[24] (data from Eberhard (2004)).

[24] This was not explicitly mentioned/acknowledged in Eberhard (2004), but he (Eberhard) has confirmed this fact via email to the author, Karthik Durvasula.

(43)a. Onset Position

i. ha:.**na?**.wa 'I wiggle'

ii. ja.**da:**.nã.ni 'the deer'

iii. ha^{d}n.la.**t^{h}a**.wa 'It wiggles'

b. Coda Position

i. naik+tu ––> naik.tu[25] 'a root'

ii. sin + tu ––> si^{g}ŋdu 'a meat'

In the onset position, there is a contrast between voiceless aspirated stops, voiceless/voiced unaspirated stops, and simple nasals (43a). In the coda, there is a contrast only between, voiced/voiceless unaspirated stop and a nasal (43b). It is exactly in the coda where there is no laryngeal contrast that PNS appear. This again suggests that the absence of laryngeal contrast is crucial for the appearance of the occluded nasals (or, as claimed in the next subsection, PNS).

Furthermore, these PNS are clearly N-PNS because they show the characteristics of regular N-PNS. They are simple nasal stops when adjacent to a tautosyllabic nasal vowel as shown by (44).

(44) a. ja.lãn.du 'toucan'

b. ja.da^{d}n.du 'deer'

---

[25] From Eberhard's (2004) paper and his email, one is led to believe that voiceless unaspirated stops and voiced unaspirated stops are allophones in this language as evidenced by:

(i) [naik.tu] 'a root'

(ii) [nai.ga.ni] 'the root'

Further evidence that these PNS are really N-PNS is observed when one looks at the voicing of the oral portion of the segment. The spectrograms of these segments shown in Eberhard (2004) – especially that on pg. 5 of his paper – shows that there is no clear voicing bar during the oral portion of these segments exactly like in the case of other N-PNS (section 3.1.1.4).

The crucial alternations are those in which suffixes are added to N-PNS final morphemes. There are active alternations involving the 'nasals' wherein, the nasal surfaces as a simple nasal when it is in the onset position (45a) – where there is a laryngeal contrast (43a), and as an N-PNS when they are in the coda position (45b) – where there is no laryngeal contrast (43b).

(45)a. In the onset position

/han + á?wa/ → [ha.ná?.wa] 'It does not flop'

b. In the coda position

/han + lat^{h}awa/ → [ha^{d}n.la.t^{h}wa] 'it flops'

Mamaindé provides strong support to the observation that the absence of a laryngeal contrast is crucial for the appearance of N-PNS (as in Jambi Malay).

3.3.1.3 Mundurukú

Mundurukú is a Tupi language spoken in the Amazonian basin of Brazil (Picanço 2005). Like Jambi Malay and Mamaindé, Mundurukú has a syllabically-asymmetric laryngeal contrast system. In the onset, it has a contrast between truly voiced stops, voiceless stops and simple nasal stops (46a); and in the coda, there is 2-way stop contrast between voiceless stops and PNS (46b).

(46) Stop Contrast in Onset and Codas (Picanço 2005)
a. Onset Position
i. àpát 'alligator'
ii. kàbá 'parrot, sp.'
iii. àʃimá 'fish'

b. Coda Position
i. kíp 'louse'
ii. tírɛ̀^{b}m 's/he is wet'

The PNS in Mundurukú show the classic the oral/nasal alternation characteristic of N-PNS (47) - adjacent to tauto-syllabic oral vowels, N-PNS surface (47a), but adjacent to tauto-syllabic nasal vowels, only simple-nasal stops surface (47b) (Picanço 2005).

(47) a. Adajacent to tauto-syllabic oral vowel
i. ʤ ɛ̀pĩ́rɛ̃́m 'to put a fire out'
ii. ʤ ɛ̀kɔ̃́n 'to eat (intr.)'
iii. ì̃tàbɛ̃̆ŋ 's/he is alert'

b. Adjacent to tauto-syllabic nasal vowel
i. tírɛ̀^{b}m 's/he is wet'
ii. ì̆kó^{d}n 'to dig something'
iii. ì̆bɛ̀^{g}ŋ bɛ̀^{g}ŋ 's/he is full'

Like in Jambi Malay and Mamaindé, the N-PNS in Mundurukú can surface only when there is no laryngeal contrast in the stops, i.e., in the coda position.

3.4.1.4 Summary for syllabically-asymmetrical laryngeal contrast languages

In sections 3.4.1.1-3.4.1.3, I showed that N-PNS systematically alternate with simple nasal stops. The alternation is completely predictable from the nature of laryngeal contrast in the respective syllable position. Given this, the simplest statement one can make about N-PNS, is that they are the same as simple nasal stops in the (featural) phonology. The different surface manifestations could then be viewed as different (gestural) surface forms that are conditioned by the nature of laryngeal contrast in the respective syllabic positions.

The crucial data for this view comes form syllabically-asymmetric laryngeal contrast systems like Jambi Malay (section 3.4.1.1), Mamaindé (section 3.4.1.2), and Mundurukú (section 3.4.1.3) where one can actually observe alternations between simple nasals and N-PNS.

I recapitulate the crucial data that shows this laryngeal-contrast based conditioning from Mamaindé which has a laryngeal contrast in the onset position, but no laryngeal contrast in the coda position (section 3.4.1.2). Alternations between simple nasals and N-PNS, within the same morpheme, can be seen in (48a-b), where, the morpheme final segment ('n') appears as a PNS when it surfaces in the coda position (48a), and as a simple nasal when the segment surfaces in the onset position (48b).

(48)a. In the coda position[26]

/han + lat^{h}awa/ → [ha^{d}n.la.t^{h}wa] 'it flops'

[26] A syllable boundary is marked with a '.'

b. In the onset position

/han + á?wa/ → [ha.ná?.wa] 'It does not flop'

One could propose a rule that changes '^{d}n' to 'n' or vice-versa depending on onset/coda position for all three languages; however, such a rule is not only ad hoc, but it is also unnecessary because the alternation observed in (48) is completely predictable from the characteristics of laryngeal contrasts in the onset/coda. The facts about the laryngeal contrast can be used to derive the actual phonetic contrast between simple nasal stops and N-PNS (but in the (gestural) phonetics component, and not in the (featural) phonology.)

The position that N-PNS are representationally identical to simple nasal stops in the (featural) phonology allows us to account for their characteristic of N-PNS that was most problematic for the previous analyses these segments. The strongest evidence against the previous analyses of N-PNS was the fact that, contrary to predictions, N-PNS can spread nasality in a variety of languages as seen in Guaraní (49) (section 3.2.1.5). Given the new view that N-PNS are featurally identical to simple nasal stops, this comes as no surprise.

(49) Guaraní - Rivas 1975, Walker (1998)

/ro + ^{m}bo +γ^{w}atá/ → [r̃õ^{m}bo γ^{w}atá] 'I made you walk'

A second problematic characteristic of N-PNS that finds an explanation is that N-PNS alternate with oral stops, and not 'voiced' stops. On the view that [obstruent] is the specified feature, and that sonorants are just segments unspecified for [obstruent] (Stevens 1998; Clements & Osu 2002), simple nasal stops (and sonorants, in general) surface as voiced because their articulatory configuration facilitates voicing, and not because they are actively specified for voicing or sonorancy. So, if the nasal gesture itself is missing, there is no expectation of any necessary voicing. Whatever phonetic voicing there might be in such segments might be a result of passive voicing or the result of a phonetic rule of voicing. This would explain both the non-occurrence of consistent voicing in the oral portion of an N-PNS, and the fact that if the nasal gesture itself is missing, the segment could surface as similar to a voiceless stop, as in the Sarolangun dialect of Jambi Malay dialect discussed in section 3.2.1.3.

While the present analysis makes interesting progress in understanding N-PNS, as is clear it contributes nothing towards understanding the nasal/oral alternation (section 3.2.1.2), the likelihood of the appearance of an N-PNS in prosodically-strong positions (section 3.2.1.6), and the way in which the effect of laryngeal contrast on the surface manifestation of simple nasal stops or N-PNS is to be formally modeled.

As will be shown in the following sections, accounting for these facts involves reconceptualising the phonological feature [nasal] and our view of the phonology-phonetics interface.

3.4.2 Getting the appropriate level of abstraction

In the previous section (3.4.1), I showed that N-PNS behave exactly like simple nasals stops, and are thus most succinctly analysed as representationlly identical to simple nasal stops in the (featural) phonology. However, given the common understanding of the representation of simple nasal stops, capturing this intuition is difficult.

The usual phonological representation for simple nasal stops includes a positive specification for the feature [+nasal] – which implies that they will consistently surface as nasal (50).

(50) Traditional representation of simple nasal stops

```
      X
      |
  [+nasal]
```

However, using the same specification for N-PNS leads us to a very unappealing situation. Since N-PNS have been observed to (freely) vary with oral stops and simple nasal stops, one would now have to say that, though, the phonological specification demands the phonetic interpretation of the feature [+nasal], i.e., lowered velum, the phonetics can disregard this instruction and interpret the same representation as an oral (or [-nasal]) segments in some conditions. This goes against the basic understanding of phonological features that most phonologists share – that they are interpreted faithfully by the phonetics. Clements and Hertz (1996) make this assumption explicit in discussing the relationship between phonological and phonetic representations (51).

(51) ‘One of our central working hypotheses is that given an appropriately integrated framework for phonological and phonetic description, the optimal representations required for the expression of generalizations at both levels, phonological and phonetic, will be largely *congruent*: that is, we should find no substantial mismatch between surface-phonological representations and phonetic representations, the

latter consisting of a fuller specification of the former.' (Clements & Hertz 1996, pg. 144)

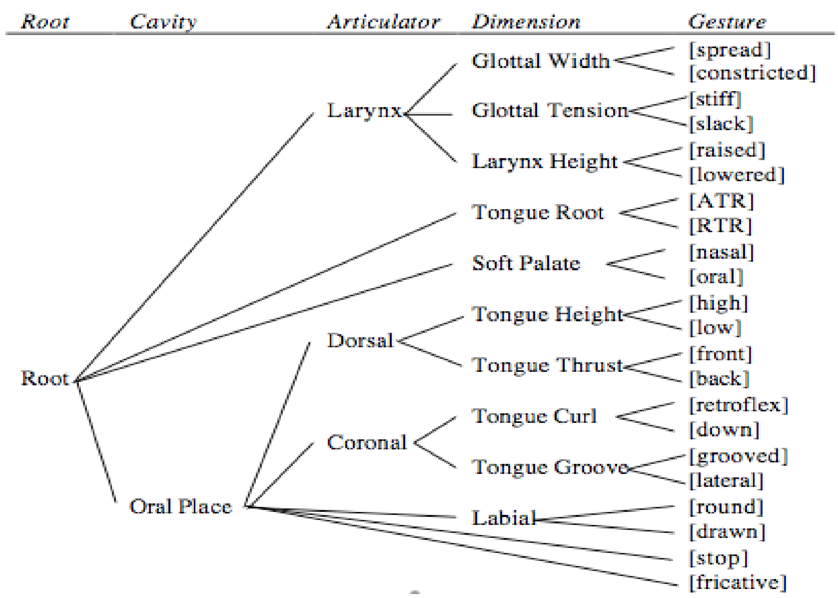
It is clear that the standard view of the phonological feature [nasal] is incapable of accounting for the phonetic patterns of N-PNS – which are for all (phonological) purposes, equivalent to simple nasal stops.

Similar considerations led Rice (1993), and Avery & Rice (1989), to conclude that the representation of nasals and of sonorants, in general, is to be accounted for with a Sonorant-Voicing Node (SV-Node) – which was an attempt at more abstract phonological representations. However, as discussed in section 3.2.2, the specific proposal falls short on many grounds.

More recently, in an attempt to account for the observable laryngeal contrasts across languages, Avery & Idsardi (2001) have argued for a specific view of phonological features – what has been labeled of 'Dimension Theory.' What is exciting about this new view of phonological features is that, as far as laryngeal contrasts are concerned, the proposal appears to have achieved 'the appropriate level of abstraction' (Avery 2006, also see Iverson & Ahn 2002; Iverson & Salmons 2003b; interalia). As will be shown below, the feature theory when extended to account for nasals allows us to maintain that phonological and phonetic representations are largely congruent (51). Furthermore, it allows us to clearly delimit the phonetic variation observable for a phonological representation.

The feature tree that Avery and Idsardi propose is as in (52) – a snapshot of the feature tree in their paper. The terminal features are all what Avery and Idsardi call *gestures* - motor instructions to the articulators. The pre-terminal nodes are called *dimensions*, which are abstract organizations/nodes that pair phonetically-antagonistic "gestures". For example, the *gestures* [constricted (vocal folds)] and [spread (vocal folds)] are articulatorily antagonistic and are, therefore, paired under the abstract *dimension* Glottal Width (GW).

(52)



(Although Avery and Idsardi (2001) propose the above feature geometry, they do so tentatively, as their paper especially focuses on laryngeal systems.)

In Avery and Idsardi's model, phonological representations are specified only to the degree that is necessary to maintain contrast within the phonological system. Furthermore, representations are either marked for a *dimension* or not – essentially, Ø/Marked. The representations in (53) exemplify their model for a system that contrasts voiceless aspirated stops and voiced stops. Another important aspect of their theory is that phonological representations are almost always[27] specified for on the phonetic *dimensions* (Glottal Width (GW) as in 49a). Finally, the *dimensions* are realized phonetically through the use of *completion* rules that supply the actual phonetic gesture that will be implemented under the *dimension* – in (53b), the *dimension* GW is *completed* with a [spread (vocal folds)] gesture.

(53) a. Phonological Representation

i. Voiceless aspirated stops

Root
|
GW

ii. "Voiced" stops

Root

b. Phonetic Implementation[28]

i. Voiceless aspirated stops

Root
|
GW
|
[spread]

According to Avery and Idsardi (2001), English voiceless stops are marked for the *dimension* 'Glottal Width' (GW), and the voiced ones are unmarked for laryngeal features (54).

(54) Laryngeal specifications of English Stops

a. Voiceless Stops

Root
|
GW

b. Voiced Stops

Root

[27] The one exception to this is in representing/marking the *head* of the segment – in this one case, the phonetic feature/gesture is also specified.

[28] In a system such as the one represented in (53), the unmarked segment is claimed to vary in it phonetic manifestation (in this case, only for the laryngeal features), and for that reason no phonetic representation is shown for the voiced stop in (53a-ii)

The marked segment is identified by its relative invariance along the *dimension* – voiceless stops are either aspirated or glottalised, both of which are gestures of the same dimension, hence they have an invariant *dimension*; however, voiced stops can surface as voiced/voiceless/partially voiceless, hence they do not appear to surface consistently with one *dimension*[29]. While voiceless stops surface with aspiration or glottalisation which are both different phonetic manifestation of the dimension 'glottal width' (GW).

Another important characteristic of their analysis is that they allow for contextual *completion* of different *dimensions*. For example, English voiceless stops are aspirated in the onset but glottalised in the coda. The GW dimension is completed with [spread glottis] in the onset and [constricted glottis] in the coda – this, they claim, depends on the phasing relationship between the dimension GW and the oral constriction.

The *dimension*/organizational node that is relevant for this paper is the Soft Palate (SP) dimension. The gestures possible under this dimension are the oral gesture (soft palate is raised) and the nasal gesture (soft palate is lowered) as in (55).

```
(55)          SP
             /  \
        [oral]  [nasal]
```

However, only SP can be specified in the phonology – the gestures are results of feature-gesture mapping (*completion*) rules (53b). And the default (unless blocked by a language specific phonetic rule) mapping for the SP node/dimension is with the gesture [nasal].

[29] Swedish appears to be the one counter-example to this. In Swedish, Helgason & Rinen (2008) argue that the putatively underspecified segments consistently surface as voiced, and the aspirated series is consistently aspirated.

What should now be obvious is that Dimension Theory based feature analysis here is more abstract than the standard featural view that is used for the feature [nasal]. As per this analysis, what surface as simple nasal stops are phonologically not marked for a positive value of nasality, per se, but are in stead represented by the SP-dimension (56).

(56) Simple Nasals (and N-PNS) [30]

    X (root node)
    |
    SP

Furthermore, it was argued in section 3.4.1, that N-PNS have the same phonological representation as simple nasals, so N-PNS have the representation in (52), too.

The representation in (56) is sufficient to account for the phonological facts of simple nasals and PNS – the ability to spread nasality. The rest of the facts (regarding their actual phonetic manifestation) are predictable from the general characteristics of laryngeal contrast in the relevant syllabic position, and need not be in the phonology at all (section 3.4.1), but can in stead be in the interface between featural phonology and gestural phonology – where features get mapped on to gestures.

Since the actual phonetic manifestation of this node varies between languages (simple nasals/PNS/oral stops), the three proposed phonetic implementations of the node are as in (57). If SP is mapped to the gesture [nasal], then simple nasals surface (57a); if it is mapped with [oral], what surface are oral stops (57b); and if it is not mapped to either

[30] These representations here and those that follow are, of course, partial representations of the segments being discussed.

gesture, what surface are reduced nasal gestures on the segments that surface as PNS (57c)[31].

(57) Phonetic implementation of the SP node

a. Simple Nasals	b. Oral stops	c. PNS
X	X	X
|	|	|
SP	SP	SP
|	|	
[nasal]	[oral]	

I formalize the generalization with the following three feature-gesture mapping principles below in (58).

(58) Rules of *feature-gesture mapping* for SP.

a. Nasal Rule 1: If there is a laryngeal contrast amongst obstruents in the consonant inventory in the relevant syllabic position, the SP node is necessarily *completed* to with the gesture [nasal]

b. Nasal Rule 2: An SP node linked to syllabic segments is always *completed* with [nasal].

c. Nasal Rule 3: An obstruent segment NOT linked to an SP node is always completed with an [oral] gesture[32].

[31] See section 5.1, for more on this mapping.

[32] It could be argued that this rule is in fact better captured by specifying obstruent segments for [-nasal] is the phonology. However, the specification is redundant as the phonetic reflex of orality is completely predictable for obstruents (if they are not specified for nasality), while the obstruency is not predictable for [-nasal] segments. Furthermore, the use of the negative operator 'NOT' in structural descriptions is not a standard practice in, at least, rule-based phonology. However, Reiss (2003) argues for a similar negative operator, in structural descriptions, to account for OCP patterns in rule-based phonology; furthermore, the NOT could be seen as an equivalent of the *-operator in Optimality Theoretic conceptions of phonology.

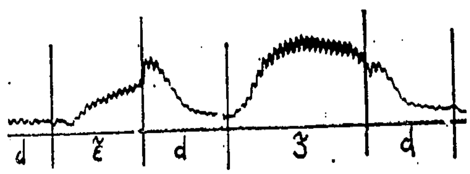
The generalization that the representations surface as simple nasals in syllabic positions with a laryngeal contrast is a universal *gestural completion rule* at the interface of featural phonology and gestural phonology (58a)[33].

A second universal *gestural completion rule* is necessary to account for two observations: first, when nasality from a simple nasal stop spreads to an adjacent vowel, the vowel is always nasal – there is no variability with respect to this. Second, in general, when an SP node is linked to a vowel, i.e., when a vowel is marked for phonological nasality, the vowel is always nasalized; again, there is no variation with respect to this. A gestural completion rule that guarantees the nasality of an SP-node linked to a vowel is needed. This is formalized in (58b).

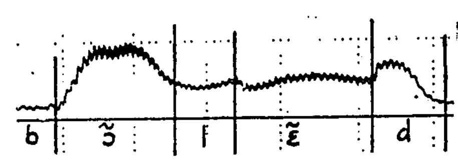
A third universal feature-*gesture mapping rule* is necessary to account for the fact that non-nasal obstruent segments *always* have an oral target (Cohn 1993). An oral gesture is achieved in a non-nasal obstruent segment, unlike with 'non-nasal' sonorants, even when it is between two nasal vowels (Cohn 1990). Cohn shows cases from French where the obstruent segment between two nasal vowels has an oral target (Fig. 3.5a). Contrastingly, a non-obstruent oral segment /l/ between two nasalized vowels (Fig. 3.5b), or an oral vowel between two nasal consonants (Fig. 3.5c) can surface with no oral target[34]. Even V-PNS which I show are best analysed as voiced stops enhanced for nasality show an oral target, and are never completely nasalized. In fact, the only cases of

[33] It might be that similar obligatory completion rules exist for larger phonological units like feet, phonological-word… Contrastingly, it might in fact be the case that the syllable has a privileged position along during feature-gesture mapping. This is an unresolved issue left for future research to answer.
[34] Cohn notes that, while the vowel in (Fig. 5c) is nasalized throughout, it does not show as much nasalization as might be expected as per analysis of phonetic interpolation. The data might suggest that the vowel is not phonologically nasalized, and the nasalization observed is of a co-articulatory nature from the adjacent nasal segments.

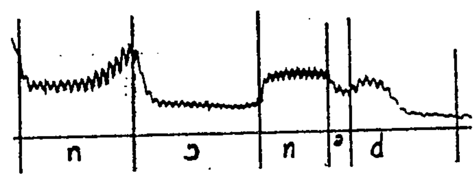
obstruents that ever surface as fully nasal are obstruents that are phonologically specified for nasality, i.e., obstruent nasals, as discussed in Chapter 4. Therefore, a *feature-gesture mapping rule* that maps an [oral] target onto ‘non-nasal’ obstruent segments is needed to account for the obligatory oral target in non-nasal obstruent segments (unlike other non-nasal segments)[35]. This is formalized in (58c), above.



(a) [dε̃dɔ̃] ‘turkey’



(b) [bɔ̃lε̃] ‘good flax’



(c) [nɔn] ‘nun’

Fig. 3.5. Nasal airflow tracings from Cohn (1990).

The phonetic rule of (58a) can be seen as a kind of enhancement (Stevens and Keyser 2006) where phonological representations are phonetically enhanced when there are more (structurally similar) contrasts. A segment with a [nasal] *completion* would be more acoustically different from voiceless stops and voiced stops that the other two manifestations of SP.

[35] This principle may afford an explanation for the surprising asymmetry observed in Sundanese (discussed in Chapter 2), wherein, an alveolar trill [r] between two nasal vowels surfaces as oral, but an alveolar lateral [l] surfaces as fully nasal. Solé (2002) argues that voiced trills and fricatives show very similar values for intra-oral pressure, so it is possible that the alveolar trill is in fact specified [+obstruent], as the per the definition of increased intra-oral pressure discussed in chapter 4; Therefore, the fact that the alveolar trill surfaces as oral could be because of its obstruency specification.

The phonetic rule in (58b) receives strong support from the nasal spread phenomena discussed before – where an N-PNS, in spite of itself being partially-nasal (i.e., an SP-node without gestural completion), spreads the SP node to an adjacent vowel, and the vowel surfaces as nasalised.[36]

The feature-gesture mapping rule in (58c) can be seen as an obligatory enhancement for the feature [obstruent], when not specified for the feature [SP]. In the absence of any [SP] specification, the feature [obstruent] is enhanced by a closed velum, as this would prevent any pressure leakage in the oral cavity behind the constriction.

In the feature-gesture mapping rules listed in (58), there is no mention of how the SP node is *completed* in the case of an absence of a laryngeal contrast. This is, clearly, the best way to analyse the situation, for under such contrast circumstances, the SP-node appears not to be forced in to any one gesture as is apparent from both the inter-dialectal and intra-dialectal variation observed in the phonetic manifestation of these segments. The surface manifestations of such stops are better modeled as languages-specific phonetic rules of *completion* to achieve one of the 3 configurations in (57).

Another characteristic of N-PNS that finds a natural explanation is the tendency that N-PNS appear to be more likely in prosodically-strong positions. As discussed in an earlier section (3.2.1.6), it seems to be a natural extension of enhancement theory to say that prosodically-weak positions need more enhancement than prosodically-strong positions - such an enhancement would also increase the auditory salience of segments

[36] This might be linked to the fact that phonemically contrasting contour nasal vowels (single segments) have not to my knowledge been recorded. *Completion* of nodes linked to vowels might be obligatory. Though it is not clear what phonetic reasons motivate this.

that are otherwise in reduced-auditory salience positions (prosodically-weak positions). If this is the case, N-PNS are more likely to surface as fully nasal in prosodically-weak positions, as this would constitute an (auditorily) enhanced version of the same phonological specification (57b-c).

A final invariant characteristic of N-PNS is the nasal/oral alternation, according to which N-PNS always surface as simple nasals next to tauto-syllabic nasal vowels (section 3.1.1.2), i.e., while there is variation in the manifestation of N-PNS adjacent to tauto-syllabic oral vowels, there is no such variation next to tauto-syllabic nasal vowels, as schematized below (59).

(59) Phonetic variation of N-PNS

a. Adjacent to tauto-syllabic oral vowel

/am/ → [ab^{m}] (or) [ab] (or) [am]

b. Adjacent to tauto-syllabic nasal vowel

/ãm/ → [ãm], but *[ãb^{m}] and *[ãb]

With the Dimension Theory framework, the phonological representations for the patterns in (60) are as shown in (58a-b). We know from *Nasal rule 2* (58b) that the vowel will surface as a nasal vowel. So the generalization about N-PNS appears to be that they are obligatorily completed with a nasal gesture adjacent to a tauto-syllabic segment that is specified for SP, and is forced to surface as a nasal segment.

(60) a. N-PNS next to a tauto-syllabic oral vowel

```
[syl V   X  ]
         |
         SP
```

b. N-PNS next to a tauto-syllabic nasal vowel

```
[syl V   X  ]
     |   |
     SP  SP
```

Within the Dimension theory framework, we could just propose a fourth *nasal rule* that captures this universal property (61). The phonetic effect of such a completion rule will be as in (62).

(61) (Possible) Nasal Rule 4: Consonants specified for SP adjacent to tautosyllabic vowels linked to an SP node are completed with the gesture [nasal].

(62) Identically specified adjacent *dimensions* within a syllable.

```
[syl X   X  ]  ------->   [syl X      X  ]
     |   |                     |      |
     SP  SP                    SP     SP
                               |      |
                          [nasal]  [nasal]
```

However, it would be preferable to derive this property through a more general property of the feature-gesture interface. It is this option that I shall pursue in the next section.

3.4.3 Deriving Nasal Rule 4 from more General Properties

Many Germanic languages (English, German, Icelandic, Swedish amongst others) have voiceless stops that are aspirated and have been argued to be specified for the feature [spread glottis], or in the Dimension Theory for a Glottal Width (GW) dimension/node

(Pétursson 1977; Lofqvist and Yoshioka 1980; Iverson & Salmons 1995; Jessen 1998; Avery & Idsardi 2001; Vaux 2002). In these languages, a well-known property of the voiceless stops in [s+stop] clusters is that they are consistently not post-aspirated (Kim 1970; Iverson & Salmons 1995; inter alia). That is, these voiceless stops (specified for GW) do not appear to have aspiration when they are preceded by an [s], which is also specified for the dimension GW (63). Furthermore, at least for English, it has clearly been shown that this generalization holds only for tauto-syllabic [s+stop] clusters (Vaux 2002, references therein).

(63) [s+stop] clusters in English, German, Swedish…

[$_{syl}$ s C …]
| |
GW GW

Some researchers have argued based on phonetic studies that such sequences have a single glottal abduction gesture that is timed to be maximum around the centre (or between the two segments) of the sequence (Kim 1970; Lofqvist and Yoshioka 1980; Browman & Goldstein 1986; Iverson & Salmons 1995; inter alia). The generalization seems to be that a single glottal abduction or spread glottis gesture completes two adjacent tauto-syllabic GW gestures (64).

(64) *Gestural completion* of [s+stop] clusters

[$_{syl}$ X X …] ———> [$_{syl}$ X X …]
| | | |
GW GW GW GW
\/
[spread glottis]

The generalization needed for voiceless stops in English, German, Iceleandic, Swedish and other Germanic languages (65).

(65) **Phonetics-phonology principle**

Only a single *gesture* completes identically specified adjacent phonological features/*dimensions* within a syllable (Durvasula 2007).

Further support for the phonetic-phonology principle developed in (65) comes from a recent photoelectroglottographic study from Tashlhiyt Berber (Ridouane, Hoole, & Fuchs 2007). Tashlhiyt Berber has gained notoriety in modern generative phonology ever since Dell & Elmedlaoui (1985) first showed that it has a variety of syllabic consonants ranging from syllabic nasals to syllabic voiceless (aspirated) stops. Tashlhiyt Berber has a contrast between 'voiced' and voiceless stops, where it is arguably the voiceless stops that are phonologically marked for the dimension [Glottal Width] (or the feature [spread glottis]) as in the Germanic languages discussed above (Ridouane, Fuchs, & Hoole 2006). Ridouane et al (2007), while studying the patterns of the glottal abduction gesture in Tashlhiyt Berber, argue that in words with only voiceless consonants (66a-b), glottal abduction peaks appear on the voiceless fricatives of the words (Fig 3.6).

(66)a. ʃtf 'crush'

b. ftχt 'she crushed'

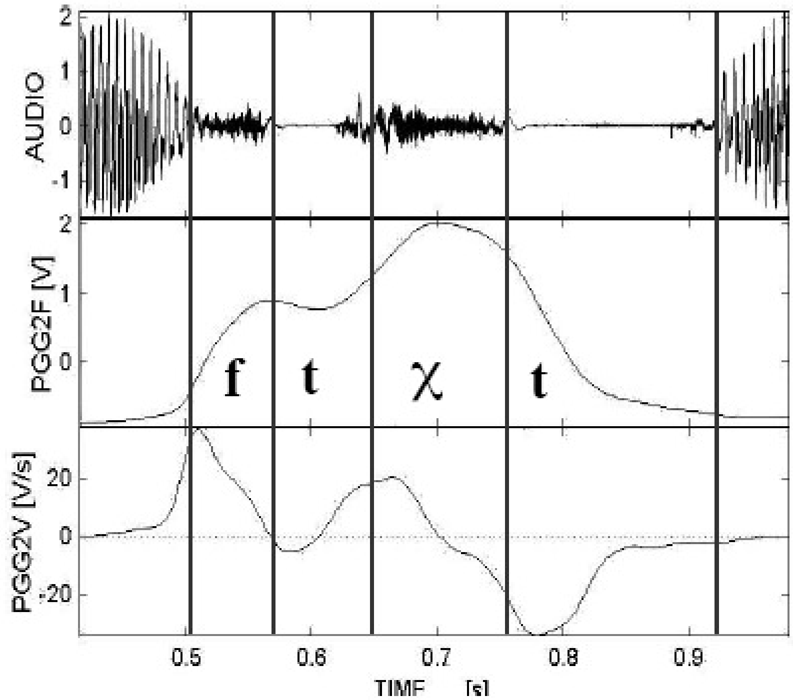


Fig. 3.6. Acoustic waveform and glottal abduction pattern for [ftχt] 'she crushed'

(Ridouane et al 2007)

As can be seen in Fig. 3.6, there is a glottal opening peak associated with each of the fricatives. They claim that this analysis accounts for the presence of glottal opening peaks in most of their data. However, their paper presents a few problematic data for their claim. In cases, where there are two adjacent fricatives, a glottal peak surfaces on only one of the fricative (typically on the first one). In Fig. 3.7, in a sequence of two fricative [ʃ] and [f], there is a glottal opening peak associated only with the first fricative [ʃ]; in fact, there is a glottal opening valley (or glottal closing gesture) associated with the phone [f].

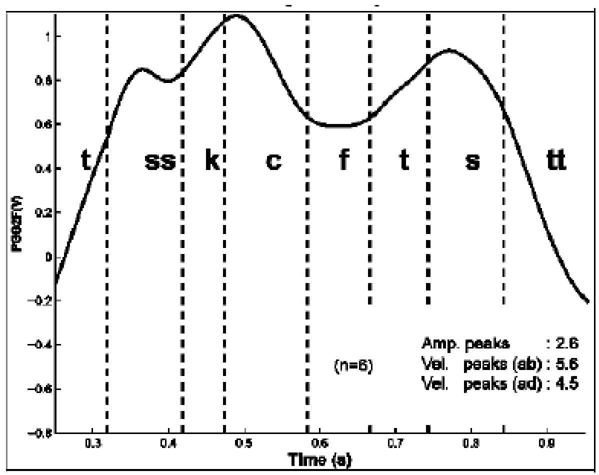


Fig. 3.7. Averaged glottal abduction pattern for [tsskʃftstt] 'you dried it'. The label 'c' stands for the alveopalatal [ʃ] (Ridouane et al 2007)

Further problematic data for their analysis is the existence of minor peaks (indicative of a separate gesture) on some of the voiceless stops in some words (Fig 3.8-3.9).

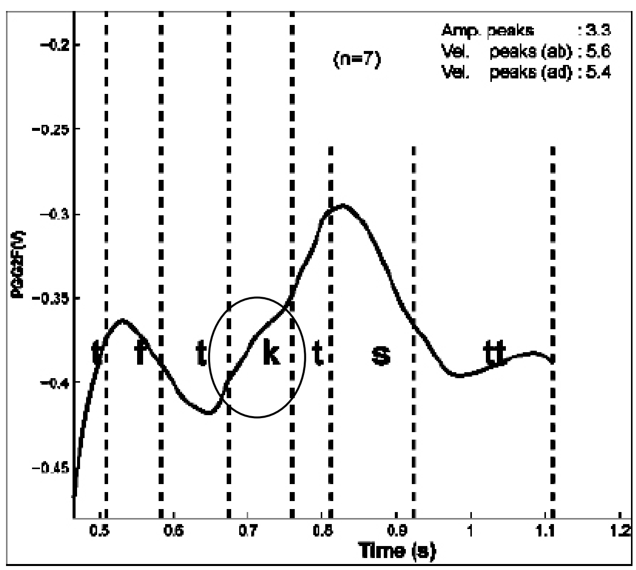


Fig. 3.8. Averaged glottal abduction pattern for the form [tftktstt] 'you gave it' (Ridouane et al 2007)

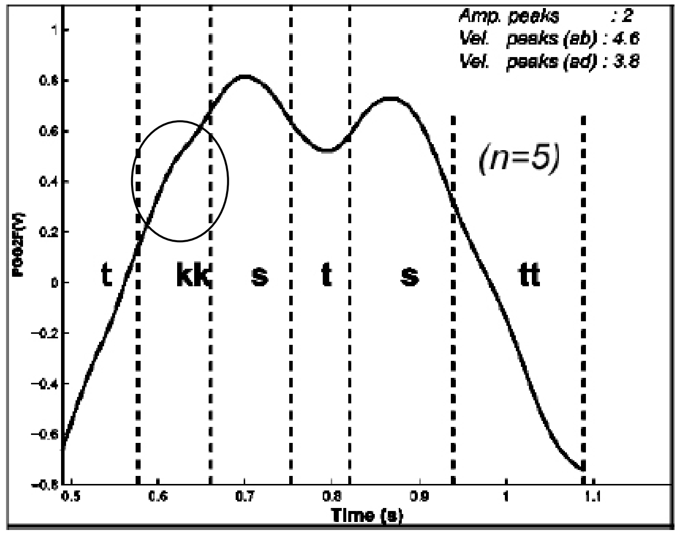


Fig. 3.9. Averaged glottal abduction pattern for the form [tkkststt] 'you took it off'.

(Ridouane et al 2007)

In Fig. 3.8-3.9, the first [k] segments in the words clearly have a minor peak that correlates with them, which is indicative of a somewhat merged, but distinct, glottal abduction/opening peak.

All the data that is presented in their paper is actually more consistent with the view that the number of glottal abductions in these words patterns with the number of syllables in the word, and not the number of voiceless fricatives as they claim. Following the standard syllabification procedure for Imdlawn Tashlhiyt Berber (Dell & Elmedlaoui 1985, Kenstowicz 1995, Dell & Elmedlaoui 2003), we arrive at the following syllabification for the words discussed till now (67) – the period marks a syllable boundary.

(67) a. ʃ.tf 'crush'

b. f.tχt 'she crushed'

c. tss.kʃf.tstt (or) tss.kʃf.ts.tt 'you dried it'

d. tf.tk.tstt (or) tf.tk.ts.tt 'you gave it'

e. tk.ks.tstt (or) tk.ks.ts.tt 'you took it off'

Through the syllable structures that are generated by the syllabification procedure, [ʃ.tf], and [f.tχt] each have two syllable - the number of syllables corresponds with the number of glottal abductions they each have (Fig. 3.6-3.7).

[tss.kʃf.ts(.)tt], [tf.tk.ts(.)tt], and [tk.ks.ts(.)tt] each have either three or four syllables, because final geminates in complex codas can optionally form their own syllable (Dell & Elmedlaoui 2003). Including the minor peaks, one can see 3 glottal abduction peaks/gestures for [tss.kʃf.ts(.)tt] and [tk.ks.ts(.)tt] (Fig. 3.7 & 3.9, respectively), and 4 glottal abduction peaks/gestures for [tf.tk.ts(.)tt] (Fig. 3.8). Again the correspondences between the putative syllables and the number of glottal abductions/gestures is perfect. The optional syllabification of the final geminates is nicely captured by one of the three final geminate stop words showing an abduction, while the others do not.

Within Dimension theory, all the segments in each of the words are modeled with a Glottal Width (GW) dimension as shown for [f.tχt] in (68).

(68)	**UR**		**Syllabification**
	/ f t χ t /	→	f . t χ t
	| | | |		| | | |
	GW GW GW GW		GW GW GW GW

As was observed, though the segments are each specified for GW, only two gestures surface for the word in (68), corresponding to the number of syllables. The phonetic-phonology principle developed in (65) explains this phenomenon as a result of the completion of all adjacent tauto-syllabic GW-specified segments by a single gesture of [spread (glottis)]. Given that all the segments in the second syllable are specified for GW, the resulting gestural form of the word should be one with only two [spread (glottis)] gestures – one for each of the syllables.

As in the case of [s+stop] sequences in the Germanic languages above, the glottal abductions of words in Tashlhiyt Berber make a strong case for the phonetics-phonology principle stated in (65).

Given the phonetics-phonology principle in (65), we can finally derive why N-PNS are invariably simple nasals adjacent to tauto-syllabic nasal vowels, thereby making nasal completion rule 4 (61) superfluous. Recall the featural/dimensional configuration N-PNS and tauto-syllabic nasal vowels are in (69a). Now, by the principle in (65), the vowel and the following segment in (69a) have to be *completed* by the same gesture; and by the *Nasal rule 2* in (58b), the SP linked to the vowel has to be completed by a [nasal] gesture. Therefore, the two principles together force a single nasal gesture to *complete* the configuration in (69a) as in (69b).

(69) a. N-PNS next to a tauto-syllabic nasal vowel

```
[syl V    X  ]
     |    |
     SP   SP
```

b. Gestural completion for two adjacent tauto-syllabic SP dimensions/nodes

$[_{syl}$ X X] → $[_{syl}$ X X]

SP SP SP SP

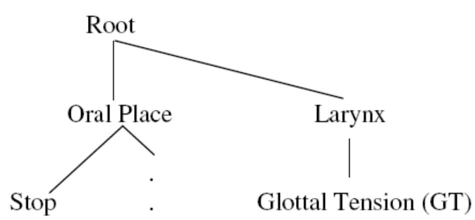
Phonetic nasal gesture[37] : 

3.4.4 Applying the Analysis

In this section, I will show the overall derivations of N-PNS and V-PNS with the account developed in the previous sub-sections.

As argued, the phonological representations of V-PNS is exactly the same as that of a fully/truly voiced stop (70), and the phonetic manifestation of these segments is mediated by the process of enhancement that introduces a nasal gesture on the voiced stops for the purpose of improved auditory salience.

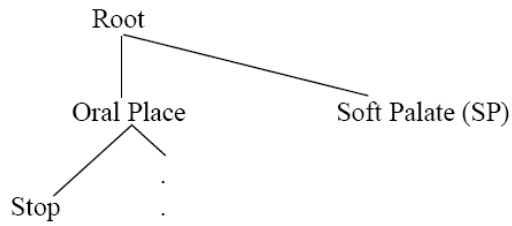
(70) Voice-based partially-nasal stop (V-PNS)



N-PNS, in contrast, have been argued to be phonologically identical to simple nasals, and their phonetic manifestation is mediated by universal feature-gesture mapping principles (71).

[37] I use '[lowered velum symbol]' to mark a lowered velum; hence an obligatory nasal target. And '[raised velum symbol]' to represent a raised velum; hence, an obligatory oral target.

(71) Nasal-based partially-nasal stop (N-PNS)

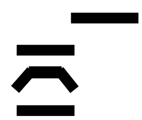
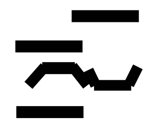
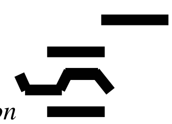
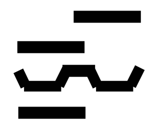


In the discussion that follows, I collapse enhancement rules with language specific phonetic rules, as the distinction / ordering between the two types of processes is not relevant to the discussion at hand.

In (72), I show the derivation for V-PNS in two situations, namely, next to a tauto-syllabic oral vowel (72a), and next to a tauto-syllabic nasal vowel (72b). Next to a tauto-syllabic oral vowel, the V-PNS is obligatorily oral because of *Nasal Rule 3*; and, the dimension Glottal Tension (GT) is completed with a [stiff glottis] specification that surfaces as pre-voicing (or full/true-voicing). However, the V-PNS is enhanced by a nasal gesture in the phonetic/enhancement component. The resulting observable phonetic surface form is [^{n}da].

Next to a tauto-syllabic nasal vowel, the V-PNS undergoes essentially the same processes. As before, there is a necessary oral portion on the V-PNS. However, the vowel is also completed by a nasal gesture as a result of *Nasal rule 2*, which forces a syllabic segment specified for the dimension SP to surface with a nasal gesture. In the enhancement/phonetics module, the V-PNS gestures are enhanced with a nasal gesture. The results observable surface form is [^{n}dã].

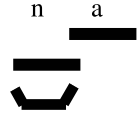
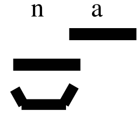
(72) Derivation of V-PNS

	a. Adjacent to tauto-syllabic oral vowel	b. Adjacent to tauto-syllabic nasal vowel
Underlying representation	d a | [GT]	d ã | | [GT] [SP]
Phonological rules	N/A	N/A
Surface Phonological Form (SR)	d a | [GT]	d ã | | [GT] [SP]
Gestural mapping	d a *V-Place* *C-Place* *Velum* *Gl. Tension* 	d ã *V-Place* *C-Place* *Velum* *Gl. Tension* 
Enhancement…	d a *V-Place* *C-Place* *Velum* *Gl. Tension* 	d ã *V-Place* *C-Place* *Velum* *Gl. Tension* 
Observable surface form	d a	^{n}dã

In the case of N-PNS, the derivations have been broken down into two special types, namely, when there is laryngeal contrast in the relevant syllabic position (73), and when there is no laryngeal contrast in the relevant syllabic position (74).

When there is a laryngeal contrast in the relevant syllabic position, there are still two distinct cases to consider: when the tauto-syllabic vowel is oral (73a); and when it is nasal (73b). When the tauto-syllabic vowel is oral, the SP dimension of the N-PNS is completed with the universal feature-gesture mapping principle *Nasal rule 1*, which forces the SP dimension to be completed by a [nasal] gesture; the vowel does not undergo any nasality specific processes, so the observable surface form is [na]. When the tauto-syllabic vowel is nasal, the SP dimensions of both the N-PNS and vowel are simultaneously completed with a [nasal] gesture by *Nasal rule 2* and the *Phonetics-phonology principle*. Therefore, the observed surface form is [nã]

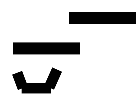
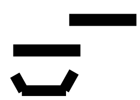
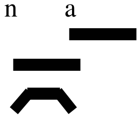
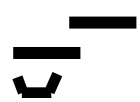
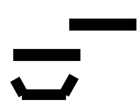
(73) Derivation of simple nasals in the presence of a laryngeal contrast in the relevant syllabic position

<table>
<tr><td></td><td>a. Adjacent to tauto-syllabic oral vowel</td><td>b. Adjacent to tauto-syllabic nasal vowel</td></tr>
<tr><td>Underlying representation</td><td>n a
|
[SP]</td><td>n ã
| |
[SP] [SP]</td></tr>
<tr><td>Phonological rules</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Surface Phonological Form (SR)</td><td>n a
|
[SP]</td><td>n ã
| |
[SP] [SP]</td></tr>
<tr><td>Gestural mapping</td><td>n a
V-Place
C-Place
Velum
</td><td>Gesture n ã
V-Place
C-Place
Velum
</td></tr>
<tr><td>Enhancement…</td><td>n a
V-Place
C-Place
Velum
</td><td>Gesture n ã
V-Place
C-Place
Velum
</td></tr>
<tr><td>Observable surface form</td><td>n a</td><td>nã</td></tr>
</table>

When there is no laryngeal contrast in the relevant syllabic position, again, there are still two distinct cases to consider. When the tauto-syllabic vowel is oral (74a), there is no specific feature-gesture mapping rule to force a specific gesture for the SP dimension. The enhancement/language specific phonetics module is free to complete the representation is any way. The vowel does not undergo any nasality specific processes, so the observable surface form varies between [na], [n^{d}a], and [da]. When the tauto-syllabic vowel is nasal, the process is identical to that in (69b). Therefore, the observed surface form is [nã]

(74) Derivation of N-PNS - no laryngeal contrast in the relevant syllabic position

<table>
<tr><td></td><td>a. Adjacent to tauto-syllabic oral vowel</td><td>b. Adjacent to tauto-syllabic nasal vowel</td></tr>
<tr><td>Underlying representation</td><td>n a
|
[SP]</td><td>n ã
| |
[SP] [SP]</td></tr>
<tr><td>Phonological rules</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Surface Phonological Form (SR)</td><td>n a
|
[SP]</td><td>n ã
| |
[SP] [SP]</td></tr>
<tr><td>Gestural mapping</td><td>n a
V-Place
C-Place
Velum

(or)
V-Place
C-Place
Velum

(or)
V-Place
C-Place
Velum
</td><td>Gesture n ã
V-Place
C-Place
Velum
</td></tr>
<tr><td>Enhancement…</td><td>n a
V-Place
C-Place
Velum

(or)
V-Place
C-Place
Velum

(or)
V-Place
C-Place
Velum
</td><td>Gesture n ã
V-Place
C-Place
Velum
</td></tr>
<tr><td>Observable surface form</td><td>na (or) nda (or) da</td><td>nã</td></tr>
</table>

3.5. Open Questions

3.5.1 Reducing the some of the nasal mapping to other phonetic facts

In section 3.4.2, I propose that if the dimension SP is mapped to the gesture [nasal], then simple nasals surface (75a); if it is mapped to [oral], what surface are oral stops (75b); and if it is not mapped to either gesture, what surface are reduced nasal gestures on the segments that surface as PNS (75c).

(75) Phonetic implementation of the SP node

a. Simple Nasals	b. Oral stops	c. PNS
X	X	X
|	|	|
SP	SP	SP
|	|	
[nasal]	[oral]	

The implementation of a bare SP as a partially-nasal stop is a stipulation I have made that does not follow directly from the Avery & Idsardi's (2001) proposal for what the possible mappings for SP could be. It is possible that there is nothing more to be said about this mapping, except this is how it is. However, it would be more in the spirit of Avery & Idsardi's proposal to derive the phonetic implementation of partial-nasalisation in N-PNS through some other mechanism other than feature-gesture mapping.

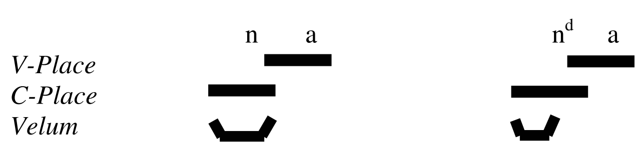
I believe an important starting point for such a reduction could be the fact that N-PNS are more likely in prosodically-strong positions. There is research that shows that phonetic gestures are 'stronger' or more extreme in prosodically-strong positions than in prosodically-weak positions (Fougeron & Keating 1997; Cho 2003 Keating 2003 inter alia). A correlate of such prosodic strengthening is that phonetic gestures are longer in prosodically-strong positions than prosodically-weak positions.

It is possible that the phonetically partially-nasal segments (in the case of N-PNS) are also completed with a nasal gesture as in (75a), thereby eliminating the need for the mapping in (75c), and what is really happening is that the other gestures in the segment (place gestures, …) are being phonetically lengthened in prosodically-strong positions, thereby causing a brief 'oral' portion. For such an phonetic event to occur, one needs to be able to show that gestures that are obligatorily completed or mapped have different strengthening/lengthening properties as compared to gestures that are non-obligatory completions/mappings.

If this is indeed the case, then in languages with a laryngeal contrast, the dimension SP is obligatorily completed with the [nasal] gesture, and lengthens just like the other consonant gestures of the segment (76a); while in languages which have N-PNS, the nasal gesture is not lengthened as compared to the other consonantal gestures, and so can surface as 'displaced' with respect to the other consonantal gestures, primarily the place gestures. Therefore, the gesture can surface as in (76a) or as in (76b) – or any position in between, as this is not a categorical distinction anymore.

(76) Gestural representations for Simple Nasals and PNS

a. Simple Nasal b. PNS



As mentioned above, for this analysis to be at least tenable, one needs to show that the other phonetic gestures in N-PNS vary more in prosodically-strong positions than in prosodically-weak positions.

3.5.2 Non-trans-derivationality

In section 3.4.2, I argued that a specific *feature-gesture mapping* principle, Nasal Rule 1 (77), is necessary to account for the effect of a laryngeal contrast in the specific syllabic position on nasal consonants.

(77) Nasal Rule 1: If there is a laryngeal contrast amongst obstruents in the consonant inventory in the relevant syllabic position, the SP node is necessarily *completed* to with the gesture [nasal].

While the feature-mapping principle presented above could be thought of as suggesting a "transderivational" account since it refers to the availability of other (laryngeal) contrast in the relevant syllabic position , I suggest at least three non-transderivational views that are consistent with the mapping principle: (a) A separately stored segment inventory list independent of the underlying representations; (b) A separately stored 'possible' segment feature-tree; (c) A feature-tree template for each segment that includes the "active" dimensions/features in the language.

Recently, a host of researchers have argued that phonological processes and the phonology-phonetics mapping is affected by the contrastive segments that are present in a language in a manner that is not directly derivable from the underlying representation of the morpheme/stem under consideration (Flemming 1995, Calabrese 1995, Halle et al 2000, Padgett 2003, Nevins & Vaux 2007 inter alia). While they argue for a need for knowledge about the possible contrasts in the language, there appears to be no direct claim for the exact nature of the representation of this knowledge. A trivial extrapolation of the research work might suggest that the knowledge of possible contrasts in a language is stored simply as a list of either contrasting segments or matrices of features of contrasting segments as in (78). If the set of contrasting segments is indeed represented in this manner, then for Nasal Rule 1 (77) to apply properly, the feature-gesture interface should have access to the information in (78).

(78) List representation of contrasting segments in a language

a. [p^h, p, t^h, t, m, n, u, a, i]

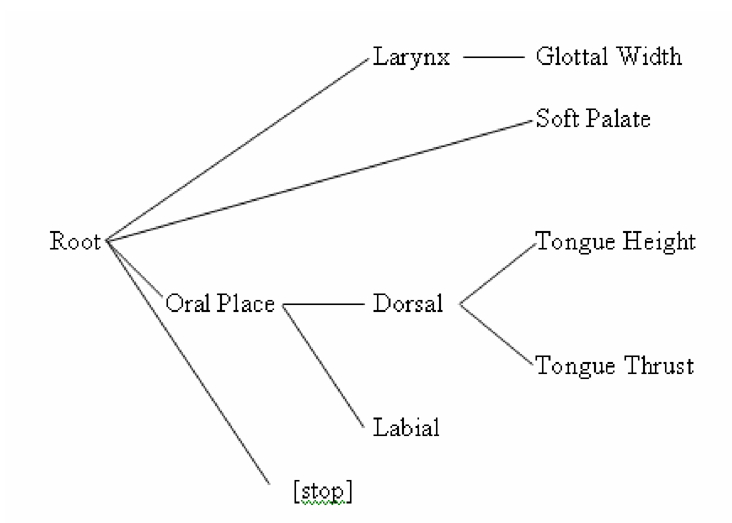
b. [[Obstruent, stop, Labial, Glottal Width],
[Obstruent, stop, Labial],
[Obstruent, stop, Glottal Width],
[Obstruent, stop],
[stop, Labial, Soft Palate],
[stop, Soft Palate],
[vocalic, Tongue Thrust, Tongue Height],
[vocalic, Tongue Thrust],
[vocalic]]

A second possible manner in which such knowledge might be represented is as a separate feature-tree that includes all the *dimensions*/features that are contrastive in a language. Therefore, if a language has the consonants listed in (79a), then the separate feature tree that encodes all the possible contrast might be as in (79b).

(79) a. List of contrasting segments in a language

[p^h, p, t^h, t, m, n, u, a, i]

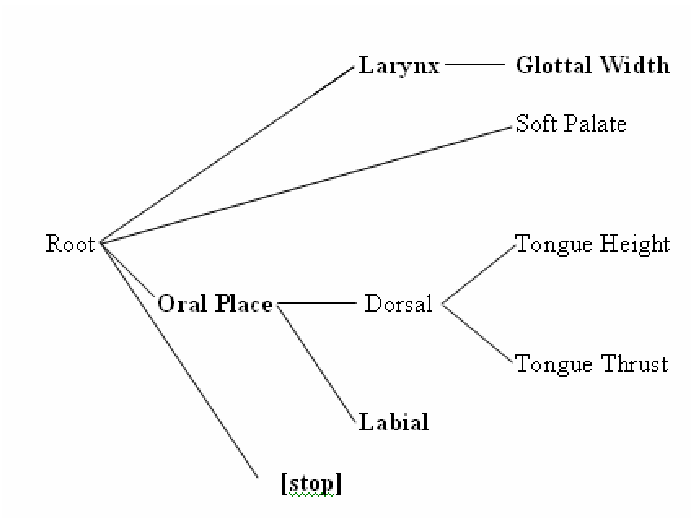
b.



A third possibility is that the feature-tree shown in (79b) forms a template for the root node of each segment in a representation, and the contrasting *dimensions*/features for each segment are "activated" from the template, as in (80) – the activated *dimensions*/features for a segment are boldfaced in (80b). Therefore, the knowledge of possible contrasts is directly available in each representation and can be used in phonological processes or phonology-phonetics mappings, without recourse to any additional information.

(80) a. /p^h/

b. Activation of contrastive features in the segmental representation [the contrastive *dimensions*/features of the segment are boldfaced]



3.5.3 Nasals in Australian Languages

As per the analysis developed in the preceding sections, a segment that is specified for the dimension SP in the phonology necessarily surfaces as a simple nasal stop in the presence of a laryngeal contrast in the relevant syllabic position, because of a universal feature-gesture mapping principle. However, in the absence of a laryngeal contrast, variation between PNS, simple stops, and oral stops is possible.

Given this analysis, it would be surprising, but not inconsistent or contradictory, to not find the expected variation in N-PNS in the absence of laryngeal contrast. Many Australian languages appear to have this property

Australian languages, typically, have consonant inventories without a laryngeal contrast in any syllabic position (81) (Butcher 2006; Harrington 2006).

(81) Typical stop contrast in Australian languages

voiceless stops	p t̪ t c ʈ k
nasals	m n n ɲ ɳ ŋ

The nasal stops in these languages always surface as simple nasals, with no observed variation. It is possible that there are other unidentified factors or universal feature-gesture mapping principles that force these segments specified for the dimension SP to surface as simple nasal stops.

Delving deeper into the phonologies of these languages reveals that the present analysis might have an answer for the situation.

Voiceless stops are regularly voiced in certain phonological positions (82). Voiced stops appear to be regularly voiced in intervocalic environments (82a & c) and post-nasal environments (82b).

(82) Voicing alternation in Australian languages

a. Warlpiri (Butcher 2006)

/waca kanpa/ → [ˈwaɟa ɰab]
'Are you going?'

b. Matjiltjara (Marsh 1969)

/kumpila/ → [kʊmbila]
'hide!'

c. Pitjantjatjara (Butcher 2006)

/ˈja:cikutun/ → [ˈja:lcɪgʊrʊn]

It is possible that the relevant syllabic positions have the necessary laryngeal contrast (created by phonological rules) for the specific feature-gesture mapping rules to force a segment specified for SP to surface as a simple nasal stop. While this rough analysis is sufficient, perhaps, for the nasal segments in onset positions (which is typically where voiceless stops are voiced), it is far from clear that it can be extended to coda positions, where voiceless stops do not even appear for many of the languages. Therefore, there appear to be other factors that force an SP-specified representation to surface as a simple nasal stop. I leave this as a topic of study for future work.

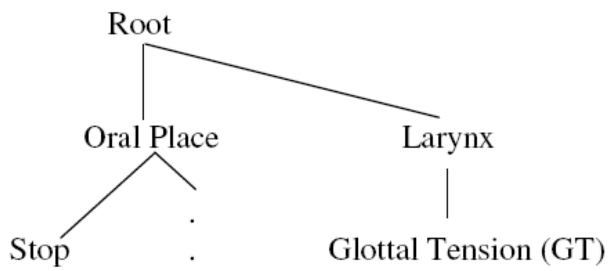
3.6 Conclusion

In this chapter, I have shown that there are at least two different kinds of partially nasal stops (PNS). Some PNS, I have argued, are derived from segments that are featurally-identical to fully-voiced stops (83a) – these PNS, I have labeled *voice-based partially nasal stops* (V-PNS). These segments surface as PNS as a result of language specific enhancement rules that boost the auditory salience of the featural representations.

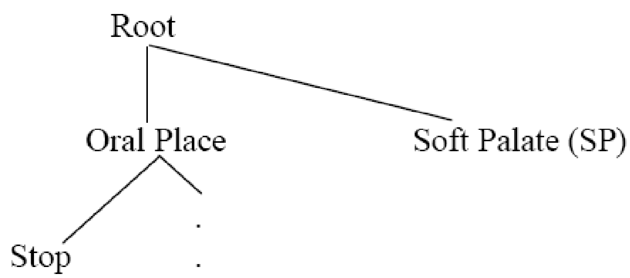
The other kind of PNS are derived from segments that are featurally-identical to simple nasal stops (83b) – these PNS, I have labeled *nasal-based partially nasal stops* (N-PNS). In an effort to account for the universal and language-specific phonetic manifestations of these segments in different environments, I have proposed a featural analysis of nasal segments within Dimension Theory (Avery & Idsardi 2001), and three universal feature-gesture mapping principles – two to do specifically with the dimension Soft Palate (SP); and the third is a general phonetics-phonology principle that mediates between featural and gestural representatiosn.

(83) Featural specification of PNS

a. V-PNS



b. N-PNS



An important point in this chapter is that the mapping of features on to gestures is crucially mediated by the knowledge of specific contrasts in relevant syllabic positions. More specifically, with respect to nasal segments, I have shown that the gestural completion of the phonological specification for nasal segments – the dimension SP – is sensitive to the nature of laryngeal contrast in the respective syllabic position.

Furthermore, I have shown that gestural mapping of featural information is sensitive to the nature of local contrast in syllabic position, i.e., featural representations in onsets are sensitive to featural contrasts in onsets, while featural representations in codas are sensitive to featural contrasts in codas.

Finally, the analysis developed in the chapter suggests that contrast (or the lack of it) need not always reflect in the (under-)specification of segments, and can instead reflect itself in how the phonetic component deals with the phonological representation.

Chapter 4

OBSTRUENT NASALS EXIST !

AND WHAT THEY SAY ABOUT NASAL HARMONY.

4. 1 Introduction

In this chapter, I shall argue that *Obstruent Nasals*, i.e., segments concurrently specified for the features [+obstruent] and the *dimension* Soft Palate (SP) ([+nasal] in traditional features), exist[1]. Specifically, I shall show that some segments that have previously been described/categorised as *pre-nasalised stops* (or) *post-stopped nasals* (or) *post-stopped nasals* (or) *post-occluded nasals* (or) *barred* nasals (or) *phonetically ingressive nasals* are most insightfully analysed as *Obstruent Nasals.* I shall argue that categorizing the relevant segments as *Obstruent Nasals* will clarify our understanding of the phonology-phonetics interface, and will, further, allow us to maintain robust phonological generalisations about true partially-nasal stops.

Furthermore, I shall show that the existence of *Obstruent Nasals* forces us to reconsider the problem of opaque generalizations in some nasal harmony processes. Specifically, the process of 'obstruent opacity' in nasal harmony patterns as schematised below in (1). There is a gap in the expected typology of nasal harmony patterns in that nasality can 'skip over' intervening obstruent segments (1a), but cannot actually result in

[1] I follow Clements and Osu (2002) in using the feature [+/-obstruent].

their total nasalization as in (1b) even if they are within the nasal harmony span. Sonorant consonants can, however, be totally nasalized if they are within the harmony domain (1c).

(1) a. ãta → ãtã

b. *ãta → ãt̃ã

c. ãra → ãr̃ã

Previous phonological analyses of this problem will be argued to be, at best, descriptions of the facts in (1a-c), with no true explanatory power to exclude the unattested pattern in (1b). The analyses appear to employ either ad hoc mechanisms that can describe the pattern but not capture the typological gap, or are based on the claim that obstruents cannot be nasalised. However, as I will show in the following sections, obstruent nasals do exist, and so analyses that depend on the position are untenable.

The gist of the solution that I shall propose is that the typological gap results from of how *features* are mapped on to *gestures*.

In Section 4.2, I will review the received position on the phonological and phonetic possibility of the features [+obstruent] and the *dimension* Soft Palate (SP) – the feature [nasal], in traditional conceptions. In Section 4.3, I will discuss phonetic and phonological data related to specific languages (Cantonese dialects, Acehnese, Jambi Malay dialects) and show that what have been previously described as *pre-nasalised stops* (also called, partially-nasal stops in this dissertation), amongst other descriptive categorizations, are in fact best analysed as *Obstruent Nasals.* In Section 4.4, I show how and why the existence of *Obstruent Nasals* leads to a reconsideration of the 'obstruent opacity' data mentioned in (1). The section will also include my proposed reanalysis of the relevant facts. Section 4.5 concludes the chapter.

4.2 Received position on obstruent nasals

The received position in regards to the phonological/phonetic co-occurrence of the features [+obstruent] and [+nasal] has been that it is impossible. In fact, the assumption has been made throughout the history of generative phonology, and it has to my knowledge never been questioned seriously.

The assumption that the phonological co-occurrence of the two features, [+obstruent] and [+nasal], is impossible is, tacitly, based on the view that the two features are phonetically incompatible. Therefore, nasal segments have almost always been viewed as *inherently* sonorant (or [-obstruent]). Such a view that nasals are inherently sonorant is pervasive in the literature on phonological/phonetic features as the sample excerpts below from notable sources demonstrate.

(2) Kenstowicz (1994: 36)

> "The stricture associated with [+sonorant] segments does not disrupt airflow enough to inhibit voicing… While nasals are articulated with an oral closure, the nasal cavity is open and hence airflow is not impeded."

(3) Stevens (1998)

> "Finally, the value attached to the feature [sonorant] specifies whether pressure builds up behind the constriction [-sonorant] …" (pg. 249)

"…for a nasal consonant the velopharyngeal port is open during the time there is a supraglottal closure, and there is no pressure increase behind the constriction." (pg. 487)

(4) Solé (2007)

"If the obstruent constriction is anterior to the velopharyngeal port (i.e., labial to uvular), a tightly sealed velum is necessary to build up intraoral pressure… velic openings which do not impair the build up of pressure for audible turbulence would be insufficient to create the percept of nasalization in the consonant."

(5) Ohala & Ohala (1993)

"The velic valve must be closed (i.e., the soft palate must be elevated) for an obstruent articulated further forward than the point where the velic valve joins the nasal cavity and the oral cavity."

For Kenstowicz (1994) as in (2), nasals are *inherently* sonorant because, like all sonorant segments, their production does not disrupt airflow sufficiently to inhibit voicing. It is to be noted, however, that it is not at all clear what the phonetic implementation of the feature [+sonorant] would involve if defined as such. The possibility of voicing is, at best, a characteristic of typical sonorants. This characteristic is neither necessary nor sufficient for the characterization of sonorants cross-linguistically as evidenced by the existence of voiceless sonorants (more precisely, aspirated sonorants) in a variety of languages across the world; in Comaltepec Chinantec, voiceless nasals in coda position are completely voiceless - Silverman (1996) notes that 'we witness the full simultaneity of all gestures, oral stop, velic lowering, and glottal spreading, with no voicing whatsoever.' (Silverman 1996, pg. 5)

For Stevens (1998), Solé (2007), and Ohala & Ohala (1993) as in (3), (4) and (5), respectively, the feature [sonorant]/[obstruent] is defined in terms of pressure behind the constriction in the oral cavity – [-sonorant]/[+obstruents] have an intra-oral pressure build-up. Nasals are seen to be *inherently* sonorant based on the assumption that their production would preclude a speaker from producing sufficient oral pressure for obstruent production.

A diagrammatic representation of the standard understanding of obstruents is shown in (Fig. 4.1). The velo-pharyngeal port (velic opening) is closed or nearly closed in the case of a [+obstruent]/[-sonorant] sound. A failure to reach this articulatory position would entail the failure of the manifestation of the feature [+obstruent]/[-sonorant].

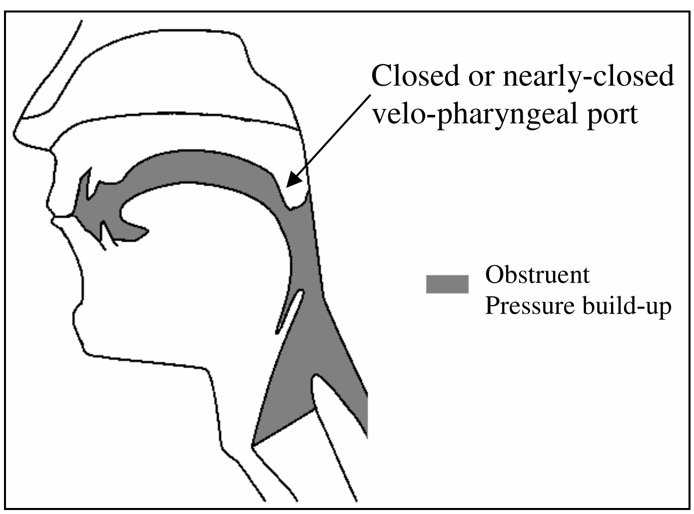


Fig. 4.1. Condition for obstruent pressure build-up

However, the claim that Stevens (1998) Solé (2007), and Ohala & Ohala (1993) make crucially relies on the assumption that sufficient oral pressure build-up is not possible with ‘some’ velic opening. The notion of ‘sufficient oral pressure build-up’ is also not well-defined by them.

Warren, Dalston and Mayo (1993) suggest that, while “normal subjects invariably achieve closure of less than 0.03 cm^2 during nonnasal consonant production,” the velopharyngeal port can be open upto, at least, 0.1 cm^2 for sufficient intra-oral pressure build-up[1]. Between 0.1 cm^2 and 0.4 cm^2, there is still some pressure build-up, but it is not as much as for openings smaller than 0.1 cm^2. A typical nasal consonant has a velopharygeal opening of 0.5 cm^2 – 1.0 cm^2. (Kuehn 1976; Lubker 1968; Warren & Dubois 1964; as cited in, Warren, Dalston and Mayo 1993).

This means that there is sufficient lee-way for there to be some, possibly substantial amount of velopharyngeal opening with concurrent intra-oral pressure build-up. Given this, it is easily possible to imagine a phonetic scenario where the value of the ‘sufficient oral pressure build-up’ is achieved despite some (but, significant) velic opening. The diagrammatic representation below (Fig. 4.2) clarifies the possibility. While obstruents and simple nasals stops are said to involve ‘sufficient closure’ and ‘sufficient opening’, respectively, of the velo-pharyngeal port, there is no fact in their discussion that precludes the possibility of *obstruent nasals* that satisfy the criteria of ‘sufficient closure’ (for [+obstruent]/[-sonorant]) and ‘sufficient opening’ (for [+nasal]) of the velo-

[1] However, the figure of 0.1 cm^2 was gathered from cleft-palate speakers. The researchers extend these results to normal speakers, but it is important to remember that there might some variation between these results and those from normal speakers.

pharyngeal port *simultaneously*. It is exactly this possibility that is pursued in this chapter. However, I provide only indirect, acoustic and aerodynamic, data to argue for this, and there is a need for direct articulatory measurements (via ultrasound, fMRI, nasograph … techniques)

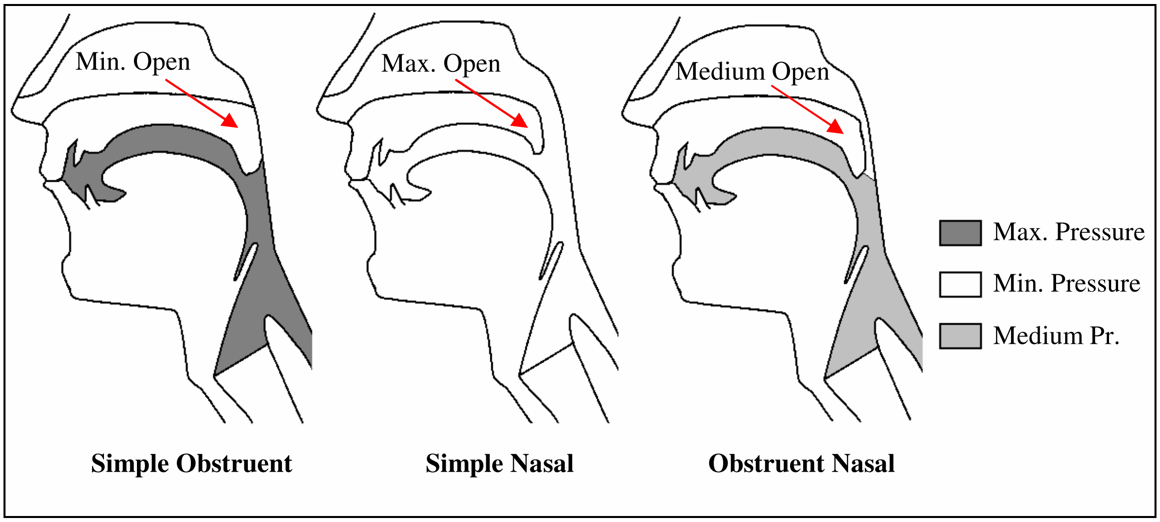


Fig. 4.2. Simple obstruents, Simple nasals, Obstruent nasal

4.3 Post-stopped nasals are *obstruent nasals*

In this section, I shall put forward and defend the claim that some segments that have been called pre-nasalised stops (or) post-stopped nasals (or) funny nasals (or) post-occluded nasals amongst others are better analysed featurally as *Obstruent Nasals.*

Post-stopped nasals, despite having observably different phonetic manifestations from regular pre-nasalised stops, have been argued to be phonologically identical to pre-nasalised stops[2] in other languages as the two types of segments never contrast in any

[2] Partially-nasal stops in this dissertation

language (Maddieson & Ladefoged 1993; Botma 2004).

I shall argue, below, that this view is problematic for at least two independent reasons, and should, therefore, be abandoned. First, it does not explain why post-stopped nasals have consistently different phonetic manifestations from true partially-nasal stops. As will be shown below, some of the phonetic characteristics of post-stopped nasals are surprising if one were to espouse the position that they are no different from true partially-nasal stops. Therefore, the claim leads to a loss of clarity about the nature of the phonology-phonetics interface since the mapping of the same set of phonological features can lead to substantially different phonetic manifestations. Second, we lose phonological generalizations about where (and in what kind of inventories) true partially-nasal stops occur. As was argued in the previous chapter, surface partially-nasal stops can result from two phonologically distinct sources: simple nasals, and voiced stops. However, post-stopped nasals appear in languages that have contrasting sets of voiced stops and simple nasals, therefore they fall into neither category of partially-nasal stops.

The following few sub-sections (4.3.1-4.3.3) will discuss case-studies of languages that have been claimed to have pre-stopped nasals. The case-studies presented will include Acehnese, some Chinese languages/dialects, and Jambi Malay dialects. It will be argued that the pre-stopped nasals in these languages show remarkably similar phonetic manifestations, and are indeed correctly identified as the same phonological entity. The results of the case-studies show that segments argued to be post-stopped nasals share the following phonetic properties when compared with simple nasal stops and partially nasal stops:

(6) Phonetic properties of post-stopped nasals

a. Substantial oral pressure during the nasal murmur.

b. A relatively weak nasal murmur.

c. A strong observable release burst unlike with PNS or simple nasals.

d. No clearly observable "oral" portion unlike with PNS.

The discussion of post-stopped nasals also reveals that post-stopped nasals could not be the same as true partially nasal stops, phonologically. Classifying post-stopped nasals as partially-nasal stops goes against otherwise robust phonological generalizations about partially-nasal stops with respect to inventory and phonetic enhancement effects. Typical partially-nasal stops in surface phonological/phonetic inventories of languages are either phonetic manifestations of simple nasals in 2-way stop contrast inventories (Durvasula 2007) or enhanced versions of voiced stops (Iverson & Salmons 1996). However, in Acehnese (section 4.3.2) Jambi Malay (section 4.3.3), these generalisations do not hold for the *post-stopped nasals* as they contrast with voiced stops and simple nasals in onsets – sections 4.3.2 & 4.3.3.

The discussion of the phonetics and phonology of these segments in different languages prompts us to reclassify these segments as different phonological entities from true partially nasal stops. I show how reclassifying post-stopped nasals as *obstruent nasals* allows us a clearer picture of the phonology-phonetics interface, and lets us maintain the generalizations regarding contrast and phonetic enhancements.

Finally, it is to be noted that the case-studies highlight the fact that post-stopped nasals are phonologically and phonetically distinct from other partially-nasal stops, but are not necessarily from the same phonemic source in all the languages studied. What is instead argued for is that, post-stopped nasals could have multiple phonemic/underlying representational sources, but they all 'leave the phonology' with the same feature specification, that of [+obstruent] and [SP] (or in more traditional terms, [-sonorant] and [+nasal]).[3]

4.3.1 Case Study 1: Chinese Languages/Dialects – Chan & Ren (1987), Hu (2007)

Chan & Ren (1987) examine the acoustic properties of syllable initial nasal consonants, which are called *post-stopped nasals,* in Zhongshan and Kaiping, two varieties of Cantonese. Diachronically, these post-stopped nasals are reflexes of "simple nasals" (Hu 2007).

Based on auditory impressions, these segments are typically transcribed as nasal segments with an oral stop superscript as in (7), to represent the claim that they have relatively weak or short non-nasal stop portion.

(7)a. m^{b}a 'mother'

b. ŋ^{g}y 'fish'

They appear in onsets, where there is a 3-way stop contrast between unaspirated stops, aspirated stops and the nasal series.

---

[3] Bill Idsardi suggests the possibility of using the feature [stop] instead of [obstruent] to get the same phonetic effect. While this is possible, there are cases of the use of the feature [stop] to indicate just closure (with no concomitant increase in intra-oral pressure). The resistance displayed by regular oral stops after nasal consonant towards lenition (as compared to stops after other sonorants) has typically been analysed as the effect of the [stop] feature on simple nasal stops. Given, that regular nasal consonants do not usually surface with such a cluster of properties as post-occluded nasals, it might be unlikely that the feature [stop] could be used in place of [obstruents] to derive these effects in post-stopped nasals.

(8) Onset contrast in Zhong-sang (Chan 1980)

unaspirated voiceless stop	-	p
aspirated voiceless stop	-	p^h
nasal stop	-	m^b

However, in their study, Chan & Ren (1987) observe that the nasal segments, in Zhongshan, do not have a (oral) closure duration preceding the burst. What is perceived as an oral stop portion of the segments is actually a strong burst. They further observe that these segments also have a 'weak' nasal murmur.

Hu (2007), in an aerodynamic and acoustic study of post-stopped nasals in Shanxi, Cantonese and Hakka, makes similar observations. These stops are 'characterized by a strong burst, and an abrupt energy drop during consonant release.' The post-stopped nasals do not have a transition from a nasal to an oral postion. Furthermore, he observes that there is an intra-oral pressure build up in these segments.

The three characteristic traits of these segments that emerge are those in (9).

(9)a. They have a strong burst release, and no 'oral' portion.

b. They have a reduced or weak nasal murmur.

c. They have intra-oral pressure build-up

Chan & Ren (1987) in a comparison with pre-nasalised stops in Malagasy show that none of these characteristics is true of the segments in Malagasy.

4.3.2 Acehnese – Durie (1985), Ladefoged and Maddieson (1996)

Durie (1985) observes similar post-stopped nasals in Acehnese. The post-stopped nasals in Acehnese are diachronic reflexes of simple nasal – voiced stops sequences ($N+C_{[+voiced]}$). These segments appear in onset position, where they contrast with 3 other kinds of stops. The contrast in onset positions is, thus, a 4-way stop contrast (10).

(10) Stop contrast in Acehnese (in onset position)

a. voiceless unaspirated - p

b. fully voiced - b

c. simple nasal stop - m

d. post-stopped nasal - M (m^b)

Ladefoged and Maddieson (1996), from Durie (1985), provide sample aerodynamic records of the simple and post-occluded nasals in Achenese. What is notable about post-stopped nasals in the description in the above sources, and the sample aerodynamic records is that there is no clearly 'oral' portion in these segments. Furthermore, throughout, there is a consistently smaller nasal murmur in the nasal portion of the post-occluded nasal (Fig. 4.4) than in the nasal portion of the simple nasal (Fig. 4.3). Finally, there is an observable intra-oral pressure throughout the manifestation of the post-occluded nasal (Fig. 4.4). While there is no discussion of the quality of the release burst, it is possible to imagine that there is a noticeable one because of the sustained intra-oral pressure in post-stopped nasals. Simple Nasals (Fig. 4.3) and Post-stopped Nasals (Fig. 4.4) in Acehnese

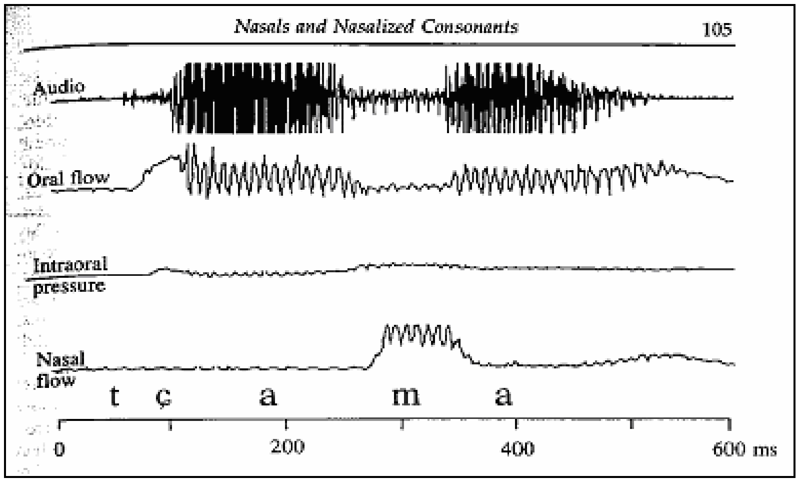


Fig. 4.3. Simple Nasal (tɕama 'sea-mew')

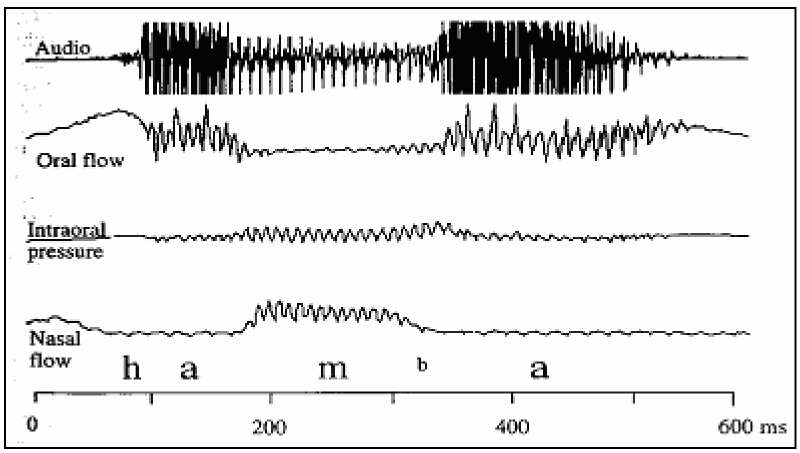


Fig. 4.4. Post-stoped Nasal (ham^ba 'servant')

The three characteristics that emerge again for post-stopped nasals, paralleling the observations for post-stopped nasals in Chinese dialects, are in (11)

(11) a. Reduced nasal murmur throughout the segment.

b. No clear 'oral' portion in these segments.

c. Increased intra-oral pressure during closure – strong release burst could be inferred.

Durie (1985) analyses these segments as phonemically simple nasal segments next to oral vowels (12a), because these segments always surface adjacent to an oral vowel; while he analyses the simple nasals as phonemically simple nasals next to nasal vowels as in (12b), as they always surface next to nasal vowels. He argues that this analysis is able to maintain a symmetry between nasal and non-nasal vowels following other consonants (12 c-d). The other fact that appears to point to the same conclusion is the fact that vowel nasalization is contrastive only in stressed syllables, and it is exactly in the onsets of these syllables that you find 'post-stopped nasals', thereby, further supporting the connection between vowel nasality and post-stopped nasals.

(12) a. /ma/ → [m^ba]
b. /mã/ → [mã]
c. /ba/ → [ba]
d. /bã/ → [bã]

However, native speaker linguists disagree with this analysis as they are more keen on placing the contrast between simple nasals and post-stopped nasals on the consonants themselves (13), as opposed to the following vowels (Asyik 1972; Sulaiman 1977 – as quoted in Stokhof 1992); and the nasality of the vowel following simple nasals as non-contrastive (13b).

(13) a. /m^ba/ → [m^ba]
b. /mã/ → [ma]

Furthermore, Durie (1985) himself acknowledge that his native informants have the following intuitions about the segments.

(14) Native speaker intuitions in Acehnese - Durie (1985, pg. 23)

a. 'Nasal vowels after nasal consonants are not thought of as marked for nasality.'

b. 'Their nasality is thought of as being conditioned by the preceding consonant.'

c. 'Funny nasals" .... are felt to be in contrast with the shorter, "plain" nasals.'

d. '[T]he contrast between [má] ([mã], K.D.) and [ma] ([m^{b}a], K.D.) is felt to be in the consonant rather than in the vowel, and it is the second combination which is felt to be the specially marked one.

While either phonemic analysis is possible, it is clear that one has to say something more about the surface representation (than just call them simple nasals) to capture the phonetic facts presented above in (11).

4.3.3 Jambi Malay – Yanti & Tadmor (2004), my field work

In field work on Jambi Malay dialects, Yanti & Tadmor (2004) have found some dialects with 'post-stopped nasals'. These segments, like in Acehnese, are diachronic reflexes of simple nasals-voiced stop sequences $NC_{[+voiced]}$. Yanti & Tadmor transcribe these segments as simple nasal with superscripted oral stops (15) – thereby implying that these segments have an oral stop portion. However, this could be a mistranscription, as these segments have phonetic characteristics that are very similar to those of the post-stopped nasals discussed in the preceding subsections. As in Acehnese, these segments appear in a 4-way stop contrast in this position (15).

(15) la**b**a-la**b**a 'spider'

ba**p**a? 'father'

ka**m**ãr 'room'

ta**m**^**b**^at 'to tie' **(taMat)** - post-stopped nasal

As I show in what follows, more recent field work by me shows that these segments are unlike typical partially-nasal stops in other languages, and are more like the post-stopped nasals found in the Chinese dialects/languages and Acehnese described in the preceding sub-sections. Unlike the partially-nasal stops described in the previous chapter, these nasal segments do not have an observable oral release as can be seen in the nasometer recordings and spectrograph shown below[4] (The post-stopped nasal is circled in Fig. 4.5).

[4] The waveform and spectrogram were created using Praat (Boersma and Weenink 2003)

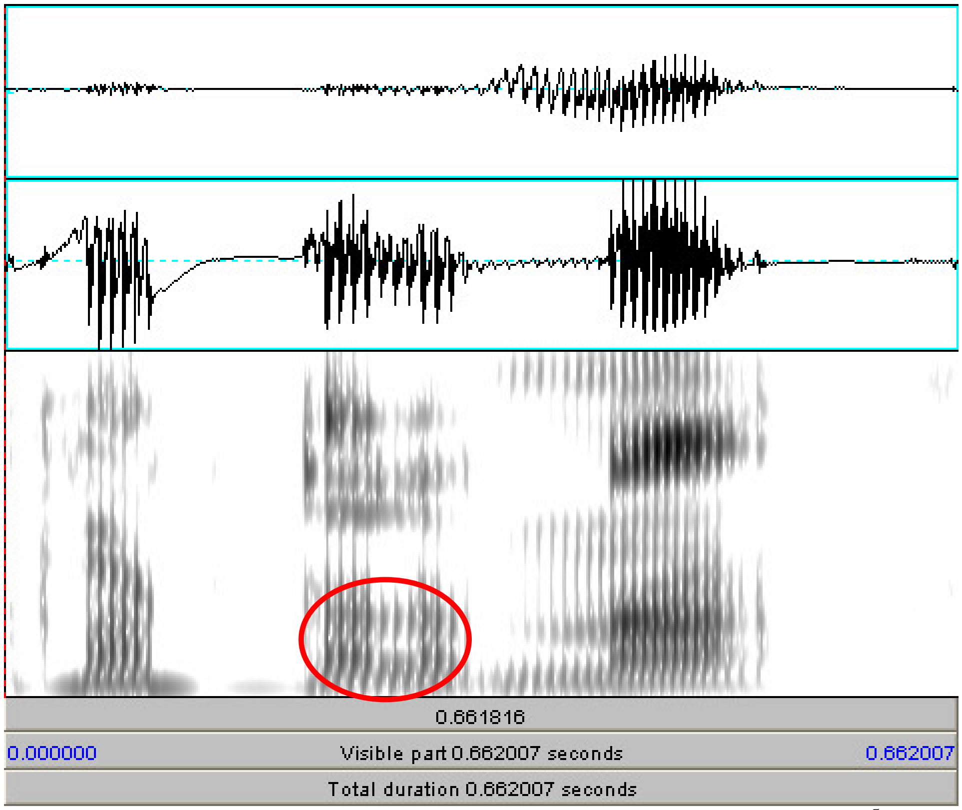


Fig. 4.5. Post-stopped nasals in Jambi Malay [ləMap] 'damp'[5]

Furthermore, these segments appear to have weaker nasal murmurs that regular simple nasals in the same position.

It is clear form the above descriptions, that the post-stopped nasals in Jambi Malay share their phonetic characteristics with those in the Chinese language/dialects and Acehnese.

Unlike in Acehnese, it is difficult to maintain that the post-stopped nasals are phonetic reflexes of phonemic simple nasals next to oral vowels, and simple nasals are phonetic reflexes of phonemic simple nasals next to nasal vowels - nasalization on vowels is largely allophonic, as a result of a nasal harmony rule from simple nasals, and the few

[5] The topmost waveform in the figure is the pressure wave recording through the nose, and the lower waveform is the oral pressure waveform recording.

phonemically nasal vowels are relegated to loan-word borrowings. However, even in Tanjung Raden Jambi Malay, post-stopped nasals could have two different accounts. First, they could be surface forms for phonemic $NC_{[+voiced]}$ sequences (16a). Second, they could be underlyingly specified for post-occlusion (16b).

(16) a. /mba/ → [m^ba]

b. /m^ba/ → [m^ba]

The first analysis (16a) gains support from the fact that there are active morpho-phonological alternations that show this connection. In (17a), the agentive nasal prefix attaches to the verb stem and then nasalizes it. In (17b), the same nasal prefix, causes the initial voiced stop of the stem to change into a post-stopped nasal.

(17) a. /ŋ + aŋkʊt/ [ŋãŋkʊ́^{n}t] 'ACT-transport' (='to transport')

b. /ŋ + buat/ [m^buá^{n}t] 'ACT-make (='to make')

It is possible that the nasal prefix in (17b) first attaches to the stem, and then causes (perhaps) the coalescence with the following voiced stop to surface as a post-stopped nasal as in (18). If the nasal harmony rule is ordered before the coalescence, such an analysis would be able to explain why there is nasal harmony in (17a), but not in (17b), as nasal harmony is Tanjung Raden Jambi Malay is blocked by all obstruents (amongst other consonants).

(18) /ŋ + buat/ → /ŋbuat/ → /mbuat/ → /m^buat/

The other possible analysis of post-stopped nasals is that they are underlyingly present as such (16b). This accords well with native speaker intuitions, as native speakers clearly identify the post-stopped consonant as one consonant (contrasting with the simple nasals in the same position) and are typically unhappy with representing them as $NC_{[+voiced]}$ sequences, even though the standard orthography represents them as clusters. Of course, even if we were to say that post-stopped nasals in mono-morphemic words are underlyingly present, it is still possible to maintain the analysis in (18) for those derived from nasal prefixation.

As in the Acehnese case, whatever is the analysis one proposes for the underlying representations of post-stopped nasals, one cannot maintain a simple nasal stop representation for them at the surface phonological level given their phonetic characteristics.

4.3.4 Reclassification: Post-stopped nasals are Obstruent nasals

The case-studies in the previous subsections reveal that post-stopped nasals have the following phonetic properties:

(19) Phonetic properties of post-stopped nasals

a. Intra-oral pressure during the nasal murmur.

b. A relatively weak nasal murmur.

c. A strong observable release burst (unlike with PNS or simple nasals).

d. No clearly observable "oral" portion (unlike with PNS).

Reclassifying post-stopped nasals as *obstruent nasals*, i.e., [+obstruent, SP], accounts for all of their phonetic characteristics. Following Stevens (1998), Clements and Osu (2002), I assume that the feature [+obstruent] is marked by an increase in oral pressure behind the constriction of a consonant. If this is so, then the increased oral pressure and decreased nasal murmur in post-stopped nasals can be seen as a trade-off between the usual manifestation of [+obstruent] and the gesture [nasal] (the manifestation of SP). Furthermore, a strong release burst is now expected because of the oral-pressure build-up behind the constriction. Finally, there is no expectation (or need) of an "oral" portion during the production of these segments.

A diagrammatic representation of the approximate phonetic effects is shown in Fig. 4.6. In the case of the simple obstruent case, there is (near) complete closure of the velo-pharyngeal port (nasal cavity) and there is pressure build-up to satisfy the [+obstruent] feature on these segments. In the case of a simple nasal (which is either unspecified for obstruency or is [-obstruent]), the velo-pharyngeal port is open as the result of an implementation of the gesture [nasal], and there is no featurally-specified increase in oral pressure. In the case of obstruent nasals, there is both pressure build-up in the oral cavity, and the velo-pharyngeal port is lowered; however, there is a trade-of between the two features so as to allow both the features to be implemented.

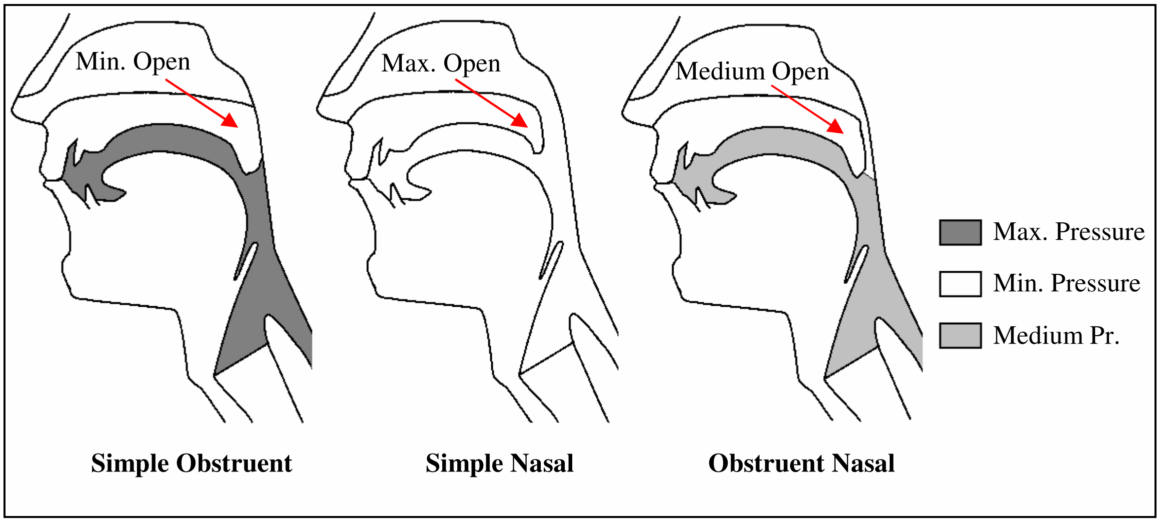


Fig. 4.6. Simple obstruents, Simple nasals, Obstruent nasal

This reclassification also allows us to maintain the phonological/inventory-based generalization about the occurrence of true partially nasal stops – that they are phonetic manifestations of the phonological feature responsible for nasality [+nasal] (or SP in this dissertation), or are the phonetic enhancement of truly voiced stops.

An important consequence of the reclassification of post-stopped nasal as obstruent nasals is the acknowledgement that SP (or [+nasal]) and [+obstruent] can phonologically co-exist on a single segment.

This view receives further supported from phonological data in Jambi Malay and Yabem.

Jambi Malay word-final voiceless stops (obstruents) undergo a process of optionally nasalisation as in (20).

(20) Jambi Malay – final stop nasalisation

ikat → ika$^{(n)}$**t** 'fish'

In Yabem, an Oceanic language, the irrealis mood is marked by a ‘floating’ SP ([+nasal]) segment which links to all the voiced stops in the verb root[6] (21) (Dempwolff 1939; Bradshaw 1979; Ross 1993, 1995; data from Hansson 2001)

(21) Yabem – Irrealis marking

	Realis	Irrealis	
a.	ká-létí́	já-létí́	‘run (1sg.)’
b.	ká-dàm^{w}è	já-^{n}dàm^{w}è	‘lick (1sg.)’
c.	ká-dàbȉŋ	já-^{n}dà^{m}bȉŋ	‘approach (1sg.)’

The two phonological processes (20-21) are further evidence that it is possible for obstruents to be nasalized, phonologically.

4.4. Implications for Nasal Harmony

In this section, I highlight the fact that the acknowledgement that [+obstruent] [SP] ([+nasal]) segments are both phonologically and phonetically possible has a bearing on our understanding of nasal harmony through obstruent segments.

A curious typological gap in nasal harmony patterns across the world is the absence of nasal harmony systems where obstruent segments within a harmony span are ‘nasalised’ along with their adjacent segments. A schematic of the gap is shown in (22a).

[6] The process also targets /s/ in low-tone contexts (Hansson 2001).

(22) a. Unattested: *ã t a → ã t̃ ã

b. Attested: ã t a → ã t ã

c. Attested: ã r a → ã r̃ ã

d. Unattested: *ã r a → ã r ã

The pattern we do find, repeatedly, is one in which nasal harmony appears to 'skip' the obstruent segment to spread to the next vowel, as schematized in (22b). However, with sonorant segments, this is not the case: the situation is the exact opposite. Any intervening sonorant segment is always nasalized in a nasal harmony span, as schematized in (22c). One never finds phonological systems wherein, the nasal harmony appears to 'skip' intervening sonorant consonants and vowels on to adjacent vowels, as schematized in (22d).

This surprising phenomenon is not a result of some typological/areal bias. As can be seen in (23), it can be seen in a fair variety of unrelated languages; in Mòbà Yoruba (23a), a Benue-Congo languages (Welmers 1973; Piggott 2003a,b); in Barasano (23b), a Tucanoan languages (Piggott 2003a,b); and in Guaranî (23c), a Tupi language (Rivas 1975; Walker 1999). In all the languages, nasalization passes through both sonorants and obstruents, but only the sonorants are nasal on the surface.

(23) a. Mòbà Yoruba

(i) /uwã/ → [ũw̃ã] 'lie'

(ii) /ur̃i/ → [ũr̃ĩ] 'iron'

(iii)/itã/ → [ĩtã] 'story'

(iv)/udũ/ → [ũdũ] 'lover of sweet things'

(v) /isĩ/ → [ĩsĩ] 'worship'

b. Barasana

(i) /wãre + re/ → [w̃ãr̃ẽr̃ẽ] 'to watch'

(ii) /mini + aka/ → [m̃ĩñĩãk̃ã] 'small bird'

c. Guaranî

(i) /ro + ᵐbo + porã/ → [r̃õmõp̃õr̃ã]

I-you + CAUS + nice 'I embellished you'

An SPE style analysis of nasal harmony past obstruents was briefly discussed in Walker (1998). This analysis is described below in (24). The nasalization phenomenon involves two distinct rules, a nasal spreading rule (24ai), and an obstruent stop denasalisation rule (24aii), ordered as listed. As can be seen in (24b), the derivation involves the spread of nasals through the obstruent stop on to following vowels, followed by the denasalisation of the obstruent stop.

(24) Transparency through derivationally-opaque rule interaction:

a. Rules:

i. Nasal Spreading (iterative):

X → [+nasal] / [+nasal] __ (X is any segment)

ii. Obstruent stop denasalization:

[-sonorant, -continuant] → [-nasal]

Nasal spreading is ordered before obstruent stop denasalization.

b. Derivation:

Underlying representation /ãrato/

Nasal spreading ãr̃ãt̃õ

Obstruent stop denasalization ãr̃ãtõ

Surface representation [ãr̃ãtõ]

Such an analysis captures the fact that all intervening sonorants in a harmony span will be nasalized, but intervening obstruent segments will not be. The surfacing of non-nasal (or oral) obstruents is attributed to the effects of an obstruent stop denasalisation rule (24aii).

While such an analysis is descriptively adequate, it does not explain why we see a typological gap in nasalization patterns. Given such an analysis, one could easily imagine another language with no rule obstruent stop denasalisation. The prediction for such a phonological system would be that obstruents would surface as nasalized (25).

(25) Derivation:

Underlying representation	/ãrato/
Nasal spreading	ãr̃ãt̃õ
Surface representation	[ãr̃ãt̃õ]

The absence of such languages could be considered an accidental gap in the observed typological pattern. However, doing so would lead to the curious situation that a more complex phonological system (interpreted here as one with more rules) is observed repeatedly, but a less complex one is not.

To put it in perspective, if nasal harmony is seen as a phonological rule, then it would be predicted that there would be languages without nasal harmony, for it is a ‘simpler’ sytem by virtue of not having the nasal harmony rule. This prediction is confirmed by the host of languages that do not have nasal harmony. Similarly, if final devoicing is seen as a rule, then we would predict the existence of languages without final devoicing – again, a prediction that is confirmed. However, one does not see languages without obstruent stop denasalisation in nasal harmony spans. If obstruent stop denasalisation is seen as a phonological rule/process, it is surprising, then, that the simpler system lacking the rule/process is unattested.

The analysis sketched out in (24-25) suffers not only from a lack of predictive power, it presents a theoretically unappealing state of affairs – the existence of more 'complex' (phonological) systems, in the absence of the simpler systems.

4.4.1 Some recent analyses

Most recent accounts of nasal harmony agree that nasal harmony through sonorants is the "normal" harmony pattern, wherein harmony proceeds through adjacent segments (Walker 1998; Piggott 1988,1992, 2003; Piggott & Hulst 1998); thereby respecting the No-Gap Condition that featural spreading respects segmentally-strict locality (Ní Chiosáin and Padgett 1997; Walker 1999, inter alia). This accounts for the fact that sonorant consonants and vowels are always nasalized in harmony domains; i.e., (22c) is attested, but (22d) is not. However, they diverge on the account for the obstruent nasalization facts.

Walker (1998) argues that nasalization through obstruent segments is driven by the same process/constraint of nasal harmony that drives nasalization through other (sonorant) segments, while Piggott (1988, 1992, 2003a,b) and Piggott & Hulst (1998) contend that nasalization through obstruents is through a separate process of syllable nasalization. In the following sub-sections, I shall describe the details of the two different accounts of nasal harmony.

4.4.1.1 Walker (1998)

Walker (1998) bases her analysis of nasal harmony on the robust observation of previous studies that nasal harmony obeys a compatibility hierarchy as in (26) (Schourup 1972; Piggott 1992; Cohn 1993c);

(26) Nasalisation Hierarchy (Walker (1998))

① Vowels ② Glides ③ Liquids ④ Fricatives ⑤ Obstruent Stops ⑥
← high————————*compatibility with nasalization*————————low →

The nasalization hierarchy in (26) captures the implicational universal that when a segment undergoes / is transparent to nasalization, every segment in the hierarchy which is more compatible with nasalization also undergoes / is transparent to nasalization in the language. For example, if a language allows nasalization through liquids, then it will also allow nasalization through glides and vowels. The nasalization hierarchy itself appears to be phonetically grounded in that it respects the compatibility of phonetic nasalization with the different segments in the hierarchy – nasalization is easier to perceive/produce with a glide than with a liquid, which in turn is easier than with a fricative or a stop (Solé 2007)

Walker (1998) formalizes the nasalisation hierarchy in an optimality-theoretic framework as a result of intrinsically-ranked nasal feature co-occurrence constraints (27), wherein, a constraint against nasal obstruent stops is *always* higher ranked than a constraint against the nasalization of another segment that is more compatible with nasalization (for example, liquids).

(27) Nasal Hierarchy Constraint Ranking
*NASOBSSTOP » *NASFRICATIVE » *NASLIQUID » *NASGLIDE » *NASVOWEL » *NASSONSTOP

She formalizes the nasal harmony process as the result of a Spread [+nasal] constraint that penalizes a candidate for having a non-nasal segment (28).

(28) SPREAD([+nasal], M)
Let n be a variable ranging over occurrences of the feature specification [+nasal], and S consist of the ordered set of segments $s_1 ... s_k$ in a morpheme M. Let Assoc(n, s_i) mean that n is associated to s_i, where $s_i \in S$.

Then SPREAD([+nasal], M) holds iff
i. $(\forall s_i \in S)\ [[\exists n\ (Assoc(n, s_i)] \longrightarrow [(\forall s_j \in S)\ [Assoc(n, s_j)]]]$.
ii. For each feature occurrence n associated to some segment in M, a violation is incurred for every $s_j \in S$ for which (i) is false.

Walker derives the implicational relations between the nasalization of different segments as a re-ranking of 'SPREAD [+nasal]' with respect to the Nasal Hierarchy Constraint Ranking (27). So, if Language A has 'SPREAD [+nasal]' ranked between *NASFRICATIVE and *NASLIQUID, then, liquids will be transparent to nasal harmony (29a-b). Furthermore, since the constraints against nasalized glides, nasalized vowels, and nasalized sonorant stops (*NASGLIDE, *NASVOWEL, *NASSONSTOP, respectively) are all ranked below 'SPREAD [+nasal]', they too will be nasalized. Therefore, it derives the fact that, in Language A, 'SPREAD [+nasal]' will force the nasalization of all the segments below fricatives in the nasalization hierarchy (29ci-iii), but cannot force nasalization of fricatives and obstruent stops, which will remain oral (29civ-v).

(29)Language A
a. *NASOBSSTOP » *NASFRICATIVE » **SPREAD [+nasal]** » *NASLIQUID » *NASGLIDE » *NASVOWEL » *NASSONSTOP

b.

sɔɾɔ̃	*NAS OBSSTOP	*NAS FRIC	SPREAD-L ([+nas], Pwd)	*NAS LIQUID	*NAS GLIDE	*NAS VOWEL	*NAS SONSTOP
☞ a. s[ɔ̃ɾ̃ɔ̃]			*	*		**	
b. [s̃ɔ̃ɾ̃ɔ̃]		*!		*		**	
c. sɔɾ[ɔ̃]			**!*			*	

c. (i) ã l a → ã l̃ ã

(ii) ã y a → ã ỹ ã

(iii) ã a → ã ã

(iv) ã s a → ã s a

(v) ã t a → ã t a

With respect to obstruent nasalization patterns, the primary ingredient of her analysis is the observation "When voiceless obstruents behave transparent to nasal harmony, all other classes of segments undergo nasalization" (Walker 1998, pg. 22). Nasalization through obstruents in spite of being opaque on the surface has the same implication characteristic as nasalization through other segments – i.e., in languages where nasalization appears to 'skip' past (voiceless) segments, nasalization always passes through all the other segments (30).

(30) If a language has

(a) ã t a → ã t ã

It also has the following nasalization patterns

(b) ã l a → ã l̃ ã

(c) ã y a → ã ỹ ã

(d) ã a → ã ã

Thus, phonologically, the process responsible for nasalization through obstruents appears to be the same process as nasalization though other segments, i.e, nasalisation proceeds through adjacent segments even when an intervening obstruent appears (31)[7].

(31) Nasal Harmony for Walker (1998)

```
     a    t    a        →  a       t       a
     |                     |       |       |
  [nasal]                [nasal] [nasal] [nasal]
```

Her analysis, as it stands, runs into problems because it would predict that when obstruent sounds are transparent to nasal harmony, i.e., 'SPREAD [+nasal]' is ranked above *NASOBSSTOP, obstruent segments should be nasalized, as in (32). However, as has been pointed out earlier, this is never seen. In stead, in such cases, we see nasalization 'skips' over the obstruent segment.

(32)

	wãti	SPREAD ([+nas], M)	*NAS OBSSTOP	*NAS FRIC	*NAS LIQUID	*NAS GLIDE	*NAS VOWEL	*NAS SONSTOP
☞	a. [w̃ãt̃ĩ]		*			*	**	
	b. [w̃ã]ti	*!*				*	*	
	c. w[ã]ti	*!**					*	
	d. [w̃ã]t[ĩ]	*!****				*	**	

7 This basic insight was also captured by the SPE style analysis described in (9) that Walker discusses in her dissertation.

To explain the fact that obstruents segments despite being transparent to nasalization never surface as nasalized (22a), she claims that nasalized obstruents are phonologically possible, but phonetically impossible. That is, phonologically, nasal harmony could be as in (22a), where the nasaliation spreads to the intervening obstruent. However, it would never surface as such because it is phonetically impossible (33).

(33) “Although a strong dispreference for a feature combination in a language can drive transparency in the case of vowel harmony, the transparency of buccal obstruent stops to nasal spreading is somewhat more extreme. This is a case of antagonistic transparency where the segment that would be derived from spreading onto the transparent segment is more than just disfavored, it is a phonetically impossible segment, that is, it cannot not be pronounced in any language.” (Walker 1998, pg. 84)

In light of the above claim, Walker, rather puzzlingly, attempts to account for the fact that nasalization through obstruents always results in opaque surface forms (22b), with a Sympathy based Optimality Theoretic explanation – a purely phonological explanation – according to which, the output candidate is forced to agree with a ‘sympathetic’ candidate by a sympathetic faithfulness constraint – in this case ‘IDENT-❀O [+nasal]’ that selects a sympathetic candidate that the output candidate should be faithful to (McCarthy 1998, 1999).

The gist of her analysis is as described below. The output candidate in (34) is ‘designated’ as the *sympathetic candidate* – identified with a ‘flower’ symbol (34). This sympathetic candidate is submitted to another round of candidate selection in which a new *sympathetic* faithfulness constraint ‘IDENT-❀O [+nasal]’ is ranked between *NASOBSSTOP and SPREAD[+nasal]. The *sympathetic* faithfulness constraint ‘IDENT-❀O [+nasal]’ requires identity for the feature [+nasal] between the sympathetic candidate [ãr̃ãt̃õ] and the output candidate. As can been seen in the tableau in (34), the ranking results in the surface form [ãr̃ãtõ], wherein, the intervening obstruent stop is not nasal.

(34)

	ãrato	*NAS OBSSTOP	IDENT-❀O [+nasal]	SPREAD [+nasal]
❀	a. [ãr̃ãt̃õ]	*!		
	b. [ãr̃ã]to		**!	**
☞	c. [ãr̃ã]t[õ]		*	******

The problems with such a Sympathy-based analysis are manifold. I refer the readers to Idsardi (1997, 2000), Idsardi & Kim (2000) inter alia for general problems with Sympathy Theory. More specific problems regarding the ad hoc nature of Walker’s analysis are mentioned in Piggott (2001, 2003).

Walker’s analysis looses predictive power as it predicts a whole range of unattested processes. For example, by ranking the sympathy constraint below, *NASLIQUID, one could expect a language where all segments in the Nasalisation Hierarchy above liquids (including liquids) allow nasalization to ‘skip’ them (35). However, such languages are not to be found. The 'skipping' of segments happens only with obstruents as noticed by Walker, and not with non-obstruent segments.

(35) Unattested pattern predicted by Walker's analysis

(i) ã a → ã ã

(ii) ã y a → ã ỹ ã

(iii) ã l a → ã l ã

(iv) ã s a → ã s a

(v) ã t a → ã t a

Furthermore, Walker does not discuss what happens if the phonology does select a nasalized obstruent in the output/surface form (possible if the sympathetic faithfulness constraint is low ranked). She claims it is phonetically impossible, but phonologically possible. So if the phonology were to select it as the optimal candidate, then how does the phonetics interpret it? This raises the bigger issues of what happens to representations that are phonologically legitimate, but phonetically impossible.

Finally, Walker's analysis of the obstruent opacity facts crucially relies on the claim that nasalized obstruents are phonetically impossible - a claim which the data in this chapter challenges/disproves.

4.4.1.2 Piggott (1988, 1992, 2003a.b), Piggott & Hulst (1998)

Walker's general thesis is that nasalization through obstruents is the same process of nasal harmony as nasalization through other segments. Contrary to this, in a series of papers, Piggott (1988, 1992, 2003a,b) , and Piggott & Hulst (1998) claim that the obstruent (stop) opacity pattern (36) is not a case of nasal harmony. Piggott has recast this fundamental claim in various versions of rule-based theories and OT. In this dissertation, in stead of discussing the different manifestations of this basic claim, I will outline the basis of all the proposals and discuss the general problems with it.

(36) Intervening obstruent stop: ã t a → ã t ã

Piggott argues that canonical nasal harmony (37) – which is the copy of the feature nasal to adjacent segments within a certain span – is always blocked by obstruent segments (37b) – i.e., nasal harmony never proceeds past obstruent (stop) segments.

(37) Nasal Harmony for Piggott (1988, 1992, 2003a,b) , and Piggott & Hulst (1998)

a. Intervening sonorants or fricatives: ã r a → ã r̃ ã

b. Intervening obstruent (stops): ã t a → ã t a

He captures the implicational relation that nasalization through a segment implies nasalization is allowed by a segments below it in the nasalization hierarchy, by stipulating that nasal harmony respects the nasalization hierarchy (in older, rule-based analyses), or through the interaction of a priori ranked constraints (a la Walker 1998) with a nasal harmony constraint (in more recent analyses). So, like Walker (1998), he accounts for the fact that when a liquid is transparent to nasalization (38a), then all the segments lower than liquids in the nasalization hierarchy (26) are transparent to nasalization (38b-c), but segments above liquids in the hierarchy block nasalization (38d-e).

(38) (a) ã l a → ã l̃ ã

(b) ã y a → ã ỹ ã

(c) ã a → ã ã

(d) ã s a → ã s a

(e) ã t a → ã t a

To account for the case in (38), he posits an independent process of syllable nasalization. Syllable nasalization involves the spread of the feature [+nasal] when it is linked to the syllable node (39).

(39) Syllable Nasalisation

```
          a    t    a       →      a    t    a
          |    \ /                 |    \ /
          σ     σ                  σ     σ
          |                        |     |
       [nasal]                 [nasal] [nasal]
```

The opacity of stops – i.e., the non-nasal surface manifestation - is ‘explained’ by the claim that in nasal syllables, ‘the nasal feature must be associated with the (vocalic) head of the syllable and with all other tauto-syllabic sonorants.’ (Piggott 2003, p.376).

Obstruents are claimed to be inherently incompatible with the feature [+nasal], so when a syllable is nasalized, the obstruent segments in the syllable can remain non-nasal. So, in languages with syllable nasalization, nasalization appears to pass through all the sonorants, but is blocked by obstruents – thereby, capturing the implication relation that when nasalization appears to pass through obstruents, it also passes through sonorants. For Piggott, languages that show nasalization through obstruent segments, as in Guaranî, Tuyuca, Barasana (40) where nasal harmony 'skips' intervening obstruent stops, there is no nasal harmony. In stead, there is a process of *syllable nasalization.*

(40) Barasana (Piggott 2003b)

a. w̃are + re → [w̃ãr̃ẽr̃ẽ] 'to watch'

b. mini + aka → [m̃ĩñĩãkã] 'small bird'

In Piggott's account, the implicational relational similarity between nasalization through obstruents and that through other segments is accidental.

Piggott's analyses boil down to three essential points/claims: nasal harmony never crosses obstruents; nasalization that skips obstruents is a separate process of syllable nasalization; obstruents cannot be nasalized.

The third claim/point is falsified by the data in section 4.3, where it was shown that nasalized obstruents do exist. Given this result, the claim that nasal harmony never crosses obstruents is also rather puzzling. What motivation would be there for such a claim? Finally, the process of syllable nasalization appears to be an ad hoc process invented solely for the purpose of account for the typological gap.

4.4.1.3 Summary

As can be seen neither Walker (1998) nor Piggott (1988, 1992, 2003a,b), and Piggott & Hulst (1998) really provides a satisfactory explanation to the problem at hand. On the one hand, Walker's is a brute force analysis through Sympathy Theory that accounts for the descriptive fact in languages, but fails to explain why (41a) is the only observed pattern for intervening obstruent segments. Her discussion is also completely silent about what it means to be 'phonetically impossible', while 'phonologically possible'. She does not answer the question of how phonologically-possible but phonetically-impossible representations such as (41b) are 'fixed' in the mapping between phonology and phonetics. Finally, while she motivates her analysis with the claim about 'phonetic impossibility', she never gives substance to this motivation.

(41) a. Attested: ã t a → ã t ã

b. Unattested: *ã t a → ã t̃ ã

On the other hand Piggott (1988,1992, 2003a,b), Piggott & Hulst (1998) stipulate the fact that nasal harmony cannot cross obstruents. This is especially surprising given the data in this chapter which shows that obstruent nasals are both phonologically and phonetically possible. They further stipulate that the process in (41a) is an entirely separate process of *syllable nasalization*, wherein, the feature [+nasal] links to the syllable node, and obstruents cannot be nasalized because they are incompatible with nasality. This final claim has been shown to be false in section 4.3 of this dissertation.

This sub-section (4.1) shows that a true explanation for the fact that allowing *nasal obstruents* means, we no longer have an "explanation" for the typological gap in (41b).

4.4.2 A New Analysis

The new analysis that I argue for essentially proposes that the nasal spreading though obstruents is the same as nasal harmony through other segments, as modeled in the process of nasal harmony in (42) – in the spirit of Walker (1998).

(42) Nasal Harmony for Walker (1998)

```
  a    t    a     →    a     t     a
  |                    |     |     |
[SP]                 [SP]  [SP]  [SP]
```

The subsequent 'denasalisation' of the intervening obstruent is argued to be the effect of general feature-gesture interface properties.

The analysis builds on four major theoretical insights. First is the new generalization that obstruents can be nasalized in nasal harmony spans if they are at the right-edge of the span; it is only obstruents adjacent to *tauto-syllabic nasal vowels* that appear to not be nasalized on the surface. Second, it maintains Walker's generalization that nasal spreading through obstruent stops is the same process as the nasal spread through other segments, namely, nasal harmony (43).

(43) Walker's Generalisation

> Nasal spreading through obstruent stops is the same process as the nasal spread through other segments, namely, nasal harmony.

Third, it employs the distinction between *featural phonology* and *gestural phonology* as clarified by Zsiga (1997). Third, it uses the concept of *gestural phasing* proposed by Silverman (1997, 2003a). Finally, the notion of a phonetics-phonology (completion) principle proposed in the previous chapter to explain the behaviour of partially-nasal stops is utilized to derive the apparent 'opacity' of obstruents.

4.4.2.1 An Important Generalisation

The first observation that is relevant to a new analysis of the facts is a reiteration of what has already been noted - nasal harmony *through obstruents* is *always* an opaque interaction, i.e, the obstruent is always oral, not even pre/post-nasalised (44). This particular phenomenon doesn't seem to have any exceptions. The key observation is that there is *no* variation in the details of nasalization past obstruents.

(44) ã t a → ã t ã

Additional data that is equally important to our understanding of the process comes from Terena, an Arawakan language (Piggott 2003, Bendor-Samuel 1960, 1966). In Terena, the first person morpheme is a [+nasal] (SP) prefix that appears link to the first segment of a word and spreads until the first obstruent in the word. In (45a), nasalization spreads from the first vowel to the end of the word as there are no intervening obstruents. In (45b), the nasalization spreads from the first segment until the velar stop [g] which is prenasalised. Finally, in (45c), the nasal prefix attaches to the first segment and spreads no further because the first segment is an obstruent.

(45) Terena nasal harmony

	3rd person	1st person	
a.	emoʔu	ẽmõʔũ	‘sickness’
b.	owoku	õw̃õ^{ŋ}gu	‘house’
c.	tuti	^{n}duti	‘head’

What is interesting about this data set is that obstruents aren’t absolute blockers to nasal harmony[8]. In fact, they can even be nasalized! In which case, they surface as, what have been described in the descriptive literature as, pre-nasalised stops. The relevant observation here is that when the obstruent is to the right-edge of the nasal harmony span, the obstruent *can* be nasalized.

As a result of the two observations noted in this section, one cannot maintain that obstruents categorically resist (or) are opaque to nasalization in nasal harmony phenomena. In stead, the real generalization is that obstruents appear to be nasalised except when a tautosyllabic nasal vowel follows (46).

(46) New generalisation regarding obstruent opacity in nasal harmony

When a tauto-syllabic vowel is nasalized, the obstruent appears *not* to be nasalized (phonetically) in nasal harmony.

[8] Piggott (2003) observes that it is theoretically difficult to block the nasal harmony from continuing past the obstruent in OT, especially, his version of it. Instead, he analyses the process as one in which, the nasal morpheme links to the first obstruent in the word, and spreads leftwards; and in the absence of an obstruent in the word, it links to the last segment of the word, and then spreads leftwards. Even if this analysis were to be maintained, what is important for the present purposes is that obstruents can be nasalized as long as they are at the right-edge of a nasal harmony span.

The new generalization has no counter examples. Given the universal nature of this generalization, it would be a mistake to situate the locus of the solution in the phonology proper – which, putatively, has 'soft' universals at best in the form of rerankable constraints in OT variants of phonological theory. Instead, as will be seen in the following sub-section, a more insightful analysis would be one in which this generalization is a result of interface properties – in this case, the interface between 'featural phonology' and 'gestural phonology.'

4.4.2.2 The New Account

The account that I propose is based on Walker's generalization (43) – that, phonologically, nasal harmony through obstruents is the same as with other consonants and vowels. With respect to nasal harmony, obstruents are at the end of the nasalization hierarchy, but are not always opaque to the process. In the (featural) phonology, nasal harmony can pass through obstruents as with other segments. The surface opacity facts are explained with a gestural phasing account which phases the nasal gesture associated with an obstruent and a tauto-syllabic vowel primarily with the vowel gestures. The account proposed here depends on two principles: the behaviour of the *dimension* SP (or the feature [nasal]) as per a *Phonetics-phonology Principle* developed in the previous chapter, and the concept of temporal constraints on gestural phasing discussed in the next sub-section.

The essential elements of this account are all independently needed for other processes. So, it is illuminating to realize that by accepting that the opacity with nasal harmony through obstruents is not a phonological fact, we are able to explain what has been seen as a problem for the theory till now with pre-existing mechanisms.

4.4.2.2.1 Features, Gestures and Phonology

Some important background information necessary to account for the obstruent opacity pattern discussed above was already presented in Chapter 1. I shall re-iterate the relevant information, and ask the reader to refer to Chapter 1 for further details.

The model of phonology-phonetic that is assumed in the dissertation is that in which there is both a *featural phonology* and a *gestural phonology* (47) – based on (Zsiga 1993, 1997).

(47) Representations in the phonology

Lexical Representations:	Discrete (atemporal) representations
	↓
(Featural) Phonology:	Discrete (atemporal) Representations
	Computations over representations
	Surface discrete representations
	↓
(Gestural) Phonology:	Gestural (temporal) Representations
	Computations over temporal representations
	Surface gestural (temporal) representations
	↓
Phonetics:	Concrete Phonetic Representations

In this model, featural representations are mapped to gestural representations while respecting the temporal alignment constraint in (48), which forces there to be some overlap between gestural correlates of features connected to the same segments.

(48) Temporal constraint on feature-gesture mapping[9]

There is (at least) some overlap between gestural manifestations of different features linked to the same X-slot.

Finally, the alignment of gestures also appears to be sensitive to the optimization of perceptual recoverability, as was pointed by Silverman (1997), and Chitoran, Goldstein & Byrd (2002).

(49) Gestural Phasing

Gestures are aligned to optimise perceptual contrast. (Silverman 1997).

Gestural alignment is susceptible to language-dependent variation, and gestures (in general) seem to have different organizing principles than features. The principle in (49) is one such principle.

Silverman (1997) attempts to account for the strong tendency amongst languages to have particular articulatory configurations/relationships. Silverman motivates the proposal that there are articulatory timing relationships amongst gestures that 'render cues optimally recoverable by the listener.' The proposal makes the prediction that 'the better the percept, the less marked the pattern, and the worse the percept, the more

[9] Sagey's (1988) version of this principle is the following: 'For a feature and an x-slot to overlap means that some part of the feature and some part of the x-slot are simulataneous.' However, since x-slots have no gestural correlate, I have restated this constraint as in (6).

marked the pattern' (Silverman, 2003a). This is a proposal that finds a precursor in (Mattingly 1981), which is an attempt to understand certain gross aspects of syllable-structure.

The proposal of *gestural phasing* (49), developed by Silverman, is used to explain why some articulatory patterns are much more unmarked than others for what appear to be the same phonological specifications.

The principle has received further support from recent work on Georgian consonant clusters, where the alignment of the consonant gesture is argued to be related to the perceptual recoverability of the gestures (Chitoran, Goldstein & Byrd 2002).

Aspirated stops are present in a diverse set of languages, and are usually analysed as having the feature [+spread glottis] along with other features, such as for place of articulation, nasality etc, necessary to represent the stop (50) (Iverson and Salmons 1995, Avery & Idsardi 2001, inter alia).

(50) Aspirated Stops

```
                  X
                 / \
[+spread glottis]   …
```

While this is, arguably, the phonological representation of aspirated stops, they surface in one of at least two manifestations: post-aspirated stops, and pre-aspirated stops. In onset/initial position, post-aspirated stops (51a), wherein aspiration follows the closure portion of the stop, are much more common in the world's languages than pre-aspirated stops, wherein aspirated precedes the closure portion of the stop (51b). Silverman (1997) uses the proposal of *gestural phasing* to explain this typological disparity.

(51) a. Post-aspirated stops

p^h, t^h, k^h

b. Pre-aspirated stops

${}^hp$, ${}^ht$, ${}^hk$

Silverman argues that because of the non-linearities present at the level of the human auditory nerve, aspiration is more strongly perceptible/recoverable in the CV transition of a syllable, than at the beginning of the syllable; hence, aspiration is much more likely to be *phased* in the C-V transition of a syllable, resulting in post-aspirated stops, than before the consonant closure of a stop, which would result in pre-aspirated syllables.

4.4.2.2.2 Nasal Harmony

With the theoretical machinery laid out in the preceding subsections, we are now in a position to explain the asymmetrical behaviour of intervening obstruents in nasal harmony. Maintaining Walker's generalization (43), nasal harmony through obstruents in the *featural phonology* is a simple process and there is no phonological opacity (52). In the featural phonology, nasal harmony spreads via adjacent segments in the nasal harmony span.

(52) Nasal Harmony in the phonology

```
  a     t     a   →   a      t      a
  |                   |      |      |
[SP]                [SP]   [SP]   [SP]
```

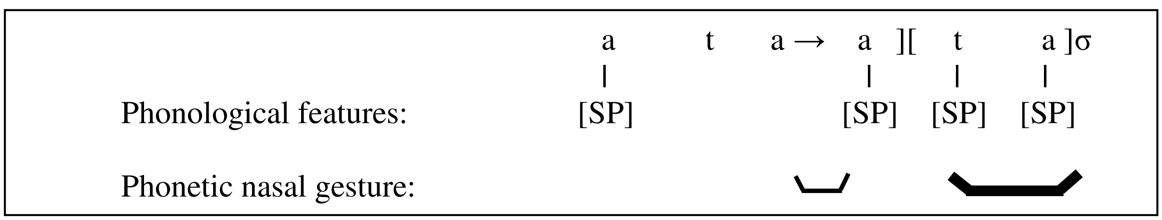
However, I have argued in a previous chapter concerned with true partially-nasal stops that *gestural completion* employs a single ([nasal]) gesture for adjacent tauto-syllabic [SP] *dimensions* (53). The gesture necessarily has to be a [nasal] gesture and not an [oral] gesture because syllabic segments linked to SP always surface as nasal as per the *Nasal Rule 2*, discussed in Chapter 3.

(53) Phonetics-phonology principle

Only a single *gesture* completes identically specified adjacent phonological features/*dimensions* within a syllable (Durvasula 2007).

This then leads to a gestural score for the featural specification in (54) that has only two [nasal] gestures.

(54) Nasal Harmony: mapping to gestures[10]

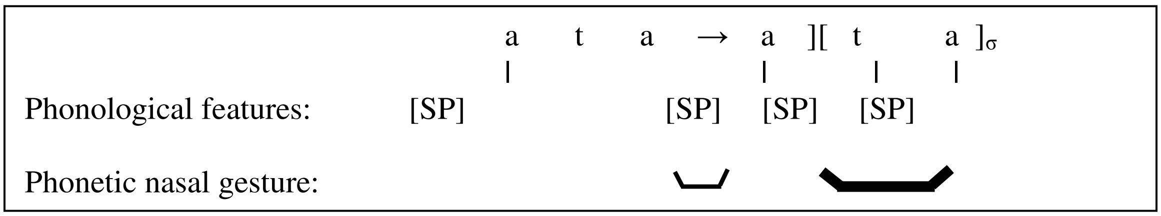


A final part of this process has to do with the temporal alignment of the gestures - that is, the mapping has to respect the *temporal constraint on feature-gesture mapping* (48) and the *gestural phasing* principle (49).

[10] For the moment, I omit the feature-gestural interface for the sake of simplicity. The feature-gesture mappings are, however, discussed in sufficient detail below in (56-57). The reader is referred to Chapter 3 for any remaining doubts regarding the derivations for the exact mappings.

The final nasal gesture in (54) aligns almost completely with the vowel (and barely overlaps with the preceding obstruent) to optimise the perceptual contrast/recoverability of the gesture (55).

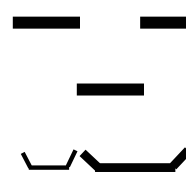
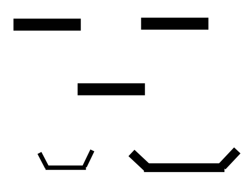
(55) Nasal Harmony: Alignment of gestures



The table in (56) summarises the expected surface forms for both obstruents and sonorants that intervene a nasal harmony span. The intervening sonorant case is schematized with an ‘r’. Nasal harmony could pass through both sonorants and obstruents in the phonology.

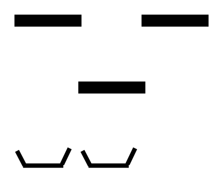
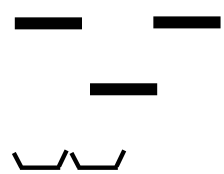
The difference in the surface manifestation is the effect of *gestural completion and phasing* rules. For both the sonorant and the obstruent cases (56), adjacent tauto-syllabic segments specified for the phonological nasal feature SP are completed with a single [nasal] gesture. In the sonorant case (56a), the perceptual contrast of the [nasal] gesture is not sacrificed/degraded when it is phased with both the sonorant and the vowel. However, in the obstruent case (56b), the [nasal] gesture is primarily phased with the vowel to maintain perceptual contrast of the gesture.

(56) Nasal Harmony: In short

	a. Transparent ‘r’ that is nasalized phonetically	**b. Transparent ‘t’ that is not nasalized phonetically**
Underlying form (UR)	V r V | [SP]	V t V | [SP]
Surface Phonological Form (SR) – after nasal harmony	V][r V $]_\sigma$ | | | [SP] [SP] [SP]	V][t V $]_\sigma$ | | | [SP] [SP] [SP]
Gestural mapping	**Gesture** V][r V$]_\sigma$ *V-Place* *C-Place* *Velum* 	**Gesture** V][t V$]_\sigma$ *V-Place* *C-Place* *Velum* 
Gestural Phasing	**Gesture** V][r V$]_\sigma$ *V-Place* *C-Place* *Velum* 	**Gesture** V][t V$]_\sigma$ *V-Place* *C-Place* *Velum* 

In the case of Terena, where the obstruents are at the right-edge of the harmony span, but the obstruents are nasalized is shown in (57). The nasal feature spreads up to the obstruent segment. When features are mapped to gestures, the final vowel and the following obstruent consonant each get their own nasal gestures. The nasal gesture associated with the consonant aligns with the initial part of the obstruent stop; therefore, what surfaces is a sound that is acoustically similar to a pre-nasalised stop (or a partially-nasal stop).

(57) Nasalisation upto the obstruent in Terena

	Nasalisation when it stops with the obstruent segment
Underlying form (UR)	V t V [SP]
Surface Phonological Form (SR) – after nasal harmony	V][t V $]_{\sigma}$ [SP] [SP]
Gestural mapping	**Gesture** V][t V$]_{\sigma}$ *V-Place* *C-Place* *Velum* 
Gestural Phasing	**Gesture** V][t V$]_{\sigma}$ *V-Place* *C-Place* *Velum* 

4.5 Conclusion

In this chapter, I showed that there is a series of segments that is aptly classified as *Obstruent Nasals*. This reclassification challenges the de facto standard view amongst phonologists and phoneticians that the features [+obstruent] and SP ([+nasal]) cannot coexist, phonologically or phonetically, on the same segment.

The existence of obstruent nasals forces us to re-examine existing accounts of obstruent opacity in nasal harmony, and it casts serious doubts on all existing analyses for nasal harmony. Specifically, it shows that previous analysis can no more account for the curios typological gap in nasal harmony patters; that (58a) – where an intervening obstruent appears to be oral – is attested, but (58b) – where the intervening obstruent is nasalized - is not an attested pattern.

(58) a. Attested: ã t a → ã t ã

b. Unattested: *ã t a → ã t̃ ã

I propose a new analysis that depends on independently documented processes/phenomena and show that obstruent opacity in nasal harmony can be derived from a simple phonological process and interface principles. The crux of the analysis is in situating the problem at the interface between *featural phonology* and *gestural phonology,* where features are mapped on to gestures.

The major insight of the new analysis is in analyzing a putative universal phenomenon as a result of an interface property, as opposed to the all-too-familiar technique, in modern phonology, of positing additional constraints or phonological machinery.

Chapter 5

CONCLUSION AND THEORETICAL IMPLICATIONS

5.1 Introduction

In this concluding chapter, I shall discuss the theoretical implications of the analyses proposed to account for partially-nasal stops in this dissertation. More specifically, the discussion will centre around three main topics: syllabification in underlying representations, the sensitivity of phonetic forms to different types of contrast, and the need for abstract, categorical features.

The model of phonology that was assumed till now was one with both a featural component and a gestural component (1) (Zsiga 1997). However, the model does not discuss what is involved in mapping featural representations to gestural representations. As it stands, the model suggests that the mapping of features to gestures is a simple process, where each (atemporal) feature is replaced by a (temporal) gesture.

(1) Representations in the phonology

Lexical Representations

↓

Featural (atemporal[1]) Representations

↓

Gestural (temporal) Representations

[1] Atemporal within segments.

The data and analyses discused in the preceding chapters, however, imply that the situation is necessarily more complicated than the simple model proposed in (1). I have shown that the mapping of featural representations to gestural representations is crucially mediated by the nature of contrast. Specifically, the gestural manifestation of the phonological representation of nasality (the dimension Soft Palate (SP)) is sensitive to the nature of laryngeal contrast in the specific syllabic position. In the rest of the chapter, I shall outline the view of the phonological grammar that is minimally necessary to account for the facts presented in the dissertation.

In section 5.2, I shall develop a specific model of phonology that is minimally needed to account for the facts of contrast, and propose that phonetic mappings are sensitive to both underlying contrast and surface contrast. Furthermore, I shall argue that this is coherent only under the view that underlying (lexical) representations are syllabified, despite meta-theoretical concerns raised in earlier phonological theories.

In section 5.3, I shall argue that, contrary to recent models which argue against a division between abstract (atemporal) categorical representations and concrete phonetic representations, there is a genuine need for both abstract (categorical) representations and an ‘interface’ between abstract and more concrete representations in order to account for the phonological biases observed in the face of bewildering phonetic variation.

5.2 What contrast is SP sensitive to?

In chapters 3 and 4 of this dissertation, I argued that the phonological ‘feature’ for nasality is not the traditional feature [+/- nasal], but the *dimensional* node Soft Palate

(SP), in (2a), a la Avery and Idsardi (2001). This dimension node is argued to have three possible gestural manifestations: a nasal gesture that results in simple/completely nasal segments (2bi); an oral gesture that results in completely oral segments (2bii); and a partially-nasal gesture that results in partially-nasal stops (2bii).

(2) Organisation of phonological nasality

a. Phonological representation: SP

b. Phonetic manifestations of SP

(i) Simple nasals	(ii) Oral segments	(iii) Partially-nasal segments
SP	SP	SP
|	|	
[nasal]	[oral]	

Furthermore, based on the behaviour of the dimension SP in specific conditions, a set of (universal) *feature-gesture mapping rules* were proposed to account for its phonetic manifestation: one, to account for the fact that nasals segments are sensitive to the nature of laryngeal contrast in the relevant syllabic position (3a); the second, to account for the fact that phonologically nasal vowels, and syllabic nasals are always nasal, and show no sensitivity to contrast (3b); and the third to account for the obligatory orality linked to non-nasal obstruents.

(3) Rules of feature-gesture mapping for SP.

a. Nasal Rule 1: If there is a laryngeal contrast amongst obstruents in the consonant inventory in the relevant syllabic position, the SP node is necessarily *completed* to with the gesture [nasal]

b. Nasal Rule 2: An SP node linked to syllabic segments is always *completed* with [nasal].

c. Nasal Rule 3: An obstruent segment NOT linked to an SP node is always completed with an [oral] gesture

It was argued that when there was no laryngeal contrast in a specific syllabic position, nasals could surface as nasal-based partially-nasal stops (N-PNS), but in syllabic positions where there is a laryngeal contrast, nasals segments *never* surface as N-PNS, in stead surfacing as simple nasal stops. However, for the languages discussed, the absence of laryngeal contrast (in the relevant syllabic position) was in both underlying representations and surface representations. So, it is not clear what level of contrast is responsible for nasals to come out (consistently with no variation) as simple nasals stops. The question that comes up is, is the dimension SP sensitive to underlying contrast, i.e., phonemic contrast used for lexical distinctions, or surface contrast, i.e., contrast between segments/sounds that is apparent after the application of phonological processes?

In answering the above question, it is instructive to look at languages that disambiguate between the contributions of surface and underlying (phonemic) laryngeal contrast. There are two such cases: languages which have a phonemic laryngeal contrast, but the contrast is neutralized on the surface (section 5.2.1); and languages that do not have a phonemic laryngeal contrast, but have a surface laryngeal contrast as a result of phonological processes (section 5.2.1).

In the following sub-sections, I shall develop the notion of 'contrast' referred to in (3). I specifically show that the gestural manifestation of SP is sensitive to *both* underlying laryngeal contrast and surface laryngeal contrast, and neither notion by itself is enough to account for the patterns observed.

5.2.1 Surface Neutralised Phonemic Laryngeal Contrast

If the laryngeal contrast that nasals segments were sensitive to was only *surface*[1] laryngeal contrast, then we would expect them to show up as partially-nasal segments in, at least, a few languages where there is a laryngeal contrast in underlying/phonemic representations (either an aspiration contrast as in English and many other Germanic languages (4a) or a voicing contrast as in many Romance languages (4b)), but the contrast is neutralized in specific syllabic positions in surface forms, i.e., in the surface representations, there is no laryngeal contrast in the relevant syllabic position (either in the onset or coda, depending on where the neutralization takes place).

(4) Underlying/Phonemic laryngeal contrast

a. Aspiration Contrast (English, German, …)

voiceless stops	voiced stops
X	X
|	|
Glottal Width	Ø

b. Voicing Contrast (French, Spanish, Japanese…)

voiceless stops	voiced stops
X	X
|	|
Ø	Glottal Tension

[1] I shall call representations at the end of *featural phonology*, 'surface representations' for the purposes of the discussion.

Laryngeal neutralization, or (final) devoicing as it is more commonly described, is a relatively well-observed phenomenon (Vaux & Samuels 2005; Iverson & Salmons 2006). It has been observed in a variety of unrelated languages – in Afrikaans (Wissing & Van Rooy 1992), Catalan (Mascaró 1987; Dinnsen & Charles-Luce 1984), Dutch (Iverson & Salmons 2003b), German (Lombardi 1991, 1995), Malay/Indonesian dialects (Teoh 1994), Polish (Sanders 2002), Russian (Chen 1970; Pye 1986), Korean (Kohn 1987), Somali (Saeed 1999; Kiparsky 2006) amongst others. A typical example of the process from Dutch is shown below in (5). In (5a), an underlying voiced stop is 'voiceless' in coda positions, but voiced in onset positions, but in (5b), the underlying voiceless stop is devoiced irrespective of syllabic position.

(5) Laryngeal neutralisation in Dutch (Oostendorp 2006)

a. kwaa[t]	'angry (pred.)'	but	kwa[d]ə	'angry (att.)'
b. laa[t]	'late (pred.)'	but	late	'late (att.)'

If the laryngeal contrast relevant for nasals (the dimension SP) is only the contrast in surface representations, then we would expect that at least a few languages with *surface* laryngeal neutralization in the coda would have nasals that surface as partially-nasal stops. However, nasals *never* surface as partially-nasal stops in these languages.

This could imply one of two things: underlying laryngeal contrast *is* relevant for nasals; or it could mean that none of these languages really have surface laryngeal neutralization in the coda (the relevant segments are only perceived to be neutralized by transcribers), and that nasals are in deed sensitive *only* to surface laryngeal contrasts.

The latter possibility has been discussed recently by a variety of phoneticians working on German, Dutch, Russian, Polish amongst others (Dinnsen & Charles-Luce 1984; Port & Crawford 1989; Van Rooy, Wissing & Paschall 2003; inter alia). These researchers have claimed to have found subtle phonetic differences between underlying voiced and voiceless stops in coda positions, in some languages claimed to have coda-devoicing. However, these phonetic results have been contested on three grounds. One, the interpretation of results of these experimental were called in to question by Manaster Ramer (1996), who argued that the so-called incomplete neutralization could very well be because of the effects of spelling on pronunciation, and are a result of the unnatural experimental set-ups. Second, Manaster Ramer (1996) further showed that at least for Catalan, the results were actually inconclusive, because of faulty test items. Finally, the results themselves have been contradicted by others who have found complete laryngeal neutralization for some of the same languages (German, and Polish) amongst others like Turkish in phonetic experiments that show that the laryngeal neutralization is indeed complete (Fourakis & Iverson 1984; Mascaró 1987; Jassem & Richter 1989; Kopkalli 1993).

Despite the controversy related to (coda) laryngeal neutralization in some languages, it is clear that not all the languages argued to have laryngeal neutralization can be claimed to have 'incomplete neutralisation' of contrast in surface forms (Manaster Ramer 1996).

To take an example, Korean has a three-way (surface) laryngeal contrast between unaspirated stops, voiceless aspirated stops, and 'tense' stops (surfaces as glottalised) in the onset positions (6a)[2]. However, the contrast is neutralized in coda positions, where only the simple unaspirated series surfaces (6b). In fact, the range of segments affected by coda neutralization is spectacular, especially for the coronal series (6ciii).

(6) Korean laryngeal neutralization

a. Surface laryngeal-contrast in onsets

(i) tal ‘moon’

(ii) t^hal ‘mask’

(iii) t’al ‘daughter’

b. Laryngeal neutralization in the coda (Sohn 1987)

(i) /ap^h/ → [ap] ‘front

(ii) /pat^h/ → [pat] ‘field’

c. Neutralisation in the coda (Iverson & Ahn 2003)

(i) /p^h, pp/ → [p]

(ii) /k^h, kk/ → [k]

(iii)/t^h, tt, c, c^h, cc, s, ss, h/ → [t]

What is relevant is that the neutralized segments behave in exactly the same way irrespective of the underlying representation. Korean also has a process of ‘tensification’ that unaspirated stops (also, other ‘plain obstruents’) become ‘tense’ after an unaspirated stop (7). All the stops in the coda position trigger the process irrespective of phonemic affiliation, thereby providing evidence that they are all in deed neutralized to the same (voiceless) unaspirated stop category.

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[2] There is a controversy regarding the phonological representation of the ‘tense’ stops that is not relevant to the discussion (Avery & Idsardi 2001). The tense stops are argued by some to be phonetic manifestations of geminate representations /tt, kk, pp/ → [t’, k’, p’]. Following Avery & Idsardi (2001), I shall use geminates to represent the underlying representations of these sounds

(7) Tensification in Korean (Sohn 1987)

a. /k^h + p/ → [kp’]

/puʌk^h patak/ → [puʌkp’adak][3] ‘kitchen floor’

b. /k + p/ → [kp’]

/kikpinca/ → [kikp’inja] ‘poor person’

So, it is clear that despite the controversial claim by some phoneticians that (coda) laryngeal neutralization is a myth, the position is not tenable for all languages.

What is important for this dissertation is the fact that nasals in languages with (coda) laryngeal neutralization in surface representations *never* surface as partially-nasal stops. The observation seems to be that the nature of laryngeal representations in underlying representations is relevant for the phonetic manifestation of the nasals, and the dimension SP.

5.2.2 Surface Laryngeal contrast that is phonemically absent

The second type of languages that is relevant in our understanding of the nature of contrast that nasals are sensitive to is that language with surface laryngeal contrast but no phonemic laryngeal contrast, i.e., languages where a laryngeal contrast is derived through allophonic variation.

As was mentioned in Chapter 3, Australian aboriginal languages, typically, have consonant inventories without a laryngeal contrast in any syllabic position (8) (Harrington 2006; Butcher 2006).

[3] Korean unaspirated stops are voiced after sonorants.

(8) Typical stop contrast in Australian languages

voiceless stops	p	t̪	t	c	ʈ	k
nasals	m	n	n	ɲ	ɳ	ŋ

However, the voiceless stops are often voiced in inter-sonorant (onset) position (9) (Butcher 2006).

(9) Voicing alternation in Warlpiri (Butcher 2006)

/waca kanpa/ → [ˈwaɟa ɰab]

‘Are you going?’

The stops are not consistently voiced, though, in all inter-sonorant (onset) positions. In Matjiltjara, stops are consistently voiced after nasal segments, but not after liquids or other sonorant consonants (10a). In Gugu-Yalanji, it can be seen that the stops are consistently voiced in post-nasal contexts, but not in post-vowel contexts (10b).

(10) Voicing in Australian languages

a. Matjiltjara (Marsh 1969)

i. /kumpila/ → [kʊm**b**ila]
‘hide!’

ii. /malpa/ → [mal**p**a] (or) [mal**b**a]
‘spear (type)’

b. Gugu-Yalanji (Gnanadesikan 1997, Oates & Oates 1964)

i. pa**t**a ‘lower down’

ii. tji**p**arr ‘south’

iii. yirm**b**al ‘mineral water’

iv. pun**d**ay ‘sit’

In fact, in a large-scale study of the phonotactics of Australian aboriginal languages, Hamilton (1996) details the voicing characteristics of stops in many of these languages. In many (if not almost all) languages with a 2-way stop contrast system, post-nasal environments are the only consistent voicing environments for stops. Given that other post-sonorants do not consistently voice the stops, it is most likely that the stops are voiced via a process of phonological voicing in the above data, than through passive phonetic voicing, as one would expect passive phonetic voicing to be triggered by other sonorant segments too. Therefore, these languages appear to have a laryngeal contrast in onsets of surface forms but not in underlying forms.

Despite the lack of underlying laryngeal contrast, these languages *never* appear to show nasals that surface as partially-nasal. However, they do seem to have a laryngeal contrast in surface forms. Therefore, it appears as though nasals are sensitive to the laryngeal contrast in surface forms, and surface as simple nasals in the above mentioned Australian (aborigine) languages.

5.2.3 Reconciling theory with fact

In the preceding sub-sections, I showed that the surface manifestation of nasals depended both on the nature of laryngeal contrast in a specific syllable position in both the underlying representation (section 5.2.1), and in the surface representation (section 5.2.2). However, the notion of laryngeal contrast in the relevant syllabic positions of underlying representations is not one that sits well with many modern conceptions of underlying representations.

In classical (rule-based) generative phonology, syllabification has (typically) been argued to be absent form lexical representations (Kenstowicz 1994; Blevins 1995 inter alia). As seen from the quotes in (11-12), this view stems from the meta-theoretical concern of removing any predictable information from underlying representations.

(11) ‘‘Words are represented in memory in a format that is quite abstract in that it omits many characteristics that can be observed in the acoustic signal and the articulatory gymnastics. . . . [O]ne may speculate that space in our memory is at a premium and that we must therefore store in our memory as little information as possible about the phonetic shape of each word, eliminating as many redundancies as possible and placing maximum reliance on our ability to compute the omitted information.’’ (Halle 1985: 150–151)

(12) ‘‘[T]he syllable structure of an English word . . . is totally predictable from the sounds that compose the word. In short, both syllable structure and stress are predictable; therefore, they do not appear in the underlying representation but are introduced into the surface representation as a result of the application of certain rules.’’ (Bromberger and Halle 1989:57).

So, for a word like ‘bet’ [bɛt] in English, the underlying representation is expected to be /bɛt/ without any syllabic or prosodic information (13).

(13) UR → Surface form

/bɛt/ → σ[4] (b ɛ t)

[4] I have not represented syllable internal organization as that is not relevant for the present exposition.

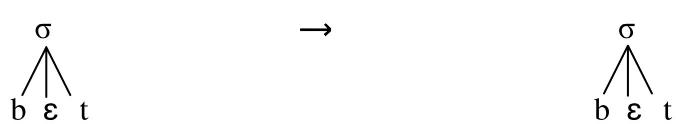
In Optimality Theory, the need for maximally redundance-free lexical representations is traded for surface-true representations in the absence of counter-evidence, through the principle of Lexicon Optimization (14).

(14) Lexicon Optimization (Prince & Smolensky 1993; Kager 1999)

Suppose that several different inputs I_1, I_2, . . ., In when parsed by a grammar G lead to corresponding outputs O_1, O_2,. . .,O_n, all of which are realized as the same phonetic form P – these inputs are all phonetically equivalent with respect to G. Now one of these outputs must be the most harmonic, by virtue of incurring the least significant violation marks: suppose this optimal one is labeled O_k. Then the learner should choose, as the underlying form for P, the input I_k." (p.209)[5]

The principle in (14) forces underlying representations to be surface-true in the absence of any alternations to the contrary. So, ceteris paribus, a word like 'bet' would be stored with its prosodic information in the lexical representation (15).

(15) UR Surface form



However, the principle of Lexicon Optimization has been argued to be empirically inadequate as a principle for positing underlying representations. Idsardi (2005), Nevins and Yolcu-Kamali (2005), and Nevins and Vaux (2006) have shown that the choice of lexical representations depends on a variety of factors like statistical inference,

[5] Contrastingly, McCarthy (2005) argues that underlying representations (URs) need not be surface-true in non-alternating forms; i.e., a non-alternating surface form [A] need not have an identical UR /A/; if there is already a need for the mapping [B] → [A] in the language, then even non-alternating forms [A] take a 'free ride' of the alternation and therefore have /B/ in the UR, instead of /A/.

orthographic knowledge, and hypercorrection. Therefore, in the absence of the principle of Lexicon Optimization, it is unclear what exactly the nature of underlying representations is in Optimality Theory.

Despite the expectation of no syllable structure in underlying representations in classical (rule-based) generative phonology (through meta-theoretic concerns), and a noncommittal view in Optimality Theory, it is clear from the preceding sections that syllable structure needs to be there in both underlying representations and surface representations, as the gestural manifestation of nasals depends on the nature of both underlying and surface laryngeal contrast in specific syllabic positions. Therefore, in the simple case, lexical representations are similar to those in (14).

This view that lexical representations have syllable structure receives support from work on prosodically-conditioned allomorphy by Vaux (2003). Vaux (2003) shows that the selection of the allomorphs in many languages depends on 'syllable-counts'. For example, in Standard Western Armenian, the plural allomorph is /-er/ when the root is monosyllabic (16), but /-ner/ elsewhere (16).

(16) Western Armenian plural allomorphy

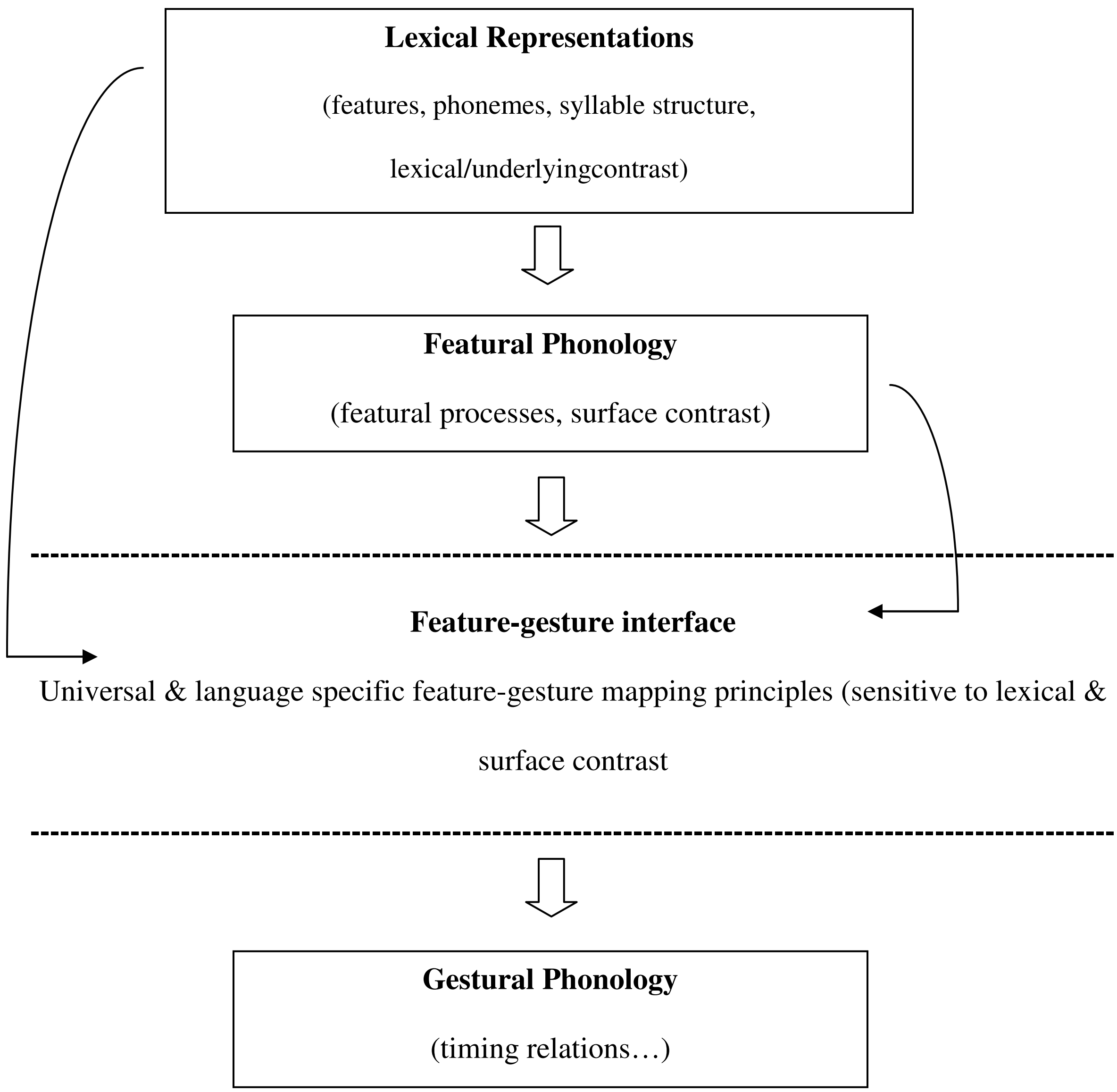
a.	ts^{h}i	ts^{h}i-er	'horse'
	k^{h}ɑr	k^{h}ɑr-er	'rock'
b.	moɾuk^h	moɾuk^h-neɾ	'beard'
	jeɾeχɑ	jeɾeχɑ-neɾ	'child'
c.	mɑnəɾ̥	mɑnɾ-eɾ	'small thing'
	p^{h}ok^{h}əɾ̥	p^{h}ok^{h}ɾ-eɾ	'small thing'

He also argues that the allomorphy is sensitive to syllables in the underlying representations, and not surface representations. In final consonant clusters that end in /ɾ̥/, there is a process of epenthesis that breaks up the clusters, when the morpheme is used by itself. Despite the surface bi-syllabicity of these morphemes, it is the plural allomorph for monosyllabic stems that surfaces with these morphemes (16c). Based on similar data in neighbouring dialects of Armenian, and many other languages, Vaux (2003) argues that underlying representations must have syllable structure.

Another aspect of phonological theory that the data has a bearing on is the sensitivity of phonetic output forms to different kinds of contrast. The traditional phonological understanding of the effect of contrast on phonetic manifestations as represented in recent work on ‘enhancement’ has been that phonemic contrast is relevant for the purposes of phonetic manifestations (Stevens & Keyser 1989; Clements 2004, Hall 2007 inter alia). Traditionally, the relevance of non-phonemic surface contrast to phonetic interpretation has received scant attention. However, recently, some work in Optimality Theory has argued that the phonetic output forms of morphemes are solely controlled by constraint ranking, thereby implying that only surface contrast is relevant for phonetic manifestations (Kirchner 1995; Flemming 1997; Kirchner 2001; Padgett 2003; Lubowicz 2003 inter alia). The data in the preceding sections show that this latter position is untenable. I have shown that both surface contrast *and* underlying (phonemic) contrast affect phonetic (gestural) interpretation of phonological features (dimensions).

The view of phonology that results from the preceding sections and the analyses in this dissertation is one in which underlying representations have syllable structure; both contrast in underlying representations and surface representations are relevant for the gestural manifestation of features/dimensions (specifically, the dimension SP); and there are specific paradigmatic and syntagmatic feature-gesture principles at the feature-gesture interface. This model of phonology is schematized below in (17).

(17)



5.3 Categorical Features

In this section, I shall show that abstract categorical representations are necessary to account for the actual processes that partially-nasal stops participate in. In particular, I shall show how the abstract representation for nasal segments, the dimension Soft Palate (SP), proposed in this dissertation accounts for the behaviour of different partially-nasal stops in nasal harmony processes.

The standard view on phonological features is that they are abstract (atemporal) and categorical; therefore, segments specified for the feature 'X' can participate in processes that refer to the feature, and segments not specified for the feature 'X' cannot participate in processes that refer to the feature (Chomsky & Halle 1968; Kenstowicz 1994, inter alia). However, more recently, some researchers have questioned this traditional/standard understanding (Port & Leary 1986; Browman & Goldstein 1986; Ohala 1990; Benus & Gafos 2006; Port 2007; VanDam 2007), instead arguing for either 'dynamic' conceptions of features with gradient qualitative distinctions (Benus & Gafos 2006; Kirov & Gafos 2007), or Articulatory gestural representations (Browman & Goldstein 1986, et seq; Ohala 1990; Gafos 2002 inter alia), or exemplar representations that have fine grained phonetic detail in lexical representations (Pierrehumbert 2001; Port 2007; VanDam 2007).

In chapter 3, I showed that there are at least two different kinds of partially-nasal stops: nasal-based partially-nasal stops (N-PNS), and voice-based partially-nasal stops (V-PNS). Both N-PNS and V-PNS show substantial variation in their surface manifestations. N-PNS can come in one of three surface forms next to tauto-syllabic oral vowels: a simple nasal stop, a partially-nasal stop, or a simple oral stop (18). V-PNS appear to show a variation between fully voiced stops and partially nasal stops (18).

(18) Variation of PNS

a. N-PNS

[m] (or) [m^{b}] (or) [b/p]

b. V-PNS

[b] (or) [^{m}b]

If this variation were, instead, represented in either lexical representations (as *exemplar theories* and *dynamic feature theories* would have to claim) or in the (featural) phonology proper, where nasal harmony takes place (as *articulatory gestural representation theories* claim), then it would be expected that we find variably cases of nasal harmony for PNS segments. Since the variation is either in the lexical representations or in the phonology itself, different variants of the PNS could trigger or not trigger nasalization for the same word/morpheme as shown in (19). In regressive harmony systems, N-PNS are expected to show nasalization with two of the variants of the same morpheme/word, but not the third (19), and V-PNS are expected to show nasalization with one of the variants of the morpheme/word but not the other (19).

(19) Logically expected variation in regressive nasal harmony

a. Expected variation for the same word/morpheme in nasalization from **N-PNS** in a language

i. ãh̃ãma (nasalization occurs)

ii. ahaba (no nasalization occurs)

iii. ãh̃ãm^{b}a (nasalization)

b. Expected variation for the same word/morphemes in nasalization from **V-PNS** in a language.
   i. ahaba (no nasalization occurs)
   ii. ãh̃ã^{m}ba (nasalization)

Similarly, in progressive nasal harmony systems, N-PNS are expected to show nasalization with only one of the variants of the same word, but not the other two (20), and V-PNS are expected to show nasalization with no variant (20).

(20) Logically expected variation in progressive nasal harmony
a. Expected variation for the same word/morpheme in nasalization from **N-PNS** in a language
   i. ahamã (nasalization occurs)
   ii. ahaba (no nasalization occurs)
   iii. aham^{b}a (no nasalization occurs)

b. Expected variation for the same word/morphemes in nasalization from **V-PNS** in a language.
   i. ahaba (no nasalization occurs)
   ii. aha^{m}ba (nasalization)

However, no such variation is found. On one hand, V-PNS are *categorically* inactive in nasal harmony rules – V-PNS never trigger nasal harmony in any language. On the other hand, if there is nasal harmony in the language, N-PNS *categorically* trigger nasal harmony. Language after language with N-PNS shows the same fact, if they spread nasality, they categorically spread nasality (21) – there is no surface variation with nasal harmony based on the surface variant of the PNS.

(21) Nasal-based partially-nasal stops spreading nasality

a. Guaraní - Walker (1998)

/ro + ^{m}bo +ɣ^{w}atá/ → [r̃õ^{m}bo ɣ^{w}atá] 'I made you walk'

b. Yuhup - Botma (2005)

/tə:d^{n} + ih/ → [tə:d^{n}ĩh̃] 'beating'

c. Tinrin – Botma (2004)

/fa + ^{n}de/ → [fã^{n}de] 'hang something up'

d. Jambi Malay (Tadmor & Yanti 2004)

(i) ayam → aya$^{(b)}$m 'chicken';

(ii) ayam-e → ayamẽ 'his chicken'

Clearly, there is a need for abstract and categorical representations – representations which are removed from phonetic variation (abstraction), and are representations that are either there or not (categoricality). The phonological representation posited for the segments in chapter 3 capture these requirements. N-PNS are argued to be representationally identical to simple nasals in the featural phonology; therefore, they will categorically spread nasality in the phonology if there is a nasal harmony process. In contrast, V-PNS were argued not to be featurally specified for nasality, the dimension SP, in the featural phonology (22); therefore, they will categorically remain inactive in nasal harmony processes.

(22) Specifications for PNS

a. N-PNS (or simple nasals) in featural phonology

X
|
SP

b. V-PNS in featural phonology

X
|
ø

With the abstract-categorical representations in (22) and the gestural completion rules motivated in chapter 3, it was shown that we are able to capture the exact variation of partially-nasal stops across the world's languages.

Appendix

A PHONOLOGICAL SKETCH OF TANJUNG RADEN JAMBI MALAY

Jambi Malay is a Malay dialect/language spoken in the province of Jambi, Indonesia. The specific dialect of Jambi Malay that I shall provide a brief phonological sketch for here is the Tanjung Raden dialect spoken in the village of Tanjung Raden that is one of the many villages across the river (Batanghari) from Jambi City.

Previous descriptions of Jambi Malay by Husin, et al. (1985) and Gani, et al. (2000) are at best descriptions of the language spoken in the Jambi City than of the neighbouring dialects. However, the authors show no awareness of the stark difference between the city dialect and the neighbouring village dialects, and speakers from multiple dialectal backgrounds were used to collect the data thereby severely contaminating the data obtained. Anderbeck (2003) was the first to systematically describe the dialectal variation that is apparent around Jambi city. However, this study was limited to collecting Swadesh word-lists from various dialects and the observations are limited to the data therein. Yanti (in prep.) in her dissertation on the Jambi Malay dialects of Tajung Raden (TR), Mudung Darat (MD) and Jambi City (JC) presents the first detailed study of any Jambi Malay dialect.

In the sub-sections that follow, I present a brief phonological sketch of the TR Jambi Malay based on the findings of Tadmor & Yanti (2005), and Yanti (in prep.), along with data collected during my own field-work.

In the following sub-sections, I first discuss the consonant and vowel inventories of the language. In section 1 through 3, I briefly discuss the consonant and vowel phonotactics. In section 4, I discuss the syllable structures observable in the morphemes of the language. In section 5, I present the facts about stress. And finally, in section 6, I briefly present some morpho-phonological and allophonic processes in the language.

I encourage the reader to refer to Yanti (in prep.) for a much more thorough description of the phonology of the language.

1 Phonological Inventory

The consonant inventory in TR Jambi Malay has a total of 23 consonants (one of which appears exclusively in loanwords) that includes 8 oral stops - 4 of which are voiceless [p, t, c, k], and the other four are voiced [b, d, ɟ, g][73]; 4 simple nasal stops [m, n, ɲ, ŋ]; 4 post-stopped nasals [M, N, NY, NG][74]; 3 fricatives [s, z, h]; 2 liquids [l, ʁ]; 2 glides [w, y]; and a glottal stop [ʔ]. This list of consonants is shown below in Fig. A.1. I refer readers to Yanti (in prep.) who suggests that it is possible to analyse the glides [w, y] as derived from underlying high vowels /u, i/, respectively.

[73] As in many other Malay languages/dialects, the voiceless counterpart of the dental-alveolar oral stop is more dental, and the voiced counterpart is more alveolar.
[74] These have variously been called 'post-occluded nasals', 'prenasalised stops', 'funny nasals'. In chapter 4, I argue that these are best classified as Obstruent Nasals. For our present purposes, I use the upper nasal symbols [M, N, NY, NG] to represent them.

		Bilabial	Dental-Alveolar	Palatal	Velar	Uvular	Glottal
Oral stop	voiceless	p	t	c	k		ʔ
	voiced	b	d	ɟ	g		
Fricative	voiceless		s				h
	voiced		(z)[75]				
Nasal stop		m	n	ɳ	ŋ		
Post-stopped Nasal		M	N	NY	NG		
Liquid			l			ʁ	
Glides		w		y			

Fig. A.1: Consonant Inventory of TR Jambi Malay

Furthermore, Yanti classifies the palatal stops /c, ɟ / as palatal affricates; this classificational choice might appear somewhat arbitrary. However, classifying them as palatal stops achieves symmetry in the inventory with respect to simple nasals and post-stopped nasals: there is an oral stop correlate for simple nasals and post-stopped nasals at each place of articulation.

The vowel inventory of the language includes 10 vowels; 4 high vowels distinguished by backness, rounding and ATRness /i, ɪ, ʊ, u/; 3 mid vowels distinguished by backness and rounding /e, ə, o/; one low vowel which surfaces as a back vowel /a/; and two nasalized vowels / õ, ã/. The nasal vowels are contrastive only in a handful of loan words, and are therefore in parentheses.

[75] The consonants in parentheses only appear in loanwards – most usually from Arabic.

		Front	Mid	Back
High	+ATR	i		u
	-ATR	ɪ		ʊ
Mid		e	ə	o, (õ)
Low				a, (ã)

Fig. 2: Vowel Inventory of TR Jambi Malay

It is important to note that while I have classified the vowels /ɪ, ʊ/ as [+high, -ATR] vowels, it is not entirely clear that this is the right description of the segments. Uri Tadmor (personal communication) and Yanti prefer describing them as 'high-mid' vowels, thereby implying that height is the relevant distinguishing feature (compared to other high vowels) for them, rather than ATRness. However, for the present purposes, I shall retain the presented description because the little phonological evidence on the matter that comes from root-vowel harmony appears to support my classification (presented abstractly in (1), and discussed in a little more detail in section A.1.2.2) – wherein, the high vowels as I have classified them interact in harmony processes, while the other vowels do not.

(1)	a. iCi	e. ɪCɪ	i. *iCɪ	m. *iCʊ
	b. iCu	f. ɪCʊ	j. *uCɪ	n. *uCʊ
	c. uCi	g. ʊCɪ	k. *ɪCi	o. *ʊCi
	d. uCu	h. ʊCʊ	l. *ɪCu	p. *ʊCu

This interaction limited to the four high vowels would be a bit puzzling in a system where the vowels were distinguished solely by vowel height – as it would not be obvious why only the highest two vowel heights interact in the harmony process. However, I submit that this classification deserves further phonological and phonetic scrutiny.

It is also important to mention that, while I choose to present the /ə/ as a separate phoneme, Yanti argues that it is possible to analyse the schwa as a derived segment; through the process of /ə/-epenthesis in some environments, and through the process of /a/-reduction in others. I refer the reader to her work for a more elaborate consideration of the topic.

2 Consonant Phonotactics

2.1 Word-initial position

Almost all the consonants in the inventory appear word-initially as shown in (2) below. In (2), I show representative examples for segments with different manners, but this is true for all other places of articulation except for those segments that I mention explicitly. The voiced fricative /z/ and the glottal fricative /h/ are found in word-initial position, only in loan-words. Furthermore, the glottal stop is always predictable for vowel-initial words, and probably best analysed as present in this context through a process of epenthesis – some support for this analysis comes from the fact that native speakers are usually not aware of the glottal stop in the word-initial position.

(2) Word-initial consonants

a. pasát	'clear'	h. ʔakú	'1SG'
b. bakáʁ	'burn'	i. mãʔãp	'apology'

c. caʁí	'search'	j. Móʔ	'older sister'
d. ɟaʁí	'finger'	k. ʁamẽ̃	'crowded'
e. sanɔ̃	'there'	l. lawáŋ	'door'
f. zamãn	'era'	m. waɟá	'face'
g. haláŋ	'prevent'	n. yakín	'believe'

2.2 Word-medial position

All the phonemic consonants in the language are contrastive in the word-medial position. Again representative examples for different manners of articulation are shown in (3).

(3) Word-medial position

a. apʊ́s	'erase'	h. mãʔãp	'apology'
b. labú	'pumpkin'	i. ʁamẽ̃	'crowded'
c. acáʁ	'pickle'	j. ɟaMí	'Jambi'
d. ʁaɟó	'king'	k. mãʁã	'angry'
e. pasáʁ	'market'	l. mãlám	'evening'
f. azán	'azan'	m. lawáŋ	'door'
g. mãhãl	'expensive'	n. layáŋ	'cross'

2.3 Word-final position

The consonant inventory in the word-final position is far more limited than in other positions in the word in TR Jambi Malay. The entire series of palatal consonants, voiced stops, and post-stopped nasal do not appear in word-final position. Along with this, the segments /h/ does not appear word-finally. The segments /p, t, k, m, n, ŋ, ʔ, s, ʁ, l, y/ do occur word finally. Representative examples of different manners of articulation are shown below in (4).

(4) Word-final position

a. saʁáp	'garbage'	e. səhəláy	'a fabric (classifier)'
b. panãs	'hot'	f. bakáʁ	'burn'
c. mãsʊ́ʔ	'enter'	g. mãhãl	'expensive'
d. mãlám	'evening'		

2.4 Syllabic consonants

The syllabic consonants in TR Jambi Malay are all sonorant consonants. These segments surface in words where an obstruent and a sonorant are separated by a /ə/ as shown in (5a-c); the schwa appears to delete and the following sonorant surfaces as syllabic[76].

(5) a. /təʁʊs/ → [tʁ̩ʊ́s] or [təʁʊ́s] 'continue'

b. /bəras/ → [bʁ̩ás] or [bəʁás] 'uncooked.rice'

c. /plaŋ/ → [pl̩a^{g}ŋ] or [pəla^{g}ŋ] 'clinch'

Syllabic sonorants also surface on the left-edge of mono-syllabic words (6)[77] - probably to satisfy a word-minimality (bi-syllabicity) requirement that can be observed for most

[76] As mentioned earlier, I posit that the /ə/ is in the underlying representations for expositional convenience, but Yanti (in prep.) agrues that it is possible to remove /ə/ from the phonemic inventory, and derive it thru the processes of /ə/-epenthesis and /a/ reduction.

words in the language. Also, note that in such cases, a glottal stop is inserted at the beginning of the word as with other word-initial vowels.

(6) a. /mpat/ [ʔm̩pa^{n}t] ‘four’

b. /nam/ [ʔn̩nãm] ‘six’

c. /laŋ/ [ʔl̩la^{g}ŋ] ‘eagle’

3 Vowel Phonotactics

3.1 Word/morpheme-final syllables

In open syllables, all vowels, except /ə/ which does not occur in any word/morpheme final syllables, occur word/morpheme-final syllable. Representative examples are in (7) below.

(7) a. bulú	‘body hair’	e. ɟaló	‘net’
b. bʊlʊ́	‘bamboo’	f. gawé	‘work’
c. sapí	‘cow’	g. tapá	‘kind of fish’
d. sapɪ́	‘wean’		

In closed final syllables, vowels appear to be subject to some restrictions (8). In general [+high +ATR] /i, u/ are largely absent in final closed syllables. And historically final high vowels in closed syllables appear to have undergone ‘lowering’ or ‘laxing’.

(8) Historical final high vowels TR Jambi Malay

a. sakít	sakɪ́t	'sick'
b. masúk	mãsʊ́ʔ	'enter'
c. kurús	kʊʁʊ́s	'thin'

However, the exact status of this process is unclear as there appear to be morphemes that resist this process as shown in (9).

(9) a. dikít 'a little'

b. kəcîʔ 'small'

3.2 Word/morpheme-non-final syllables

The vowels in morpheme internal syllables in TR Jambi Malay are again subject to some restrictions. In general all vowels are possible in both open and closed syllables in this position (10).

(10) a. gigí	'teeth'	e. mẽjá	'table'
b. gɪgɪ́t	'bite'	f. soré	'afternoon'
c. bulú	'body hair'	g. ɟaló	'net'
d. bʊlʊ́	'bamboo'	h. gəláʔ	'laugh'

However, there appears to be a root-harmony requirement for high vowels as shown in (11a). High vowels in a root must agree in ATRness. However, it is clear from (11b) that affixal vowels are not subject to this restriction.

(11) a. Root-Vowel Harmony

i. bʊkɪ́ t	'hill'	iv. gɪgɪ́t	'bite'
ii. pɪlɪ́	'choose'	v. lucú	'funny'
iii. gigí	'tooth'	vi.. bʊlʊ́	'bamboo'

b. Harmony does not spread to prefixes or suffixes

i. di+pɪlɪ́	*dɪ + pɪlɪ́	'be chosen'
ii. mãsʊ́ʔʔi	*mãsʊ́ʔʔɪ	'enter + APPL' [= 'put (it) into']

This root internal harmony, however, appears to be blocked in cases where the underlying vowels are adjacent to each other as in (12). I refer the readers to Yanti (in prep.) for more details on this harmony blocking.

(12) a. /pariʊʔ/	[pa.ri.^{y}ʊ́ʔ]	'pot'
b. /duɪt/	[du.^{w}ɪ́t]	'money'

4 Syllable Structure

The set of possible syllable types in morphemes includes the following: V, VC, CV, CVC, and CCVC, as shown below in (13). While most syllable types below are quite freely used with different segments, it appears to be the case that CCV are limited to /pw/.

(13) a. V	a.sap	'smoke',	o.jek	'motor-cycle taxi'
b. VC	an.tar	'deliver',	un.tal	'roll'
c. CV	bu.lu	'body hair',	ɟa.lo	'net'

d. CVC jan.tan ‘male’, kampʊŋ ‘village’

e. CCV pwaso ‘fast’

5 Stress

Stress in Jambi Malay is not contrastive at the word-level, and is always on the last syllable of the final root-morpheme in a phrase (14a). The main correlate of stress in Jambi Malay is a noticeable lengthening of the final syllable[78]. This is especially clear when suffixes are added to roots. As can be seen in (14b), the stress remains on the last syllable of the root.

(14) a. Stress in monomorphemic words

i. bulú ‘body hair’

ii. ɟaló ‘net’

iii. bʊlʊ́ ‘bamboo’

b. Stress in poly morphemic words

i. ayám+ẽ ‘his chicken’

ii. si^{y}á $^{(m)}$p+ʔẽ ‘ready APPL’ [= ‘to prepare’]

iii. mãsʊ́ʔ+ʔi ‘enter + APPL’ [= ‘put (it) into’]

[78] It is not clear at the moment if this lengthening is phonological or phonetic lengthening. The one possible argument to it being a phonetic fact is that native speakers are not usually aware of this. However, this is not a strong argument, so I leave it for future research to clarify this issue.

6 Some morphonological and allophonic processes

6.1 Word final nasal consonant preocclusion

Word final nasal consonants in TR Jambi Malay surface as either simple nasal segments or as post-nasalised (or pre-occluded segments), as shown in (15). This is, in fact, most-likely a phrase final process.

(15) a. /malam/ → [mãlám] or [mãlá^{b}m] 'night'

b. /ɟalan/ → [ɟalán] or [ɟalá^{d}n] 'walk'

c. /toloŋ/ → [tolóŋ] or [toló^{g}ŋ] 'please'

However, this allophonic variation is blocked in cases where the final nasal is preceded by a nasalized vowel[79]. In this case, only the simple nasal surfaces (16).

(16) a. /minum/ → [mĩnṹm] *[mĩnũ^{b}m] 'drink'

b. /taŋan/ → [taŋã́n] *[taŋã^{d}n] 'hand'

c. /kuniŋ/ → [kuñĩŋ] *[kuñĩ^{g}ŋ] 'yellow'

6.2 Final voiceless oral-stop nasalization

The final voiceless oral stops surface as simple voiceless oral stops, or as pre-nasalised segments (17).

[79] Vowel nasalization is not distinctive, but is actually the result of nasal harmony as discussed in section A.1.5.3.

(17) a. /sakɪt/ → [sakɪ́t] (or) [sakɪ́^{n}t] ‘sick’

b. /asap/ → [ʔasáp] (or) [ʔasá^{m}p] ‘smoke’

c. /ojek/ → [ʔojék] (or) [ʔojé^{ŋ}k] ‘motorcycle taxi’

6.3 Nasal Harmony

Nasal harmony in TR Jambi Malay spreads rightwards on to following segments from a nasal consonant. While the immediately following vowel is always nasalized, whether or not the following vowels are nasalized depends on the intervening consonants. The glottal segments [h, ʔ] and the glides [w, y] are transparent to the process (18a-d), but all other consonants block the spread of nasality. It is not clear if the intervening consonants in a nasal harmony span are nasalized: however, my own field-notes indicate that at least the glides are nasalized, the nasalization in the glottal segments was more difficult to ascertain, as one would need some sort of articulatory measurements for this as briefly mention in Chapter 2.

(18) a. /mahal/ → [mãhãl] ‘expensive’

b. /maʔap / → [mãʔãp] ‘apology’

c. /mawar / → [mãw̃ãr] ‘rose’

d. /mayat/ → [mãỹã^{n}t] ‘corpse’

e. /mara/ → [mãrá] ‘angry’

f. /masʊʔ / → [mãsʊ́ʔ] ‘enter’

g. /mato/ → [mãtó] ‘eyes’

Furthermore, nasal harmony also occurs when a vowel-initial suffix is added as shown below in (19a-b). What is interesting to note is that even underlying voiceless oral consonants in the root-final position appear to spread nasality (19c-d), suggesting that root-final voiceless stops are also phonologically specified for nasality at the point the harmony process happens.

(19) a. /ayam/ → [ayá$^{(b)}$m] 'chicken'

b. /ayam+e/ → [ayámẽ] 'his chicken'

c. /siap/ → [siá$^{(m)}$p] 'ready'

d. /siap+i/ → [siá$^{(m)}$pʔẽ] 'ready APPL' [= 'to prepare']

e. /masʊʔ/ → [masʊ́ʔ] 'enter']

f. /masʊʔ+i / → [mãsʊ́ʔʔi] 'enter + APPL' [= 'put (it) into']

It could be argued that the nasalization in the case of voiceless consonants is actually triggered by the glottal stop (which is also inserted in these morpho-phonological context) as a result of rhinoglottophilia (refer to Chapter 2 for more details on this phenomenon); however, underlying glottal stops in the same context do not spread the rule as is evidenced in (19e-f). Therefore, the nasal harmony rule is triggered only by nasal consonants, and root-final (nasalized) oral stops.

6.4 Nasal prefixation

The agentive prefix /ŋ-/ partakes in some interesting morpho-phonological alternations; that are similar to those in other Malayic languages When it attaches to vowel-initial roots, it surfaces as a simple velar nasal (20a-b); when it attaches to voiceless oral-stop-initial roots, the voiceless segment is deleted and the nasal surfaces with the place of articulation as the root-initial voiceless segment (20c-d); when it prefixes to voiced-stop initial roots, post-stopped nasals surfaces in place of the voiced stops (20e-f); the prefix does not surface when it attaches to nasal-initial roots (20g); and finally, when it attaches to sonorant initial stops, it surfaces as a syllabic nasal, except when it attaches to /y/ initial roots, when it surfaces as [mə] (20h-j).

(20) a. /ŋ + ikʊt/ → [ŋĩkʊ́^{n}t] ‘ACT-follow’ (=’to follow’)
b. /ŋ + aŋkʊt/ → [ŋãŋkʊ́^{n}t] ‘ACT-transport’ (=’to transport’)
c. /ŋ + panen/ → [mãnẽ̃n] ‘ACT -harvest’ (=’to harvest’)
d. /ŋ + tanam/ → [nãnã̃m] ‘ACT -plant’ (=’to plant’)
e. /ŋ + buat/ → [m^{b}uá^{n}t] ‘ACT-make (=’to make’)
f. / ŋ + dukʊŋ/ → [n^{d}ʊkʊ́^{g}ŋ] ‘ACT-support’ (= ’to support’)
g. /ŋ + naeʔ/ → [nãéʔ] ‘ACT-go.up’ (=’to go up’)
h. /ŋ + lolo + -i/ → [m̩loló y] ‘ACT-stupid-APPL’ (=’to trick’)
i. /ŋ + warɪs/ → [m̩warɪ́s] ‘ACT -heir’ (=’to inherit’)
j. / ŋ + yakɪn + kan/ → [məyakɪ́nkan] ‘ACT -believe-APPL’ (‘to believe’)

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