Phonological aspects of nasality: An element-based dependency approach

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In the previous chapter I examined the issue of laryngeal modifications in the class of nasals. In the present chapter, I consider the issue of nasal modifications in the class of laryngeals. Thus, the resulting segment type is that of “nasalized laryngeals”. Processes in which nasalized laryngeals are involved include nasalization processes which target laryngeals, processes in which laryngeals trigger vowel nasalization, alternations between nasals and laryngeals, and diachronic changes in which laryngeals develop into nasals or vice versa.

In this chapter, I will be concerned mainly with the role of laryngeals in nasalization processes. In §6.1, I discuss a number of examples of distinctively and non-distinctively nasalized laryngeals, and consider some cases of “spontaneous nasalization” of vowels by laryngeals. In §6.2, I briefly consider a number of other phenomena that involve a phonological interaction between nasality and laryngeal articulations, and examine to what extent these phenomena involve spontaneous nasalization. In §6.3, I discuss some general repercussions that the recognition of a class of nasalized laryngeals has on the Element-based Dependency representation of segmental contrasts.

### 6.1 Derived and distinctive nasalized laryngeals

In the Element-based Dependency approach to nasalization in chapter 3, the discussion of nasalized segment types was limited to nasalized sonorants. In this section, I consider the phonological status of nasalized laryngeals, i.e. placeless manner structures with dependent [L]. This concerns the two structures in (1):

(1) a. O \[ \begin{array}{c} ? \ \ \ \ L \ \ \ \ H \ \ \ \ L \\ \end{array} \] b. O \[ \begin{array}{c} \end{array} \]

Support for the representations in (1) comes from the existence of nasalization processes which target laryngeals and from the existence of processes in which nasalization is triggered by laryngeals.

Nasalized laryngeals involve the combination of a lowered velum and a constriction behind the uvula. Note that in case of complete glottal closure, as in
[?] a lowered velum does not result in any audible nasalization. However, it is important to note that there is nothing which prohibits the combination of glottal closure and velic lowering from an articulatory viewpoint. Moreover, it should be noted that the release phase of a glottal stop can be accompanied by audible nasalization. For instance, Harris (1972) reports that in Standard Thai utterance-final voiceless stops, including [?], are typically realized with a slight nasal release, so that they can be transcribed as [pʰ tʰ kʰ ?ʰ]. The same allophonic realization is found in Vietnamese (cf. Ladefoged & Maddieson 1996:129).

Most instances of nasalized laryngeals are the result of nasal harmony processes in which laryngeals are included in the target range of nasalization. According to the nasal harmony database in Walker (1998), laryngeals are in fact the consonant type that is most prone to undergo nasalization. Walker argues that segment nasalizability in nasal harmony involves the implicational hierarchy in (2):

\[(2) \quad \text{vowels} > \text{laryngeals} > \text{glides} > \text{liquids} > \text{fricatives} > \text{stops}\]

The hierarchy in (2) reflects the fact that vowels are the most likely segment type to undergo nasalization. It is implicational in the sense that it expresses the fact that if in a language a particular segment type is a nasalization target, then all segment types which are more prone to be nasalized are also targets. Thus, (2) predicts for instance that if in a language liquids are nasalized, then glides, laryngeals, and vowels will also be nasalized. The hierarchy also predicts that there are languages in which nasalization targets vowels and laryngeals only. As was noted in §3.2.1, one such language is Sundanese. Consider the forms in (3):

\[(3) \quad \text{nãjak  ‘sift-ACT’} \]
\[\text{ñawihi  ‘sing-ACT’} \]
\[\text{mãro  ‘halve-ACT’} \]
\[\text{mõlohok  ‘stare-ACT’} \]
\[\text{ñãtur  ‘arrange-ACT’} \]
\[\text{ñäfän  ‘wet-ACT’} \]
\[\text{ñãür  ‘say-ACT’} \]
\[\text{kumãhã  ‘how?’} \]
\[\text{biñhãür  ‘be rich-ACT’} \]
\[\text{mõ?iõsih  ‘love-ACT’} \]

The forms in (3) show that nasalization spreads rightward from a nasal, targets vowels and laryngeals, and is blocked by stops, fricatives, liquids, and glides. Of the laryngeals, /?/ is underlying and [?] occurs between identical vowels and at certain morphological boundaries (cf. Cohn 1990).

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1 Recall that epenthetic [w] and infixed [l] are included in the target range of nasalization.
As far as the nasalized laryngeals of Sundanese are concerned, acoustic measurements indicate that in nasal contexts /h/ is realized with nasal airflow (cf. Ohala 1990, see also Cohn 1990). There are also good grounds to consider [ʔ] in nasal contexts as nasalized. As was observed in §3.2.1, the incompatibility of nasal airflow and glottal closure does not imply that [ʔ] induces raising of the velum; indeed, velic raising is unexpected because the vowel following [ʔ] is nasalized. Hence, the interpretation of [ʔ] as nasalized in this context is essentially a matter of interpretation. If nasality is defined primarily in terms of nasal airflow, as Cohn assumes, [ʔ] is oral. If, on the other hand, nasality is defined by a lowered velum, [ʔ] can be interpreted as nasalized. This is the position taken in Walker & Pullum (1999). An argument for the latter view is that [ʔ], in Sundanese as well as in most other languages that I know, does not block nasalization. This means that an analysis which regards nasalization as being incompatible with glottal closure must explain why this incompatibility leads to transparency, while the incompatibility of obstruents, liquids, and glides leads to blocking of nasal spread.

Walker’s hierarchy seems on the whole to be descriptively adequate, although there appear to be some counterexamples involving laryngeals. However, in most of these cases there are arguments for analyzing the segments concerned as being supralaryngeal obstruents underlingly.2

Consider for instance the following facts from Terena (Tereno), an Arawakan language of Brazil (cf. Bendor-Samuel 1960; see also Ohala & Ohala 1993 and Walker & Pullum 1999). In Terena, nasalization functions as a morpheme indicating first person inflection. Nasalization spreads rightwards from the beginning of a word until it encounters a voiceless stop or fricative, which block nasalization and surface as prenasalized and voiced:

(4)  a. ajo ‘his brother’ b. ãĩ ‘my brother’
    owoku ‘his house’ õUõ’qu ‘my house’
    emoʔu ‘his word’ ūmũũ ‘my word’
    iso ‘he hoed’ ū”zo ‘I hoed’
    ah’αʔo ‘he desires’ ã”zäʔo ‘I desire’
    iha ‘his name’ ū”za ‘my name’

The forms in (4) show that nasalization spreads across [ʔ], but not across [h] and [hʔ]. With regard to this asymmetry, Ohala & Ohala (1993:231) maintain that the [h] (and perhaps the [hʔ]) derives from an earlier apical obstruent /t/, which plausibly passed through an intermediate stage of /s/ before becoming Terena /h/ in non-nasal environments.

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2 A “true” counterexample to the nasalizability hierarchy appears to be Rejang, where /ʔ/ blocks nasalization but glides do not (cf. McGinn 1979; see also Walker 1998).
Support for this diachronic scenario comes from the observation that in the synchronic grammar of Terena [h h1] pattern with fricatives rather than with [ʔ]. This can be seen in (4), where we find the surface alternations [h,s~n] and [h1,~n]. As Ohala & Ohala note, this means that nasalization of [h h1] cannot be reduced to coarticulation with an adjacent nasalized vowel, but must be viewed as being part of the phonology of Terena. More specifically, it suggests that the segments which in oral forms are realized as laryngeals function as supralaryngeal obstruents underlyingly. According to this interpretation, Terena does not constitute a counterexample to Walker’s nasalizability hierarchy.

Other apparent counterexamples involving blocking of nasalization by laryngeals are found in Inor and Bonggi. In Inor, nasal harmony appears to be blocked by [h], but this [h] can be analyzed as a surface realization of /x/ (Jean-François Prunet, p.c.). In Bonggi, an Austronesian language, word-final nasals have developed into prestopped nasals in case the word-final syllable did not begin with a nasal.3 Consider the examples in (5) (cf. Blust 1997:156):4

(5) fudâ < *puʔun ‘tree’
    buin < *bulan ‘moon’
    toriŋ < *teriŋ ‘species of bamboo’

Blust notes that there is one prestopping context which, in synchronic terms at least, is unexpected. This concerns words which in present-day Bonggi have [h] as the onset of the final syllable. The important observation here is that [h] in this context is historically derived from *k. As Blust (1997:156) notes:

In a word such as mokon [mʱʔhɔdʱ] ‘to eat’, nasal preplolion almost certainly occurred before the change of *k to [h], since h is transparent to nasal harmony virtually everywhere in island South-East Asia where we have sufficiently good descriptions to determine the point.

One interpretation of the Bonggi facts, as suggested by Blust, is to regard the variation between plain and prestopped nasals as no longer allophonic. According to this view, prestopped nasals can also occur in nasalizing contexts. While this seems reasonable, it should be observed that Blust does not transcribe the second vowel in [mʱʔhɔdʱ] as nasalized. If this vowel is indeed oral, and if, as Blust appears to suggest, Bonggi [h] is transparent to nasalization, then we

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3 This phenomenon was discussed in relation to nasal fortition in §4.3.2.

4 Blust does not give any examples of Bonggi forms in which the nasal has been retained; Blust’s description (and his discussion of prestopping in related languages) makes clear that these derive from words which have the shape *CVN VN (or *NVN VN).
may also interpret [h] as being derived from underlying /k/. It is clear that more data is required to substantiate either analysis.

The preceding discussion shows that laryngeals are among the segment types that are most prone to undergo nasalization. It is therefore surprising that a number of feature-based theories do not allow for the possibility of nasalized laryngeals. For instance, in some versions of Feature Geometry the feature [nasal] is analyzed as a dependent of the Supralaryngeal node, which is a property of all buccal segments (cf. Trigo 1993; see also Sagey 1986, Halle 1992). This organization predicts that /h/ cannot be phonologically nasalized. Another feature-based proposal that denies the phonological relevance of nasalized laryngeals is the SV-hypothesis (see Rice & Avery 1989, Piggott 1992, Rice 1993). As was observed in §3.2.2, the SV-hypothesis accounts for Tucano-type nasal harmony in terms of spreading of [nasal] to all SV-nodes within the harmonic domain. While this correctly accounts for the fact that the target range in Tucano-type systems includes all sonorants, it fails to account for the fact that in such systems laryngeals are also invariably included in the target range.

Proponents of these feature theories could maintain that the nasalization of laryngeals is phonologically irrelevant. However, there are good reasons for taking this view to be untenable. First, if the nasalization of laryngeals is simply irrelevant, then an explanation is required for the fact that in many languages with nasal harmony, such as Sundanese and Warao, supralaryngeal obstruents block nasalization while [?] is transparent to it.

A more serious problem concerns the observation that there are languages in which nasalization in laryngeals is underlyingly contrastive. As McCarthy (1988:92) notes, such a contrast is highly implausible on perceptual grounds:

An underlying phonological distinction in [nasal] for h and ? is perceptually unlikely or impossible. ? cannot be perceptually distinctive for [nasal], since glottal closure is obviously incompatible with nasal airflow. With h, even when voiced, the lack of resistance in the oral vocal tract would significantly reduce nasal airflow, rendering nasality essentially inaudible.

Nevertheless, there is evidence that, in /h/ at least, an underlying contrast in terms of nasality is possible. In the remainder of this section, I discuss a number of examples of languages which can be argued to have underlyingly nasalized

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5 Blust appears to use the term “transparent” in the sense of “nasalizable” and not—as is usually the case—in the sense of “being invisible to the nasal harmony process”.

6 According to Piggott (1992:39), a nasalized glottal stop is “an impossible phonetic entity”. Piggott attributes this impossibility to a cooccurrence restriction on [nasal] and [constricted glottis]. Piggott does not discuss the status of nasalized [h] in Tucano-type harmony systems.
Most of the data that will be discussed are also considered in Walker & Pullum (1999).

Consider first the following facts from Seimat, an Austronesian language of the Admiralty Islands. In common with most Austronesian languages with nasal harmony, Seimat vowels surface as nasalized in the context of a preceding nasal. However, as Blust (1998) observes, Seimat also has some instances of /h/ that condition the presence of a following nasalized vowel. Some examples of this “nasalizing” /h/ are provided in (6a); (6b) contains some examples of “non-nasalizing” /h/:

(6)  a. hōnõ ‘to hear’   b. han ‘to climb’
    hūhūa/hūohū ‘two’  hil ‘how much/how many?’
    mati(hū)- ‘to sleep’ hon ‘sea turtle’
    wah(ā) ‘root’ utuhi ‘to draw water’

Based on the forms in (6), it would be possible to maintain that Seimat has underlying nasalized vowels. However, compelling evidence for an underlying distinction between nasalizing and non-nasalizing /h/ comes from morphological alternations involving the transitive suffix /-ī/. Blust notes that this suffix surfaces as nasalized after nasals and some instances of /h/, as in (7a), and as oral after oral consonants and other instances of /h/, as in (7b):

(7)  a. aum-ī ‘embrace someone’   b. utuh-ī ‘to draw water’
    tih-ī ‘pour something’ salek-ī ‘boil something in a pot’
    hatuh-ī ‘make something stand’ taputu-ī ‘hit something with a fist’

This alternation strongly suggests an underlying distinction in /h/ in terms of nasality, since otherwise it would be impossible to account for the [i-ī] allomorphy.

Another candidate for an underlying distinction between an oral and a nasalized /h/ is Kwangali, a Southern Bantu language of Namibia. According to the description in Ladefoged & Maddieson (1996), nasalized vowels in Kwangali are found after some instances of /h/ but not others. Instrumental evidence shows that an /h/ preceding a nasalized vowel is realized with nasal airflow. Ladefoged & Maddieson (1996:132) provide the following near-minimal pairs:

7 Ladefoged & Maddieson (1996:133) note that nasalized vowels are also found in “the context of nasals”. Unfortunately, they do not indicate whether the nasalization in such cases is progressive, regressive, or both.
The point to note regarding the forms in (8a) is that an analysis in terms of underlying vowel nasalization or syllable nasalization seems to be inappropriate. According to such an analysis, we would expect to find nasalized vowels in word-initial position as well as after, say, voiceless stops. Based on the description by Ladefoged & Maddieson, such forms are impossible in Kwangali. Hence, a more appropriate interpretation is to posit an underlyingly nasalized /H/, which contrasts with oral /h/.

Walker & Pullum discuss two examples of Amazonian languages with underlying /H/ that are more controversial. Arabela, a Zaparoan language of Peru, displays rightward nasal harmony that targets vowels, glides, and, presumably, /[ŋ]/, which occurs predictably in word-final position following an open syllable. The forms in (9a) show that nasalization is triggered by nasals; the forms in (9b) indicate that nasalization is also triggered by /h/, which is invariably realized as nasalized phonetically (the Arabela data are taken from Rich 1963:234):

(9)  a.  mënû? ‘to kill’  b.  Hûûā? ‘a yellow bird’
     mënû? ‘swallow’     Hêêqû? ‘termites’
     kironû? ‘deep’     Hûûqû? ‘old woman’

In contrast to the languages considered so far, Arabela lacks oral /h/. This is unexpected from a markedness perspective. Indeed, there is some support for an alternative interpretation of the Arabela facts. According to Rich, Arabela has the nasals /m n H/, which might be taken to suggest that /H/ is derived from historical */ŋ*. The fact that this change affected */ŋ* and not */m* and */n* is unsurprising, since in voiced segment types velar place is relatively unstable as compared to labial and coronal place. In Element-based Dependency the change from */ŋ* to /H/ can be interpreted as involving the loss of both velar place and the stop component [?] as is illustrated in (10):

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8 This type of asymmetry is discussed in more detail in §7.2.1 (see also §5.2.3.1).
If this diachronic scenario is correct, then we are dealing synchronically with a placeless nasalized glide rather than with a nasalized laryngeal.

More direct evidence for a relation between [ŋ] and [H] can be found in Aguaruna, a Jivoroan language of Peru (cf. Payne 1974; see also Walker & Pullum 1999). According to Payne, [H] triggers bidirectional nasalization that targets vowels and glides, and is blocked by other consonants. This is illustrated by the forms in (11):

(11) ḥûm ‘later’
    tûH ‘fish’
    sûHk ‘beads’
    kûHû ‘porcupine’
    sakâHû ‘skeleton’

An analysis of Aguaruna in terms of underlying /H/ does not seem warranted since, as Payne notes, [H] is in complementary distribution with [ŋ]: the former is found in onsets and the latter in codas.9 It is therefore reasonable to suggest, as Payne does, that [H] is derived through debuccalization of /ŋ/ (see also Trigo 1988). In Element-based Dependency, this process can be accounted for in terms of the removal of the elements /ŋ/ and /A/ from the nasal, as is represented in (10) above. Note, again, that this analysis implies that [H] is a sonorant rather than a laryngeal phonologically.

The data considered in this section show that there are good grounds for recognizing the possibility of nasalized laryngeals, both at the level of surface and underlying structure. However, it should be observed that all examples of underlyingly nasalized laryngeals considered so far involve /ŋ/. This begs the question whether there are any languages that have underlyingly nasalized /ʔ/ and, should this not be the case, whether there is any principled explanation for the absence of this segment type.

9 It is intriguing that [h] and [ŋ] are in complementary distribution in a language like English. This observation has been used to argue that complementary distribution alone is not sufficient to conclude that two sounds are derived from a single phoneme (see e.g. Pike 1947). The Aguaruna facts suggest that [h] and [ŋ] might have more in common than is traditionally assumed. See Matisoff (1975) for some speculation on this issue.
As was observed in relation to Sundanese above, the recognition of nasalized \[?,\] as a possible segment type depends on one’s definition of nasality. If nasality is defined in terms of nasal airflow, as in Cohn (1990), then \[?,\] cannot be nasalized. If, on the other hand, nasality is defined in terms of velic lowering, as in Walker & Pullum (1999), then there is no a priori reason why \[?,\] should not be potentially contrastive. Like McCarthy, Walker & Pullum observe that an argument against recognizing contrastively nasalized \[?,\] is that this segment is perceptually non-distinct from oral \[?,\]. But, as Walker & Pullum (1999:776) point out, perceptual distinctness is not the only prerequisite for an underlying contrast:

> Sounds can be detected not only through their acoustic properties but also via the acoustic consequences of their effects on neighbouring segments. A child in the language acquisition phase could easily discover that a glottal stop was nasal: all that would be necessary is an identifiable spreading process in the language.

Note that this observation ties in with the spreading of nasalization that is typically observed in the case of nasalized approximants (see §3.3). The fact that such segments are perceptually similar to their oral and fully nasal congeners makes them marked as an underlying segment type, but this is in some sense compensated for by spreading the contrastive property across a larger domain. This point holds a fortiori for nasalized glottal stops, which, in perceptual terms, are not similar but identical to their oral congeners.

Like Walker & Pullum, I do not know of any clear examples of languages which have an underlying contrast between oral and nasalized glottal stop. However, I would like to propose that at least some cases of “spontaneous nasalization” qualify as evidence for the existence of underlyingly nasalized \[?,\]. I consider this type of nasalization in more detail in §6.1.1.

6.1.1 Spontaneous nasalization

The laryngeal-induced nasalization processes discussed above all involve nasalization by underlying \(\dot{H}\), which, in each of the languages considered, contrasts with \(\dot{u}\). Aside from such processes, there are also processes of vowel nasalization that are triggered by laryngeals which do not contrast in terms of nasalization. These processes involve what is sometimes referred to as “spontaneous nasalization” (cf. Grierson 1922, Ohala 1972, 1975, Ohala & Ohala 1993). Spontaneous nasalization forms part of the complex of naso-laryngeal interactions that Matisoff (1975:265) terms “rhinoglottophilia”, i.e. “the mysterious connection between nasality and glottality”. In this section, I

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10 The exception is Arabela, which has \(\dot{H}\) but not \(\dot{u}\); recall, however, that there are grounds for analyzing \(\dot{H}\) as a placeless sonorant.
briefly discuss some instances of spontaneous nasalization. As we will see, this
type of nasalization typically applies in a rather erratic and irregular manner.
However, at least some of the cases that will be considered provide evidence for
underlyingly nasalized laryngeals, including nasalized glottal stop.

Consider first of all the following facts from Thai. As Matisoff (1975:266)
observes, in northeastern dialects of Thai vowels are allophonically nasalized
after nasals and after /k/ (see also Noss 1964, Harris 1972). Some examples are
given in (12):

(12) /maa/ [māː] ‘come’
/heː/ [heː] ‘parade’
/?ɔɔk/ [ʔɔɔk] ‘leave, depart’

Matisoff notes that in central dialects of Thai, including the Bangkok dialect,
only the mid and low vowels /a/ are affected. This situation is similar to that
in Mal, a Mon-Khmer language of northern Thailand, where /a/ a 𝛿/ are
nasalized after /r/, and /i/ after /h/ (cf. Purnell 1972). With regard to Thai, Harris
(1972:18) observes that some speakers always realize [h] as nasalized, and that
this [h] always conditions the presence of a following nasalized vowel. This
suggests that, for some speakers at least, underlying /H/ must be recognized.
Matisoff’s description of Thai suggests that the same point can be made with
regard to /r/.

In some southern dialects of Thai, nasalized /h/ can be traced back to an
earlier nasal consonant. According to Li (1977), modern Thai dialects have both
/h/- and /ŋ/- as reflexes of Proto-Thai *ŋ- (see also §5.2.3.1). Li (1977:206)
oberves that these “dialects are not consistent in having either /h/- or /ŋ/-
throughout”. Consider as an illustration some reflexes of *ŋ- in a number of
modern Thai dialects:

(13) Proto-Thai Siamese Lungchow Po-ai
    *ŋ-  ŋaai  haaai  haaai  ‘moonlight’
    *ŋ-  haaui  -  ŋaau  ‘to yawn’
    *ŋ-  ŋiak  hiik  ŋiik  ‘gum, palate’

Li further notes that dialects which have h- as a reflex of both *ŋ- and *ŋ- are
much more restricted. The survey of dialects in Brown (1965) contains eight
such dialects, Krabi, Nakhon, Thung Song, Trang, Khuan Khanun, Hua Sai,
Songkhla and Ranot, all spoken in southern Thailand. In three of these, i.e.
Krabi, Songkhla, and Hua Sai, the present-day reflex is transcribed by Brown as
/H/, i.e. a nasalized laryngeal fricative which contrasts with oral /h/-. As regards
these laryngeals, Brown (1965:61) notes that:
[p]honetically, /hur/ and /Hr/ are [hur] and [hûr], but it is out of the question to consider nasalized vowels as phonemic since they occur only after [h].

In the remaining five dialects we find /h-/ rather than /H-. It seems reasonable to suggest that here *hn- has merged with *h-, possibly via intermediate /H-. These developments are summarized in (14), where I take Songkhla and Nakhon as exemplars of southern dialects, and Siamese as an exemplar of a central dialect:

(14) Proto-Thai Siamese Songkhla Nakhon

<table>
<thead>
<tr>
<th>Proto-Thai</th>
<th>Siamese</th>
<th>Songkhla</th>
<th>Nakhon</th>
</tr>
</thead>
<tbody>
<tr>
<td>*η-</td>
<td>/η~h-/</td>
<td>/H-/</td>
<td>/h-/ (&lt; /H-/)</td>
</tr>
<tr>
<td>*hη-</td>
<td>/η-/</td>
<td>/H-/</td>
<td>/h-/ (&lt; /H-/)</td>
</tr>
<tr>
<td>*h-</td>
<td>/h-/</td>
<td>/h-/</td>
<td>/h-/</td>
</tr>
</tbody>
</table>

Hence, in southern dialects of Thai such as Songkhla, nasalized /h/ is historically derived from a velar nasal.

Essentially the same diachronic scenario is observed in Sui, a language related to Thai, where the aspirated nasals in southern dialects of Sui correspond to /H/ in northern dialects of Sui (cf. Haudricourt 1967). On the assumption that aspirated nasals consist of nasal manner and dependent [H] (see §5.2), we can interpret this development as having involved the loss of both the manner element [ʔ] and the place component of the nasal, with a concomitant shift in the dependency relation between [L] and [H]:

(15) O O
    | |   |   |
    L  H > H  L
    +   |
    ?   |
    |   |
    A
    *ηh > /H/

Haudricourt observes that nasalized vowels in northern dialects of Sui occur only in the context of a preceding /h/ or /ʔ/, and notes that the same situation is found in a number of Austro-Asiatic languages, e.g. Sedang, Jeh, and Halang, as well as in the Semai and Sekai dialects of Malay.

While nasalized /h/ in Thai and Sui derives from a historical nasal consonant, there are also languages in which /h/, and sometimes also /ʔ/, have independently acquired nasalization. This is the case in for instance Lisu, Lahu,

11 The diachronic origin of aspirated nasals in Tai-Kadai, the language family of which both Thai and Sui are members, was discussed in §5.2.3.1.
Phunoi, and Bisu, Burmese-Loloish languages that are spoken in the border area of China, Burma, and Thailand.

With regard to Lisu, both the context and conditioning factor of vowel nasalization are not entirely clear. According to the description of Fraser (1922), initial onsetless syllables are realized with a nasalized vowel. However, as Matisoff (1975) points out, such vowels begin with [ʔ] phonetically, which might be interpreted to mean that vowel nasalization is triggered by glottal stop. Fraser further notes that syllables beginning with nasalized /h/ are realized as nasalized throughout. According to the description in Bradley (1979), however, some Lisu speakers report that [H] and [ʔ] do not contrast with each other in native words. Finally, Hope (1976) states that Lisu /h/ is realized as [H] before high vowels and is in free variation with [h] before non-high vowels. Hope (1976:134) gives the examples [Hî] ‘house’ and [he] (~ [HEʔ]) ‘yet’, noting that [H] always cooccurs with a following nasalized vowel. Hope’s description suggests that nasalization is more general after /m n n/ and [ʔ], where all vowels surface as nasalized.

With regard to Lahu, Matisoff (1973b, 1975) notes that distinctively nasalized vowels occur in Shan, Burmese, and Thai loanwords only. According to the description in Matisoff (1973b), vowel nasalization in native Lahu words is conditioned by a preceding nasal; compare for instance Matisoff’s (1973b:20) transcription of the diminutive markers /mu/ and /mwe/ as [më] and [më ë]. Confusingly, Matisoff (1973b:20) maintains that in Lahu “nasal consonants do not have any noticeable effect on the following vowel”. The nasalizing effect of /h/, on the other hand, is unmistakable: Matisoff (1973b:20-1) notes that Lahu has “optional vowel nasalization that occurs (even in native syllables) with the vowels -a or -o, where the initial consonant is h- or zero”. Consider the examples in (16), where I omit tonal specifications:

(16)  [ô ~ ɔ]     ‘four’
[ hô ~ hɔ]     ‘elephant’
[ hôʔ ~ hɔʔ]    ‘to coil’
[ôqa ~ ɔqa]    ‘water buffalo’
[ôhâ ~ ɔha]    ‘spirit’

Note that the nasalization of word-initial vowels does not seem to be due to the effect of a preceding laryngeal, given that Matisoff (1975:267) observes that Lahu does not have a phonetic glottal stop in this context. It is also impossible to attribute nasalization in this environment to an [h]-like on-glide, given that the forms in (16) show that the presence of /h/ is contrastive with its absence. If this kind of nasalization is indeed regular, as Matisoff suggests, then how should we account for it? One interpretation would be to assume that initial vowels are preceded by a nasalized vowel-like on-glide, which consists of a placeless vocalic manner component and a dependent element [L]. This [L] would then spread rightwards to the following vowel:
It should be emphasized that this account is extremely speculative. Part of the problem is that it is unclear just how regular word-initial vowel nasalization is, and whether it occurs in any languages other than Lahu.

The origin of vowel nasalization in Phunoi and Bisu was discussed in §5.2.3.2. There the focus was primarily on the diachronic relation between nasalized vowels and aspirated nasals, although I noted that some occurrences of nasality in Phunoi and Bisu were due to an independent process of nasalization that was triggered by glottal stops. Some examples are given in (18), repeated from (51) in §5.2.3.2:

(18)  

As was noted, this nasalization is observed in the prefix /?ɑ~?æŋ/, which derives from Proto-Tibeto-Burman *?ɑ-. The different reflexes in Phunoi and Bisoid suggest that the prefix had the form *?ɑ- in Proto-Bisoid, with a subsequent change to /?æŋ/ in Bisu. We can think of this development as having involved the “unpacking” of vowel nasalization (see Paradis & Prunet 2000).

The difference between languages like Thai and Sui and languages like Lisu and Lahu is that in the latter two nasalization in laryngeals does not have a diachronic source. The reconstruction of Proto-Loloish in Bradley (1979) suggests that /H/ developed from a variety of Proto-Loloish sounds, including oral sonorants and *x. The velar fricative has merged with *j in all Loloish languages except Lisu, where its reflexes are /x/ and /H/. (cf. Bradley 1979:153).

To sum up, the preceding discussion shows that descriptions of spontaneous nasalization phenomena are often vague and inconclusive. Nevertheless, some of these descriptions suggest that in a number of languages, such as Lahu, Sui, and in some southern dialects of Thai, spontaneous nasalization is sufficiently regular to warrant underlyingly nasalized laryngeals. In other languages, such as Lisu, more data is required to shed light on the generality of spontaneous nasalization.

Inspection of spontaneous nasalization in other languages suggests that the process is not as regular as nasal-induced vowel nasalization. While the latter type of nasalization usually applies in an across-the-board fashion, spontaneous nasalization typically applies in a more erratic manner. Moreover, the available
descriptions of languages that display spontaneous nasalization do not always indicate whether this nasalization is obligatory or optional, whether it targets all or only some vowels, and whether it affects all or only some words. Examples of languages in which spontaneous nasalization appears to have a restricted distribution include Arakanese (Bradley 1985b), Kuy (Johnston 1976), Phlong (Cooke et al. 1976), Kisi (Childs 1991), and perhaps Gourmantché (Dell 1993). With regard to Kisi, Childs notes that spontaneous nasalization is restricted to ideophones.

The haphazard nature of spontaneous nasalization can also be observed in languages in which there is evidence for a diachronic process of spontaneous nasalization. For instance, Hetzron (1969) notes that some languages of the Gurage branch of Semitic have nasals in contexts where other Semitic languages have a laryngeal or guttural consonant. Some representative correspondences are given in (19):

\begin{verbatim}
(19)  Semitic      Gurage
      a. *str : antārā (Zway)     ‘pea’
      b. *htj : enke (Ṣaltʾi)     ‘to chew’
      c. *ḥqf : enqāfā (Ṣaltʾi, Wālāne) ‘embrace’
      d. *ṣwjf : ūf (Zway, Saltʾi, Wālāne) ‘bird’
\end{verbatim}

According to Hetzron, the non-etymological nasals in (19a-c) result from a complex of sound changes in which the gutturals developed into laryngeals, which in turn triggered progressive vowel nasalization. In some Gurage forms the resulting nasalized vowels were subsequently unpacked into sequences of an oral vowel and a following nasal consonant. Presumably, the latter process took place only in case the nasalized vowel was followed by a stop, as in the forms in (19a-c). However, there is reason to believe that spontaneous nasalization did not apply whenever the structural context was met. Leslau (1970) cites several Gurage forms where spontaneous nasalization apparently did not take place, and lists a number of forms which contain non-etymological nasals that cannot be attributed to the presence of a historical guttural.

The effect of spontaneous nasalization in Hindi yields a similar picture. In Hindi, as in all languages with distinctive vowel nasalization, most instances of synchronic nasalized vowels derive from earlier sequences of an oral vowel and a following nasal. However, not all nasalized vowels in Hindi are derived from such sequences. The forms in (20), taken from Ohala (1983:77-90), appear to be the result of spontaneous nasalization:

\begin{verbatim}
12 This type of alternation is also observed in other languages. For instance, Polish displays a
complementary distribution between nasalized vowels and sequences of an oral vowel and a
following nasal, with the former occurring before fricatives and the latter before stops
\end{verbatim}
Regarding these forms, Ohala & Ohala (1993:240) conclude that spontaneous nasalization in Hindi is found in the vicinity of segments that are “characterized by high airflow, including any voiceless fricative, especially [h], aspirated stops, and affricates”.

Arun (1961:73) gives some additional examples of spontaneous nasalization in Hindi and Panjabi, a related Indo-Aryan language. Consider the examples in (20) (OIA denotes Old Indo-Aryan, as reconstructed by Arun):

(20) [p@u] ‘attain’ (< Sanskrit /praːɡhuːrṇaː/)  
[h@li] ‘collar bone’  
[h@ra] ‘sickle’  
[h@i] ‘laughter’ (< Sanskrit /haːxjaː/)  
[p^s] ‘be entangled-IMP’  
[d^s] ‘be stuck-IMP’  
[sap] ‘snake’ (< Sanskrit /sarpa/)  
[sas] ‘breath’ (< Sanskrit /vaːsa/)  
[asu] ‘tear’ (< Sanskrit /aʃru/)  
[e] ‘bite-IMP (used only for snake bites)’

The developments in (21a) show that in Hindi and Panjabi spontaneous nasalization occurred in some forms, but not in others. Arun notes that the effect of spontaneous nasalization is stronger in Panjabi. Observe in (21a) that the reflex of *h in Panjabi is a falling tone on the preceding (or in some cases following) vowel.13 Hindi and Panjabi show parallel developments in the forms in (21b).

Arun (1961:96) further notes that in Hindi the velar nasal in synchronic [ŋkʰ] clusters is often due to spontaneous nasalization:

OIA has a number of words having two forms, one with the nasal and the other without it, e.g. ukhāti–unukhāti; makhati–manjkhati, etc. Most probably it was dialectal variation … Modern Hindi/Panjabi forms with nasals derive from nasalizing dialects.

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13 I observed in §5.2.4 that the typical reflex of *h is a high tone. The low tone reflex in Panjabi could be due to the fact that *h was phonetically voiced [ɦ], as it is in present-day Panjabi and Hindi.
Some representative examples are given in (22a). The forms in (22b) show that not all instances of OIA -kh- develop into [ŋk]. Note here that the nasalized vowel in Hindi [mûh] and Panjabi [må:] is presumably due to the nasalizing effect of /ν/. This laryngeal subsequently developed into low tone in Panjabi (in (22) OIA denotes Old Indo-Aryan and MIA denotes Middle Indo-Aryan, as reconstructed by Arun):

(22)  a. Sanskrit    Prakrit    Hindi    Panjabi
    pakṣa    pakkha    pāṅka    pakkha    ‘fan’
    kakṣa    kaṅkha    kākha    kaṭṭha    ‘armpit’

b. OIA    MIA    Hindi    Panjabi
    mukha    mūha    mûh    må:    ‘mouth’
    jēkharā    seharo    seh(ə)ra:    sēra:    ‘chaplet’
    kaphōṇi    kahōṇi    kohni    kūni:    ‘elbow’

While in the forms in (20) and (21) nasalization can conceivably be attributed to high airflow segments, the nasalization in the forms in (22a) appears to be the result of the combination of velar place and voiceless aspiration. The general development observed for intervocalic aspirated stops is that they reduce to /V/, as can be seen in (22b) for some instances of /V/.

14 The general change affecting intervocalic unaspirated stops, including /V/, is that they were voiced, spirantized, and subsequently deleted in Middle Indo-Aryan.

The status of spontaneous nasalization in Hindi appears to be fairly representative of the cross-linguistic status of this process. First, spontaneous nasalization typically affects vowels after /h/. Second, spontaneous nasalization is generally progressive, although some instances of regressive nasalization are also found. Third, spontaneous nasalization as a diachronic process tends to target a limited number of forms only; in this respect, synchronic and diachronic processes of spontaneous nasalization have the same effect. With regard to Hindi, Ohala (1983) claims that the forms in (20) contain all instances of nasalized vowels in Hindi that are due to spontaneous nasalization. Given their restricted occurrence, it is perhaps not surprising that spontaneously nasalized vowels, in Hindi as well as in other languages, are rather unstable. Regarding Hindi, Ohala (1983) notes that some of the forms in (20) have alternative realizations without nasalized vowels. The facts considered suggest that most processes of spontaneous nasalization are too erratic to leave, or to have left, a firm imprint on the language concerned.

14 Bearing in mind the subsequent loss of -h- and the concomitant development of tone in Panjabi.

15 It is dubious whether this is correct, since the list in (20) does not contain most of the examples cited by Arun.

16 In fact, Ohala (1983:78,90) gives both [phûṛ] and [phûṛ], but this is probably unintentional.
6.1.2 Discussion

The number of languages with spontaneous nasalization is such that the interaction between laryngeals and nasality merits an explanation. In this regard, the first question that must be asked is whether spontaneous nasalization is in some way phonetically motivated. A number of accounts have been advanced in this respect.

Matisoff (1975:267) observes that spontaneous nasalization is manifested in everyday life when we utter a ponderous ‘hmm’, emit a perplexed ‘huh?’, or when we ‘hum’ along with a song. Or consider the following scenario:

When you arrive home exhausted with two armfuls of groceries, and finally sink into a chair, you might well utter the syllable [ŋ] as you sigh with relief.

Matisoff offers an impressionistic interpretation of this phenomenon: when uttering the syllable [ŋ], the articulators are in their most relaxed position, with both the velum and the velopharyngeal port opened and the tongue in a neutral, central position for the schwa. According to this view, spontaneous nasalization is therefore essentially caused by ease of articulation.

It is interesting to observe that this interpretation is at odds with the approach to segment inventories in Ní Chiosáin & Padgett (1997). Ní Chiosáin & Padgett claim that the two forces shaping contrastive segment specifications are perceptual distinctness and articulatory markedness. Perceptual distinctness refers to the requirement that for two segments to contrast, there must be a perceptual difference between them. As far as glottal stop is concerned, perceptual distinctness evidently does not favour an underlying nasalization contrast. Articulatory markedness refers to the requirement that segments must be minimally complex in terms of the articulatory gestures of which they are composed. Ní Chiosáin & Padgett argue that articulatory markedness favours a language with a single glottal stop to have oral /\%/ as it is “unmarked” for the soft palate to be lowered. Perhaps some languages, such as Lahu, have phonologized this velic lowering to the extent that word-initial (or utterance-initial) vowels are nasalized. The fact that we also find nasalization in case initial vowels are preceded by laryngeals could then be accounted for by Ohala’s (1972:1168) observation that “[i]t is possible to produce acoustically acceptable versions of [laryngeals] regardless of the state of the soft palate”.

As Matisoff (1975:271) notes, an explanation of spontaneous nasalization that appeals to articulatory inertia can be characterized as a “negative explanation”, in the sense that it explains the occurrence of nasalized laryngeals in terms of something that speakers fail to do (i.e. raise the velum). While this explanation might account for some instances of spontaneous nasalization, there
are also some instances—particularly those that involve an underlying contrast between oral and nasalized laryngeals—which require a positive explanation. This type of account is offered by Ohala & Ohala (1993) (see also Ohala 1975). They observe that segment types which trigger spontaneous nasalization typically involve a high rate of airflow, resulting in a relatively wide glottal opening. This glottal opening, Ohala & Ohala argue, spreads to a following vowel due to coarticulation, where it creates an acoustic effect that is similar to oro-nasal coupling.\(^{17}\) As a result, such vowels may be reinterpreted as nasalized by listeners, thus precipitating sound change.\(^{18}\)

The claim that spontaneous nasalization is associated with high-airflow segments is supported by Hindi, where nasalized vowels mostly occur in the vicinity of /h/, but, in some isolated cases at least, also in the context of an aspirated stop, sibilant, or affricate. The question is whether Ohala & Ohala’s account can be extended to include glottal stop. It could perhaps be argued that the release stage of [ʔ] produces an effect similar to that of [h].

Another question is whether the presence of spontaneous nasalization in a language depends on the presence of “normal”, nasal-induced nasalization. With the possible exception of Lahu, cross-linguistic evidence suggests that it does. A reason for this might be that nasalization must be present in the phonological system of a language in order for a listener to be able to reinterpret the effect of laryngeals as nasalization. This does not take away the fact that spontaneously nasalized vowels are unstable, both synchronically and diachronically. I suggest that this instability is due to the lack of a clear conditioning context. Diachronically, spontaneously nasalized vowels tend to lose their nasality, as in Hindi (where nasality may even shift to another vowel), or are “unpacked” into a sequence of an oral vowel and a following nasal, as in Inor and Bisu. Note that these processes do not normally target nasalized vowels that are nasalized by nasals, presumably because for such vowels the conditioning factor is more robust.

As far as I am aware, no current model of segmental structure provides an adequate characterization of the nasalizing effect of laryngeals. The facts considered suggest that some abstract element is involved that has the general interpretation of “(high) airflow” in laryngeals and of nasalization in vowels. I leave the nature of this element for further research; here I offer a rather more informal interpretation of the process in terms of Element-based Dependency. I suggest that spontaneous nasalization involves the three stages in (23):

\(^{17}\) Matisoff observes that spontaneous nasalization is more likely to affect low vowels (see also Ohala 1972). The data considered above suggest that this may hold for /ɨ/ but not (or not always) for /h/, which in some languages, such as Mal and Lisu, appears to target /i/ only.

\(^{18}\) According to Ohala (1993), this would be a typical sound change, in the sense that it is perceptually rather than articulatorily motivated.
The development from stage 1 to stage 2 involves the emergence of vowel nasalization, a phonological change that is the result of reinterpretation of the laryngeal airflow gesture as nasalization; the representation of this change is the main challenge facing a theoretical account. The change from stage 2 to stage 3 involves leftward transfer of nasalization from the vowel to the laryngeal. This process produces an underlingly nasalized laryngeal, and makes it possible to express the generalization that nasalized vowels occur in the environment of a preceding laryngeal.

6.2 Alternations between nasals and laryngeals

Matisoff (1975) maintains that spontaneous nasalization by laryngeals is an illustration of rhinoglottophilia, i.e. the relation between nasality and laryngeal articulations. In this section, I briefly consider some other types of processes which involve a phonological interaction between nasal and laryngeal articulations. While these processes might be argued to fall under the rubric of rhinoglottophilia, we will see that for most of these processes an alternative, though rather abstract, analysis is available.

Alternations between nasals and [h] are found in among others a number of North American languages. An example of such a language is Kitsai, a Caddoan language formerly spoken by a small group now associated with the Wichita tribe. Bucca & Lesser (1969) observe that in Kitsai /n/ is realized as [h] when preceding a voiceless stop, as in (24):

(24)  kukuhuná/n+ʔis/akya → kukuhuná[hʔis]akya  ‘stuck in the ground’  
ahuná/n+k/i → ahuná[hk]i  ‘hoes’  
kusa/n+ʔ/atsíu → kusa[hʔ]atsíu  ‘house grass’  

A similar process can be observed in a pattern of verbal inflection in the Algonquian language Cree. Ahekanew (1987) notes that Cree verbs containing a stem-final coronal nasal select the third person endings -k and -kik. In such cases, the nasal surfaces as [h]. A reasonable interpretation of this process is to posit an underlingly aspirated coronal nasal, as in (25):
Given (25), the surface realizations can be accounted for if we assume that the nasal manner component is deleted when /h\ occurs before a voiceless stop, and dependent \H is deleted elsewhere. Note that this interpretation is abstract to the extent that the underlying form is never phonetically realized. An argument in favour of this scenario is that it mirrors the historical situation: the origin of the aspirated nasal is in all likelihood due to a historical process of nasal devoicing that was triggered by a following voiceless obstruent (see Bloomfield 1946). I briefly discussed this diachronic scenario in §5.2.2.

Another example of a language which has a surface variation between [n] and [h] is Sarcee. In common with other Athapaskan languages, Sarcee signals the perfective form of the verb by voicing of the stem-final consonant. This is illustrated in (26) for stem-final fricatives (all Sarcee data are taken from Cook 1984:232ff.).

(26) IMPERF PERF
-dú̱s -dú̱z ‘to crawl’
-γǔc -γǔj ‘to whistle’
-ʔò̱l -ʔò̱l ‘to chew’

This pattern is obscured by alternations involving other stem-final consonants:

(27) IMPERF PERF
-tʰàh -tʰiŋ ‘to stretch’
-žíh -ziŋ ‘shoot (arrow)’
-žú̱h -žú̱w ‘scrape off’

According to Cook (1984), there is synchronic and diachronic evidence which suggests that the underlying stem-final consonant in (27) is /x/. This /x/ is regularly changed to [h] in final position, while its voiced counterpart /γ/ is realized as [j] or [w], depending on the quality of the preceding vowel.

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19 Examples of this process in Navajo and Chipewyan were considered in §4.2.

20 Note in (26) that /l/ patterns as a (sibilant) fricative.
The forms in (27) indicate that the surface alternation in perfectives and imperfectives is not always transparent. The same is true when the stem-final consonant is a nasal, as in (28):

(28)      IMPERF             PERF                      in all contexts
         #        V        
-ʔíh      -ʔíɲ-       -ʔɪn               ‘to have’
-ʔíɬh     -ʔíɬɲ-      -ʔɪɬn              ‘to sing’
-ɗíh      -ɗíɲ-       -ɗɪn               ‘to train’

The forms in (28) show that the alternation [h~n] parallels the voicing contrast found in fricatives. This leads Cook (1984) to suggest that the underlying stem-final nasal is a voiceless nasal /Ø/. Note that we are once more dealing with an abstract scenario: /Ø/ is never realized phonetically and nor does it alternate with [b] since, as is shown by the forms in the second column in (28), we always find [n] before a vowel.

On a final point, the alternation in (28) suggests that the underlying nasal patterns as phonologically voiceless. This raises the question how this alternation can be accounted for in terms of Element-based Dependency, where underlying nasals of the kind in (28) are interpreted as aspirated rather than as voiceless. I suggest that the voicing process that is associated with perfective formation involves the addition of dependent |L| in fricatives, and the deletion of dependent [H] in nasals (and perhaps laterals). This difference is shown in (29):

(29)  a.                 b.   
             H L         L H
             |               |
             …              ?
             |               |
             …

Fricative voicing    Nasal deaspiration

In (29) we are dealing with two distinct processes: fricative voicing and nasal deaspiration. What unifies these processes is that they produce a voiced output.

Another potential example of rhinoglottophilia concerns postnasal aspiration, a process in which a nasal triggers aspiration of a following voiceless obstruent stop (i.e. N± → N±b). However, while the emergence of aspiration in the context of nasality may create the impression of being “spontaneous”, here, too, an alternative and rather abstract approach is available.

An example of postnasal aspiration can be observed in Swahili. Swahili displays a morphophonemic alternation between nasals and aspirated stops in the prefixation of the nominal class 9/10 marker. The relevant prefix consists of a nasal consonant that is underlyingly unspecified for place. I will represent this
nasal as /N/. The forms in (30), taken from Hinnebusch (1975) and Mpiranya (1995), suggest that the phonetic realization of /N/ depends on both the prosodic shape of the root and the manner type of the root-initial consonant:

(30)  a. /N-bwa/ [Ôbwa] ‘dog’
    /N-ge/ [‘ge] ‘scorpion’
  b. /N-buzi/ [“buzi] ‘goat’
    /N-dege/ [ʻdege] ‘bird’
    /N-guo/ [ʻguo] ‘cloth’
  c. /N-pja/ [Ôpja] ‘new’
    /N-ta/ [Ôta] ‘wax’
    /N-tʃi/ [Ôtʃi] ‘country’
  d. /N-pepo/ [papoo] ‘spirits’
    /N-tembo/ [tæmbo] ‘elephant’
    /N-kata/ [kata] ‘head pad’
    /N-paa/ [%paa] ‘gazelle’
    /N-kuu/ [kʊu] ‘big’

Consider first those roots that begin with a voiced stop. If such a root is monosyllabic and has a short vowel, as in (30a), /N/ surfaces as a (stressed) homorganic syllabic nasal. This situation differs from that in disyllabic roots and monosyllabic roots with a long vowel or diphthong, as in (30b). In such forms, /N/ is incorporated into the stop, and the resulting sequence is realized as a prenasalized stop. Consider next the realization of /N/ before voiceless stops. The forms in (30c) illustrate that the nasal prefix is realized as syllabic before monosyllabic roots with a short vowel; in such roots, the voiceless stop surfaces as aspirated. The forms in (30d) show that in disyllabic roots and monosyllabic roots with a long vowel, the presence of /N/ is signalled by aspiration of the stop alone.

Similar to the Kitsai, Cree, and Sarcee facts considered above, I suggest that in Swahili we are dealing with an underlyingly aspirated nasal /N/>. Note again that this interpretation is abstract, since we never find an aspirated nasal at the surface. The only context in which aspiration, i.e. dependent [H], is realized is when it can be associated to a following voiceless stop. This process—postnasal aspiration—can be represented as in (31):

(31)  (PFX) O
  \[\begin{array}{c}
  \text{L} \\
  \text{H} \\
  \text{?}
  \end{array}\] \[\begin{array}{c}
  \text{?} \\
  \text{?}
  \end{array}\] \[\begin{array}{c}
  \text{…}
  \end{array}\]

/N-/ → [N±h]
The pattern of alternation in (30) suggests that the nasal prefix surfaces as syllabic to guarantee that the output of prefixation forms a minimal word. In those cases where the stem already has the required minimal prosodic size, nasal manner is either deleted, as in (30d), or incorporated into the stop, as in (30b). The fact that this incorporation does not take place in case the root-initial stop is aspirated follows naturally from (31): since the dependent position of this stop is already filled by dependent [H], there is no available landing site for nasality.

As was observed, the approach to Swahili nasal prefixation taken here is abstract to the extent that the postulated aspirated nasal never occurs at the surface. Dependent [H] is realized only if it can be associated to a following voiceless stop. [H] is deleted if the root-initial is a voiced stop (presumably because the dependent position of these stops is already occupied by [L]) or any other segment type (presumably because aspiration in Swahili can be contrastive only in stops). As in Cree, there is some historical support for my interpretation of the Swahili facts. The class 9/10 nasal prefix derives from the Proto-Bantu prefix */ni-*. Given this, we may speculate that the high vowel of this prefix underwent devoicing at some point in the history of Swahili, and subsequently merged with the preceding nasal to produce an aspirated /N/. While this scenario requires further research, it is interesting to note that the relation between high vowels, aspiration and nasality can also be found in other Bantu languages, such as Makuwa and Wambo (see §2.3.2).

The final example that I will discuss is a historical process which involves the emergence of a nasal consonant in the environment of a preaspirated stop. The relevant process concerns a diachronic development in the Ponapeic subgroup of Micronesian, which includes Pingelapese, Mokilese, and Ponapean. In these languages, durative aspect is marked by reduplication of the verb. For instance, reduplication of the verb stem /pap-/- ‘swim’ (derived from Proto-Oceanic *papV-) produces the following results in these languages (cf: Blevins & Garrett 1993:212):

(32) Mokilese /pap+pap/ → [pappap]
Pingelapese /pap+pap/ → [paapap]
Ponapean /pap+pap/ → [pampap]

As can be seen in (32), reduplication in Ponapean triggers nasal substitution. While this process is not difficult to characterize, it is unclear why /p/ would change to [m] in this environment. Blevins & Garrett (1993:212-5) consider a number of earlier accounts of this process, and conclude that there is no synchronic phonetic motivation for partial geminate nasalization. In order to

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21 The fact that the nasal does not surface as syllabic preceding a monosyllabic root with a long vowel can be taken to suggest that minimality is defined at the level of the mora (cf. McCarthy & Prince 1986). In terms of Element-based Dependency, we could say that a monosyllabic root requires a branching nucleus.
account for synchronic nasal substitution, Blevins & Garrett propose a series of
diachronic developments. The first development concerns the emergence of
aspiration in voiceless geminates. This process, they argue, is not phonetically
unnatural, given the observation that a voiceless geminate tends to have a
greater degree of glottal opening than a single voiceless stop. Blevins & Garrett
(1993:219) go on to note that if a voiceless geminate involves a relatively large
glottal opening, then

a slight temporal misalignment of oral and glottal gestures—that is,
anticipatory or perseveratory coarticulation—can result in
spontaneous aspiration.

According to Blevins & Garrett, this scenario is responsible for the development
from *pp to *hp in Pingelapese and Ponapean. In Pingelapese, this *h was
subsequently lost, resulting in a synchronic alternation which involves
compensatory lengthening of the reduplicated vowel. Ponapean, on the other
hand, underwent a subsequent process of spontaneous nasalization in which *
h developed into homorganic nasal. To this effect, Blevins & Garrett cite Ohala
(1975:303), who provides the following phonetic motivation for this type of
change:

[h] may produce an effect on vowels that ‘mocks’ that of
nasalization. Because of the open glottis during phonation
accompanying an [h] (or breathy voice), the spectrum of the vowel
will be changed in the following ways: there will be upward
shifting of the formants, especially \(F_1\) …, increased bandwidth of
the formants, presence of anti-resonances in the spectrum and an
overall lowering of the amplitude of the vowel … This is identical
to the effect of nasalization on vowels. Articulatory re-
interpretation may occur, i.e., actual nasalization may be produced
on the vowel.

Blevins & Garrett observe that other potential examples of this “articulatory re-
interpretation” are found in the Caucasian languages Bzhedukh and Shapsgh,
where vowels following aspirated fricatives are nasalized.\(^{22}\)

While the two stages in the diachronic change that led to Ponapean nasal
substitution are phonetically plausible on their own, their combined effect is
phonetically unnatural. From the point of view of synchronic phonology, I
suggest that nasal substitution in Ponapean involves the addition of dominating
[L] to the manner component of the first coda stop, turning the stop into a nasal.

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\(^{22}\) This scenario could also be responsible for the diachronic development of Proto-Uto-
Aztecan preaspirated stops to Hopi nasal-stop sequences (see Manaster-Ramer 1986).
This is illustrated in (33), where I assume that the |U|-specifications of the two consonants are merged:

(33) \[\begin{array}{ccc}
C & O & C \\
\mid & \mid & \mid \\
? & + & ? \\
\mid & \mid & \mid \\
U & U & ? \\
\Uparrow & \\
\end{array}\]

\[\ldots p-p\ldots \rightarrow \ldots mp\ldots\]

This synchronic process, while not phonetically motivated, is not difficult to express in phonological terms. We may think of this as an illustration of the fact that phonology is independent from phonetics, in the sense that not all synchronic phonological processes are necessarily phonetically natural.

6.3 The interpretation of placeless manner structures

To conclude this chapter, I briefly consider some consequences of the representation of nasalized laryngeals for the Element-based Dependency interpretation of placeless manner structures. Consider again the assumption that elements have a different, but phonetically related, interpretation, depending on their structural context. A case in point is the relation between laryngeals and laryngeal modifications. In their capacity as heads, |\text{[ʔ]}| and |\text{[H]}| are interpreted as |\text{/ʔ}| and |\text{/H}|, while in their capacity as dependents, they are interpreted as glottalization and aspiration:

(34) a. \[\begin{array}{ccc}
O & b. & O \\
\mid & \mid & \mid \\
? & H & \ldots ? \\
\mid & \mid & \mid \\
/ʔ/ & /H/ & /\ldots \text{'}/ \\
\end{array}\]

One question that emerges with regard to (34) is whether laryngeals can themselves be laryngeally modified. From a phonetic viewpoint, it is to be expected that the range of laryngeal modifications in laryngeals is severely restricted, since both the laryngeal and the laryngeal modification are produced with the same articulator.

As far as combinations of |\text{[ʔ]}| and |\text{[H]}| are concerned, it is reasonable to assume that structures with identical heads and dependents, i.e. glottalized /ʔ/ and aspirated /H/, are impossible:
I attribute the impossibility of (35a) and (35b) to the OCP. According to this interpretation, the OCP is violated in case there would be complete identity between head and dependent. This is the case only for the structures in (35); that is, while a glottalized or ejective stop like /pʰ/ also has head and dependent |ʔ|, it does not violate the OCP on account of it being also specified for |U|.

The question whether the structures in (36) are acceptable is less clear:

(36) a. O b. O
   |ʔ| H |H |
   /pʰ/ /hʰ/

(36a) denotes an aspirated glottal stop. As far as I am aware, there are no languages in which this segment type is contrastive. However, since there is neither an articulatory nor a perceptual reason to exclude aspirated glottal stops, there is no a priori reason to rule out (36a). (36b) denotes a glottalized /h/.

The fact that /h/ is postglottalized suggests that it functions as an obstruent and not as a sonorant. Kroeker (2001:78-9) provides the following obstruent inventory:

<table>
<thead>
<tr>
<th>p</th>
<th>t</th>
<th>ʔ</th>
<th>k</th>
<th>kʰ</th>
<th>?</th>
</tr>
</thead>
<tbody>
<tr>
<td>pʰ</td>
<td>tʰ</td>
<td>kʰ</td>
<td>kʰ</td>
<td>kʰ</td>
<td>?</td>
</tr>
<tr>
<td>f</td>
<td>s</td>
<td>h</td>
<td>h</td>
<td>h</td>
<td>h</td>
</tr>
</tbody>
</table>

Given this inventory, it might perhaps be argued that /h/ is phonologically velar rather than laryngeal. Kroeker’s description does not contain any evidence bearing on this issue, neither for nor against it. Note, however, that the absence of glottalized /ʔ/ means that we are dealing with an asymmetric distribution of

23 Recall that this is in line with the cross-linguistically typical realization of such sounds (see §5.3.1).
24 The labial fricative is realized as bilabial [ɸ].
glottalization in any case. In line with the sources cited above, I therefore tentatively conclude that the Nambiquara facts motivate the structure in (36b). Note, too, that there is some theory-internal support in favour of (36b): given the assumption that /h/ contains a “sibilant” manner component, and given the fact that within the class of fricatives there is a preferential association between sibilant manner and laryngeal modifications (see §2.1.2), we should not rule out the possibility of glottalized /h/ as a matter of principle.

As argued in §6.1, there are no cooccurrence restrictions on the combination of laryngeals and dependent |L|. Dependent |L| is also compatible with a placeless vocalic manner structure. The lack of cooccurrence restrictions here is unsurprising, given that the interpretation of dependent |L| in these cases is not laryngeal, but nasal. For the sake of completeness, consider in (38) the Element-based Dependency representation of a placeless nasalized vowel and a placeless nasalized approximant:

(38) a. N
   L   L
b. O
   L   L

Although these structures are marked on account of having dependent structure in the absence of place, I see no reason why they should be ruled out. Note that, according to the analysis presented in §6.1, Arabela may be an example of a language in which (38b) is underlying.

A final comment is in order with regard to the compatibility of laryngeal manner and distinctive voice. As was noted in §6.1, the hypothesis that dependent |L| in laryngeals denotes nasalization is based primarily on the cross-linguistic frequency with which we find laryngeals participating in nasal harmony. Note, however, that the recognition of nasalized laryngeals predicts that laryngeals cannot be distinctively voiced. The question whether this is correct is an empirical issue, of course. To the best of my knowledge, there are no clear examples of languages which have an underlying distinction between voiceless /h/ and voiced /b/.\(^{25}\) Distinctively voiced /b/ has been argued to occur in a number of Wu dialects of Chinese, where it is found in combination with specific register types (see Duanmu 1990, Kehrein 2002). As Kehrein notes, it is unclear whether these registers should be analyzed as being derived from /h/ or vice versa.

At first sight, the impossibility of voiced glottal stop appears to be a straightforward matter, since glottal closure is incompatible with vocal fold vibration. However, Ladefoged & Maddieson (1996:76) point out that the sound transcribed as [ʔ] is in many languages not realized with complete glottal closure—and incomplete glottal closure is compatible with voicing. The only

\(^{25}\) There are many languages with a single laryngeal fricative that is phonetically realized as voiced, but that is quite a different matter.
known language where voiced [ʔ] is arguably distinctive is Gimi, a Papuan language of New Guinea. Ladefoged & Maddieson classify the sound as a voiced glottal approximant. If it turns out that voiced /h/ and /ʔ/ are distinctive and contrast with their voiceless counterparts, then I suggest that they can be assigned the following representations:

(39) a. H b. ʔ
     |     |     
     L   L

Voiced /h/        Voiced /ʔ/

Note, however, that this move would imply the possibility of complex placeless manner types. The obvious danger of allowing such structures is that they lead to a proliferation of possible segment types, and thus to a loss of restrictiveness.

6.4 Summary

In this chapter, I have provided evidence in favour of a phonological class of nasalized laryngeals. The evidence for such a class comes primarily from nasalization processes in which laryngeals are targeted by nasalization and, more importantly, from nasalization processes that are triggered by laryngeals themselves. Two such nasalization processes can be distinguished. The first type involves an underlying contrast between an oral and a nasalized laryngeal; this type of contrast is found in, for instance, Seimat. The second type of process involves a single underlyingly nasalized laryngeal; I referred to the nasalization that is triggered by such laryngeals as spontaneous nasalization. Cross-linguistic evidence shows that spontaneous nasalization, while phonetically motivated, typically applies in an erratic manner, affecting some words but leaving others unaffected. Apart from nasalization processes that involve laryngeals, there are also other phonological phenomena that involve interaction between laryngeals and nasals. Some of these, such as the diachronic development of nasals in Ponapean, can be argued to fall under the rubric of spontaneous nasalization, at least from a diachronic perspective. Other processes, such as postnasal aspiration in Swahili, are amenable to an alternative analysis in which aspiration is triggered by an underlyingly aspirated nasal. Underlyingly aspirated nasals can also be posited in Kitsai, Cree and Sarcee, three languages which display a surface alternation between nasals and [h].