Glossa a journal of general linguistics

Breit, Florian. 2017. Melodic heads, saliency, and strength in voicing and nasality. *Glossa: a journal of general linguistics* 2(1): 85. 1–35, DOI: https://doi.org/10.5334/gjgl.462

RESEARCH

Melodic heads, saliency, and strength in voicing and nasality

Florian Breit
University College London, 2 Wakefield Street, London WC1N 1PF, GB
florian.breit.12@ucl.ac.uk

Melodic Heads in Element Theory (Kaye et al. 1985; Harris & Lindsey 1995; Backley 2011) have long been associated with higher acoustic saliency of the headed prime's properties (Lindsey & Harris 1990; Backley 1995; Harris & Lindsey 1995; et alia) and with the relative strength (e.g. alignment of melodic heads with strong positions and robustness of headed expressions against lenition) of a melodic head compared to a dependent (e.g. Backley & Nasukawa 2009). Following substantial work on the interaction of voicing and nasality (Nasukawa 1997, 2005; Ploch 1999; Botma 2004) it is commonly assumed that voicing and nasality are both represented by the same prime |L|, with dependent |L| encoding nasality and headed |$\underline{\text{L}}$| encoding voicing. In this paper I counter some of the arguments for the universality of this implementation, and develop an alternative view of a unified voicing–nasality prime, in which voicing is encoded by dependent |L| and nasality by headed |$\underline{\text{L}}$|. I show how this analysis is more consistent with both the saliency and strength arguments by considering arguments based on the represented acoustic patterns, positional strength, nasal sharing (nasal harmony within onset–nucleus pairs), and cross-linguistic biases against loss of nasality. Finally, I show how this account is compatible with a more restrictive, recursive view of the phonological interpretation component following the set theoretic model of Element Theory in Breit (2013). Based on these arguments I conclude that we have good reason to doubt the universality of Nasukawa (1997, 2005) and Ploch's (1999) implementation; instead we must give serious consideration to the reverse option with headed |$\underline{\text{L}}$| for nasality and dependent |L| for voicing. I suggest that there are two possible responses to this situation: we can either make the attempt to radically adopt the alternative, or we can adopt a more relativistic position (in the sense of Cyran 2011, 2014) which allows a choice between both options.

Keywords: Element Theory; nasals; headedness; acoustic saliency; phonological strength

1 Introduction

A large proportion of current work on laryngeal contrast takes the view that voicing distinctions are represented by a set of at least two privative primes (say for instance [spread glottis] and [voice]) rather than a single equipollent [±voice] prime (Halle & Stevens 1971; Itô & Mester 1986; Harris 1994; Iverson & Salmons 1995; Honeybone 2005; to name but a few). It is also well known that nasals are most commonly found only in the voiced series cross-linguistically, and that there is systematic interaction between nasal segments and voice in many languages. This has led to a number of proposals which treat voicing as a phonologically inherent property of nasals (e.g. Ploch 1999; Botma 2004; Nasukawa 2005). In fact, accounts in Element Theory (ET) have gone as far as proposing that voicing and nasality are melodically encoded by a single privative prime. Under such proposals, the difference between voicing and nasality is relegated to the structural properties of the segment, so that the distinctive trait is headedness and the dependency relation between the unified prime and other segmental content. The common view, following work by Ploch (1999) and Nasukawa (1997, 1999, 2000, 2005) is that a headed unified prime |$\underline{\mathrm{L}}$| encodes voicing while a dependent unified prime |L| encodes nasality.

This paper will challenge that view. It will argue that two of the notions traditionally associated with melodic headship in ET, saliency and phonological strength, both speak for an opposing view where nasality is encoded as headed |$\underline{\mathrm{L}}$| and voicing as dependent |L|. It will show how, based on assumptions about phonology's interface with phonetic interpretation, the inherency of voicing in nasal segments can logically follow only from this view and not from that advanced by Ploch (1999) and Nasukawa (2005). The paper discusses two possibilities of dealing with the conflicting proposals: abandonment of the former implementation and adoption of the reverse proposal across the board, or parametrisation allowing for individual languages to be characterised by either nasal or voicing primacy. In this regard the paper will show parametrisation to be beneficial mainly in that it offers straight-forward accounts for a number of historical/typological facts, but to ultimately remain challenging because it would require us to maintain the possibility of a parametric option that leads to representations that are not fully compatible with the broader, more general considerations about segmental representation and nasal/voiced-consonant behaviour discussed throughout the paper.

The structure of the paper is as follows: In Section 2, I recapitulate the view of segment-internal structure subscribed to by mainstream ET, with particular reference to headedness. I note how under this view the notions of acoustic saliency and melodic strength are inherently linked to melodic headship. In Section 3 I discuss the Unified Voicing and Nasality Hypothesis (UVNH) and the proposals made by Ploch (1999) and Nasukawa (2005); I make an alternative proposal at the end of that section. Following this, in Sections 4 and 5, I show that both the saliency argument and the strength argument speak for the reverse view of the head–dependency relation in |L|. Finally, before concluding, in Section 6 I describe one particular view of the interface with phonetic interpretation (based on the set theoretic model in Breit 2013) which predicts that a prime's traits are inheritable across the head–complement dimension; I show that this can derive the inherency of voicing in nasals with the reversed head–dependency relation, but not with the implementation argued for by Nasukawa (1997, 1999, 2000, 2005) and Ploch (1999).

2 Headship in Element Theory

2.1 The building blocks of melodic expressions

Element Theory (Kaye et al. 1985; Lindsey & Harris 1990; Harris 1994; Harris & Lindsey 1995; Charette & Göksel 1996; Backley 2011; et alia) takes the view that segments are composed of a number of privative atomic units, called the elements. Unlike many other versions of phonological features, elements are understood to be purely cognitive primes not inherently linked to articulatory mechanics.[1] In addition, each of the elements is assumed to be autonomously interpretable by itself as well as in combination with other elements, in contrast to say the features of SPE which are only interpretable in the context of a fully specified matrix of features (Harris & Lindsey 1995).

Inherent in the assumption that segments are composed of such autonoumous elements is the proposition that some segments are amalgamations of primitive segments. Take for instance the typology of vowel systems. It is well established that the three corner vowels [i, a, u] feature almost universally across the world's vowel systems (Crothers 1978; Lindblom 1986), and that systems expand from these basic vowels to next include vowels

[1] For an in-depth discussion of the opposing views regarding what constitutes phonetically grounded versus purely cognitive phonological primes see Kaye (1989) and part one of Ploch (1999).

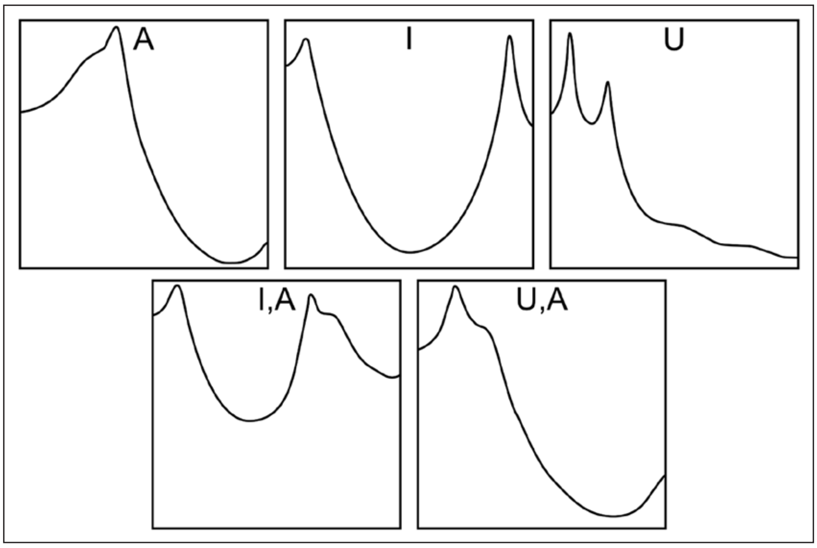


Figure 1: Spectral patterns of |A|, |I|, and |U|: mAss, dIp, and rUmp (top); and of the compounds |A, I| and |A, U| (bottom). Adapted from Backley (2011).

intermediary to the three corner vowels (i.e. [e, ɛ] between [i] and [a]; [o, ɔ] between [u] and [a]; and [ɨ] between [i] and [u]; Lindblom 1986: 14).

Because of these facts most element-based frameworks have posited that the primitive units of vocalic representation are the cognitive units autonomously manifested as [i, a, u], let us call them |I|, |A|, and |U| respectively. The intermediary vowels can then be viewed as amalgamations of these primitive units, so that a segment composed of |I, A| may be interpreted as a front mid vowel, one composed of |A, U| a back mid vowel, and so forth. See Figure 1 for an illustration of the spectral patterns of the three elements |A|, |I|, |U| together with the compounds |A, I| and |A, U|.

2.2 *Heads and dependents*

Even if we include the possibility of a segment entirely devoid of elemental content, the possible combinations of three elements would leave us with the prediction that vowel systems generally contrast no more than eight vowels.[2] This is manifestly untrue. We need to also consider that intermediary vowels composed of more than one element, i.e. complex segments, are often asymmetric, that is to say they tend to be closer in identity to one of the corner vowels than they are to another.

Different frameworks have come up with a variety of ways to increase the generative capacity of the three-prime system and account for these asymmetries. One is that of Dependency Phonology (Anderson & Jones 1974; Anderson & Ewen 1987), which allows for a variety of different dependency relations between any two primes. Another is to allow the same prime to recur several times in a single segment, a view advanced in Particle Phonology (Schane 1984, 1995), such that we may contrast a segment composed of |I, I, A| with one composed of |I, A, A|; the former more |I|-like, the latter more |A|-like. One issue with the latter proposal is that it imposes no limit on the generative potential of the theory, so that we could in principle imagine a vowel inventory with an uncountably large number of contrasts along a single plane. The view taken by Government Phonology (GP) and adopted by current ET is similar to that of Dependency Phonology, but only a single type of dependency relation is acknowledged. Thus, in ET this asymmetry is a manifestation of a head–dependency relation entered into by a segment's elements (cf. e.g.

[2] That is |I|, |A|, |U|, |I, A|, |I, U|, |A, U|, |I, A, U|, and the empty representation | |.

Harris & Lindsey 1995). Although some versions of ET allow, albeit to a very limited extent, several heads in a single segment (e.g. Backley 2011), the common view (adopted here) is that every segment may have only a single (optional) head. As Backley (1995: 402) puts it:

> "According to the notion of headship, a single element within a complex expression is identified as the head of that expression, while the remaining primes assume dependent status."

Let us call this the Single Optional Headedness Condition (SOHC). Without any additional theoretical machinery, ET with the SOHC predicts there to be a maximum of 7 contrasts along a single dimension.[3] With its five front vowels /i, ɪ, e, ɛ, æ/ and the perhaps marginal /a/ the vowel system of English makes use of a large proportion of these possibilities.

2.3 Saliency and strength

The tendency for a segment to be more like its head has been developed into what can be called the saliency argument for heads (cf. e.g. Lindsey & Harris 1990; Harris & Lindsey 1995; Carr 2005; Backley & Nasukawa 2009). Consider the following passage from Harris & Lindsey (1995: 58):

> "In terms of its effects on the signal, intrasegmental dependency is reflected in the predominance of one elemental pattern over another. The compound profile of $|\mathrm{A}, \underline{\mathrm{I}}|$, for example, can be interpreted as a relatively less salient mAss [i.e. |A|-like] pattern located in the middle of a relatively more salient dIp [i.e. |I|-like pattern]."

The saliency argument can be summed up succintly as follows: one of the reflections of the head–dependency relation is that the head distributes asymmetrically over the dependent(s) and so is more salient in the associated acoustic signal.

Apart from providing us with a mechanism to encode saliency and its practical function in limiting generative capacity to be more in line with the actual limits of typological attestation (in comparison to e.g. Schane's 1984 recurrence approach), headedness has also been linked to various other tangible properties in phonological behaviour and phonetic manifestation. The first of these is that heads are assumed to possess licensing potential over their dependents, so that Licensing Constraints which restrict what heads can license what dependents within a segment can be exploited to explain systematic absences of some theoretically possible segmental contrasts in various languages (cf. e.g. Charette & Göksel 1998; Kaye 2000). The same principle has also been extended to intersegmental relations in the form of Licensing Inheritance, thus contributing to observed phonotactic restrictions by excluding certain pairs of consonants and vowels dominated by the same category (Harris 1992, 1994, 1998).

Directly congruent with both the function of segmental heads in licensing segmental material and their acoustic predominance is the argument that segmental heads are phonologically stronger than dependents: only heads function as licensors, headed expressions occupy strong prosodic positions such as onsets (the environment traditionally considered most robust against lenition, cf. e.g. Backley & Nasukawa 2009), and heads have the potential to trigger harmonic processes (see e.g. Backley & Takahashi 1996; Charette & Göksel 1996, 1998; Lee 1996; Lee & Yoshida 1998). Beyond melodic heads'

[3] E.g. $|\underline{\mathrm{I}}|$, $|\mathrm{I}|$, $|\underline{\mathrm{I}}, \mathrm{A}|$, $|\mathrm{I}, \mathrm{A}|$, $|\mathrm{I}, \underline{\mathrm{A}}|$, $|\mathrm{A}|$, $|\underline{\mathrm{A}}|$ for the |I|–|A| dimension; for more on the generative capacity of this system see Breit (2013).

functional strength in licensing relations and harmonic processes, Backley & Nasukawa (2009) find further evidence for the strength of melodic heads in what they describe as an affinity between strong domains, so that there is an alignment between melodic heads and prosodically strong positions. For them "[...] prosodic strength is directly reflected in melodic strength, so that any headed melodic structure will have a natural tendency to be interpreted in stronger rather than weaker positions" (Backley & Nasukawa 2009: 66). Thus they argue that we often find maximal contrast, e.g. in the domain of laryngeal specification, in prosodically strong positions, similarly to how vowel systems are frequently only maximally contrastive in stressed syllables or the head of a diphthong, and reduced in unstressed nuclei (cf. e.g. Harris 2005).[4] Once more a good example comes from the behaviour of vowels. In a tense/lax system such as for instance German (Ploch 1993), English (Kaye 1990) or North Welsh (Ball & Williams 2000; Hannahs 2013b) it is only the tense series that can be long, so that we have the pairs /iː, ɪ; uː, ʊ; oː, ɔ/ etc. Given that the tense/lax distinction in these languages is implemented as headed vs unheaded vowels, so that for instance tense [iː] is represented by headed |I̲| and lax [ɪ] by unheaded |I|, this is not surprising: only the headed segments are strong enough to link to two ×-slots dominated by a single nucleus.

Above we have briefly reviewed the main characteristics of the ET view of segmental composition, specifically the segment-internal head–dependency relation and how headship is associated with saliency and strength, mainly from the example of vowels. Let us now turn to a discussion of how ET represents voicing and nasality.

3 The Unified Voicing and Nasality Hypothesis

3.1 The representation of voicing and nasality

With regards to laryngeal contrast, work in Element Theory has traditionally subscribed to laryngeal realism (Halle & Stevens 1971; Itô & Mester 1986; Iverson & Salmons 1995; et alia), the idea that although voicing contrasts in many languages appear to be equipollent on the surface, there is no underlying equipollent [±voice] opposition.[5] Instead, there are posited to be at least two phonologically active privative primes at work, one responsible for true voicing ([voice] or [constricted glottis] in traditional feature terms), and one responsible for aspiration ([spread glottis] in traditional terms). Languages with a two-way contrast are then either voicing or aspiration systems, in each case contrasting with a neutral series, while other languages, such as for instance Thai and Korean, may employ both primes to encode a three-way contrast. A fourth contrast can be encoded by the co-occurence of both primes, a possibility employed by languages such as Gujarati, where it manifests as breathy voicing. In ET, the low element |L| is said to encode true voicing in voicing systems and the high element |H| is said to encode aspiration in aspiration systems (cf. e.g. Harris 1994; Backley 2011). Thus, without reference to headedness ET can principally encode up to four contrasts, broadly reflective of the kinds of systems we find across languages, as illustrated in Table 1.

Nasality was initially believed to be represented by an independent element |N|, but it soon became clear that there were a number of issues with that proposal. For instance Cobb (1997) and Ploch (1999) point to the fact that charm theory (Kaye et al. 1985), which assigned positive charm to both the elements |N| and |A|, predicted incorrectly that the two elements could not co-occur in the same melodic expression. On the contrary, cross-linguistic evidence seemed to indicate that |N| and |A| have a certain affinity for

[4] Though note that Nasukawa & Backley (2015) have recently suggested that, at least at the constituent level, dependents might have greater freedom to encode a wide range of contrast, after all.

[5] Cf. Trubetzkoy's (1939: 69) insight that logically privative oppositions frequently appear to be factually equipollent.

Table 1: An overview of different systems of laryngeal contrast, adapted from Harris (1994: 135).

UR	***Mode***	***French***	***English***	***Thai***	***Gujarati***
|L|	voiced	/bo/ 'beautiful'		/bàa/ 'shoulder'	/bar/ 'twelve'
| |	voiceless	/po/ 'skin'	/peɪ/ 'bay'	/pàa/ 'forest'	/pɔr/ 'last year'
|H|	aspirated		/pʰeɪ/ 'pay'	/pʰàa/ 'split'	/pʰɔdz/ 'army'
|L, H|	breathy				/b̤ar/ 'burden'

each other and vowels containing |A| are frequently nasalised.[6] Apart from this inconsistency, there is also an array of positive evidence to suggest that phonological nasality is not independent, ultimately leading to the hypothesis that voicing and nasality are represented by the same melodic prime—we can call this the Unified Voicing and Nasality Hypothesis (UVNH). Let us now briefly consider some of the evidence for the UVNH, before dicussing in more detail the matter of headedness regarding the proposed unified prime.

3.2 Interactions between voicing and nasality

First, as Botma (2004, 2009) amply points out, in languages without an underlying oral–nasal contrast such as Rotokas (Firchow & Firchow 1969) and Pirahã (Everett 1986), there is optional nasalisation of the voiced series of stops. Consider the examples of the Rotokas voiced series of consonants in (1).[7]

(1) *Rotokas* (Firchow & Firchow 1969: 274)

UR	*Variants*	*Translation*
/ßaßae/	[ßaßaᵉ] ~ [babaᵉ] ~ [mamaᵉ]	'five', 'hand'
/ɾagai/	[ɾagaiⁱ] ~ [dagaⁱ] ~ [nagaⁱ]	'I', 'me'
/ßegei/	[ßeɣeⁱ] ~ [ßegeⁱ] ~ [ßeŋeⁱ]	'we two'

As Firchow & Firchow (1969: 274) note the different dialects of Rotokas have different preferences for one of the variants, so that Aita Rotokas prefers the nasal variant and Rotokas Proper the weakened oral stop, but it seems clear from their discussion that all of these variants are available to speakers regardless of their dialect, and are sometimes employed for paralinguistic effects such as imitation of a foreign accent or in reciting an English word.[8] As Botma (2004: 62) points out, it seems that languages such as Rotokas and Pirahã employ nasality as a phonetic choice for the same category as voicing, rather than treating the two as separate phonological categories.

Second, Nasukawa (1997, 1999, 2005) draws evidence from two phenomena in Japanese: postnasal voicing in Yamato Japanese and the alternation of voiced stops with prenasalised stops in Northern Tohoku Japanese. Postnasal voicing processes are commonplace cross-linguistically (cf. e.g. Locke 1983; Hayes & Stivers 1995) and various universal proposals for a *NC constraint have been made on the basis of this (e.g. Pater 1996; Hayes 1999). While attempts at a phonetic explanation for postnasal voicing have been made (e.g. Hayes & Stivers 2000), the supposed phonetic origin and implied claim of universality is hampered by the occurence of postnasal devoicing in a few languages—a process

[6] This affinity even led some researchers to put forward what Ploch (1999) termed the "Height Myth": the proposal that low vowels are, for phonetic reasons, the preferential targets of vowel nasalisation. However, as Ploch (1999) amply points out, this apparent preference does not show the cross-linguistic universality we would expect were it truly phonetically motivated, for which reason he rejects that explanation.

[7] Firchow & Firchow (1969) give [l] as a further variant of /ɾ/, omitted here for clarity.

[8] For instance Firchow & Firchow (1969: 274) give [maᵉ maᵉ] as the recitation of English *bye bye* by a speaker of Rotokas Proper.

that should not exist if postnasal voicing were a truly phonetically motivated process (see e.g. Hyman 2001; Solé et al. 2009) for further discussion). Consequently postnasal voicing must have an explanation in the cognitive representations underlying nasals and voiced segments. Crucially, two independent primes for voicing and nasality do not provide such a cognitive link, but if both voicing and nasality are due to the same prime then such interaction is easily explained. Yamato Japanese is of special interest because, in the same dialect, nasals give rise to postnasal voicing in one envirnoment but in another they don't, giving rise to what Nasukawa (1997) terms a "nasal–voice paradox." As can be seen from the examples in (2), postnasal voicing in Yamato Japanese exists both as a static (2a) and as a derived (2b) property.

(2) *Yamato Japanese* (Nasukawa 1997: 3)

a.	[ʃombori]	*[ʃompori]			'discouraged'
	[ʃindoi]	*[ʃintoi]			'tired'
	[kaŋgae]	*[kaŋkae]			'thought'
b.	/ʃin/ + /te/	→	[ʃin-de]		'die-GER'
	/ʃin/ + /ta/	→	[ʃin-da]		'die-PST.IND'
	/ʃin/ + /tara/	→	[ʃin-dara]		'die-SBJV'

The postnasal voicing data in (2) clearly show that there is a phonologically active voicing component in the Yamato Japanese nasals which spreads to the segment to its right. In contrast, consider the examples in (3), which illustrate Rendaku. Rendaku causes an initial voiceless consonant in a compound to become voiced, as illustrated in (3a). However as can be seen from (3b), if the second part of the compound already contains a voiced consonant Rendaku is blocked due to Lyman's Law, which prohibits free morphemes from containing more than one voiced consonant (Lyman 1894). As can be seen from (3c), nasals do not block Rendaku, despite the postnasal voicing evidence in (2) suggesting they are phonologically voiced.

(3) *Yamato Japanese* (Nasukawa 1997: 5–6)

a.	/oo/ + /taiko/	→	[oodaiko]	'big drum'
	/onna/ + /kokoro/	→	[onnagokoro]	'woman's heart'
	/take/ + /sao/	→	[takezao]	'bamboo pole'
b.	/maru/ + /hadaka/	→	[maruhadaka]	'completely naked'
	/kami/ + /kaze/	→	[kamikaze]	'divine wind'
	/onna/ + /kotoba/	→	[onnakotoba]	'feminine speech'
c.	/yaki/ + /sakana/	→	[yakizakana]	'grilled fish'
	/ori/ + /kami/	→	[origami]	'paper folding'
	/kami/ + /tana/	→	[kamidana]	'household altar'

If nasals in Yamato Japanese have an independent prime specifying them to be voiced, then we would have to assume that nasals are phonologically voiced some of the time, but not phonologically voiced at other times. Nasukawa's (1997) solution to this apparent paradox is to posit a single unified prime for voicing and nasality. In Nasukawa's view voiced obstruents have this prime as their head, while nasals only have it as a dependent. Lyman's Law then is only sensitive to this prime when it is the head of a melodic expression, but not when it is a dependent.

Nasukawa (1999) draws further evidence for the UVNH from an alternation of voiced stops with prenasalised voiced stops in Northern Tohoku Japanese. As can be seen in (4a) where Tokyo Japanese has an intervocalic voiced stop, Northern Tohoku Japanese has a prenasalised voiced stop. Since the same position is also associated with what Nasukawa argues is intervocalic lenition of voiceless stops, as illustrated in (4b), he concludes that the voiced stops undergo a similar lenition process in Northern Tohoku Japanese which results in prenasalisation.

(4) *Northern Tohoku Japanese* (Nasukawa 1999: 210)

a.	*Tokyo*	*N. Tohoku*	*Translation*
	[kagi]	[ka$^{\text{ŋ}}$gi]	'key'
	[hada]	[ha$^{\text{ŋ}}$da]	'skin'
	[kabɯ]	[ka$^{\text{m}}$bɯ]	'turnip'
b.	[kaki]	[kaɣi]	'persimmon'
	[hata]	[haɹa]	'flag'

Again a unified prime for voicing and nasality provides a clear connection and explanatory hypothesis for this interaction, while it would not be clear why two independent primes should otherwise show this affinity. The explanation offered by Nasukawa (1999) is that stops in Northern Tohoku uniformly receive a reduction in their melodic complexity in foot-internal positions: here voiceless stops lose the "stop element" |ʔ|, and in voiced nasals the unified prime is demoted from headhood to dependent status.

Finally, Ploch (1999: 193ff) groups evidence for the UVNH into four different categories, as follows:

First, postnasal voicing in various languages, of the kind exemplified by Nasukawa's (1997) analysis of Yamato Japanese above.

Second, nasal licensing (also called nasal sharing), where the voiced series of stops is in complementary distribution with nasals preceding oral and nasal vowels respectively. Crucially, voiceless stops show no such co-dependence on the nasality of the following vowel. Ploch (1999) argues that this patterning can be explained by assuming a unified prime and a condition that the operator version of that prime, interpreted as nasality, has to be licensed by an adjacent headed version of the same prime (see also Ploch 1997). Alternatively, Botma (2009) proposes that the stop in such configurations is in both cases linked to a unified prime and that this prime is interpreted as nasality when attached at a level of projection shared with the following nucleus, but not if it is attached at the level of the onset only.

Third, L/H-Incompatibility, that is the relatively well-known interactions between voicing and tone, for example in Zulu, where a voiced segment immediately preceeding a nucleus with high tone displaces that high tone one position to the right, as apparent from comparing examples (5a) and (5b).

(5) *Zulu* (Ploch 1999: 200)

a. /ú-ya-let$^{\text{h}}$-él-a/ → [úyalet$^{\text{h}}$éla]
3SG.SBJ-PRES-bring.BEN-ASP
'She/he is bringing for'

b. zí-ya-let$^{\text{h}}$-él-a/ → [zìyálet$^{\text{h}}$éla]
3PL.SBJ-PRES-bring.BEN-ASP
'They are bringing for'

In (5b) the lexical high tone, represented by an underlying |H| is displaced by the |L| from the voiced fricative, which spreads onto the adjacent nucleus giving it low tone. Ploch (1999) sees this antagonistic displacement as parallel to the blocking effect that voiceless (i.e. |H| containing) stops have on nasal harmony, e.g. in Warao, where rightward spreading of nasality is blocked by voiceless stops as shown in (6).

(6) *Warao* (Ploch 1999: 202)

[mẽh̃õkohi]	'shadow'
[mõãũ]	'give it to him!'
[mõãũpu]	'give them to him!'

If we accept the L/H incompatibility argument for the type of tonal effect exhibited by languages such as Zulu, then the UVNH means that the nasal harmony blocking effect of voiceless stops in languages such Warao is completely analogous.

Fourth, Dissimilation, as already illustrated by the case of Lyman's Law in Nasukawa's (1997) Rendaku analysis above. Ploch (1999) adds an additional analysis of Dahl's Law (|H| dissimilation) and Meinhof's Law (|L| dissimilation) along similar lines; I will refrain from discussing these here since the basic insight is apparent from the Japanese data already discussed.

3.3 Implementation of a unified prime

Now that we have reviewed part of the substantial evidence for the UVNH, let us turn our attention to the implementation of the unified prime, commonly assigned the label |L| in line with the prime's previous identity as low tone and voicing element.[9] Both Nasukawa (1997, 1999, 2000, 2005) and Ploch (1997, 1999) argue that the headed unified prime encodes voicing and the dependent unified prime encodes nasality in consonants, while in vowels the headed prime encodes nasality and the dependent prime low tone. Let us call this the *Conventional Implementation* (CI), summarised in (7).

(7) *UVNH—Conventional Implementation (CI):*

	Consonants	*Vowels*
Headed |L̲|	Voicing	Nasality
Dependent |L|	Nasality	Low tone

It seems quite clear from the discussion in Ploch (1999), Nasukawa (2005) and Backley & Nasukawa (2009) that they take the CI to be universal across language. Naturally, proposing a universal one-way encoding of voicing and nasality poses the question whether the opposing view might not be tenable also, a position not entertained by either of them. In what follows I will thus set out arguments, mainly based on the saliency and phonological strength of nasals, which speak for such an *Alternative Implementation* (AI), where nasality is encoded by headed |L̲| and voicing by dependent |L|, as summarised in (8).

(8) *UVNH—Alternative Implementation (AI):*

	Consonants	*Vowels*[10]
Headed |L̲|	Nasality	Nasality
Dependent |L|	Voicing	Low tone

[9] Note that Nasukawa generally refers to the unified element as |N| where the mainstream notation is |L|. This appears to be purely notational and carries no discernible implications. According to Ploch (1997) the merger was first suggested by Jonathan Kaye in lectures he gave at SOAS; a possible merger is also alluded to in Harris & Lindsey (1995).

[10] Although the question of a possible role-reversal is of course also applicable to the representation of nasality in vowels, I will here focus mainly on voicing and nasality in consonants. Consequentially I have nothing to say about the head/dependent role of |L| in nuclei at present.

Ploch (1999) and Nasukawa (2005) take as the main evidence for the CI the very fact that stipulation of the CI allows them to successfully analyse the various types of phenomena discussed above (cf. Ploch 1999: 228), but they also present two types of additional arguments for the CI, specifically relating to the claim that the CI is universal: one from constituency and one from the typological distribution of true voicing and nasality.

3.4 Nasals and constituency

Regarding the first, Ploch (1999) cites an argument originally made by Kaye (1995), namely that nasals must be headless[11] (contra Kaye et al. 1985) because they appear to be universally unable to occupy the governing position of a branching onset. Under Strict Directionality (Kaye et al. 1990), which universally defines intraconstituent government as head-initial, and with Ploch's (1999) stipulation that such governors must be headed, this means that classical GP predicts there to be no branching NC onsets if and only if nasals are universally headless, which they are under the CI but not under the AI. Thus, this strict set of assumptions makes the prediction that voiced stops in e.g. /br, dr, gr/ are good word-initial onsets in all (phonological) voicing languages, but clusters such as */mr, nr, ŋr/ do not make good branching onsets in any language.[12] It must be noted, however, that the requirement for a governor to always be headed can neither be upheld under some current versions of ET such as Backley (2011), nor for GP offshoots such as CVCV (Lowenstamm 1996; Scheer 1998, 2004), which does away with branching constituents altogether and assumes universally head-final government instead, meaning that nasals in e.g. German word-initial /kn(ɔxn̩)/ make good interconstituent governors. Nonetheless, I will here briefly discuss two cases that are incompatible with the strict predictions of the government-based argument. It is important to keep in mind here that the view I ultimately want to challenge is not the possibility of CI languages per se, but rather the claim that the CI is universal, i.e. I want to minimally make the claim that the situation is a relativistic one (in the sense of Cyran 2011; Cyran 2014), where languages have a choice between the CI and the AI.

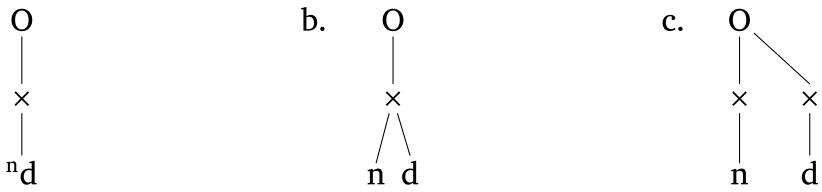
Under Kaye (1995) and Ploch's (1999) arguments against nasal-headed clusters, prenasalised stops can be discounted on the assumption that they are singular representations, attached to a "non-branching"[13] ×-slot of the type shown in (9a) and thus not subject to the usual constraints contracted between positions. Similarly, it is an implicit assumption of the prenasalisation arguments for nasal dependent |L| in Nasukawa (1999, 2005) and Backley & Nasukawa (2009) that prenasalised stops are always singular melodic representations attached to a non-branching ×-slot as in (9a). If such material can be shown to have an underlying structure where there are two separate melodic representations, either attached to a single branching ×-slot—what has traditionally been deemed the structure of contour segments—as shown in (9b), or two ×-slots in a branching onset as shown in (9c), then it would appear that in at least some languages nasals make good governors. Additionally, it would have to be conclusively shown that prenasalised stops e.g. in Japanese are not the result of diachronic segmental decomposition into two separate melodic expressions of the type in either (9b) or (9c).

[11] Or, charmless, in the terminology of Kaye et al. (1985); Kaye (1995).

[12] This claim does not deny the existence of word-initial NC *sequences*, but rather makes the strong prediction that such sequences never form a constituent, i.e. in a word such as Polish *mróz*/mrus/ 'frost' the initial /mr/-sequence is formed of two separate onsets interrupted by an empty nucleus (a configuration sometimes termed a *bogus cluster*, see Harris 1994: 222f; Ulfsbjorninn in press for discussion).

[13] What is commonly illustrated as branching below an ×-slot in Government Phonology is usually understood not to be the same as the branching of constituents on other tiers. Rather this is usually understood to mean that two expressions attached to that slot remain unfused. I will refer to these unfused subsegmental structures as "branching" simply out of convenience.

(9) a. b. c.



While it seems clear that cross-linguistically good arguments can usually be made to treat prenasalised stops as occupants of single ×-slots of the kind in (9b), if not as consisting of singular representations as in (9a), the following two cases should at least shed some initial doubt on the tacit assumption that such “sounds” are universally represented by a singular melodic entity of type (9a). The first are nasal-initial branching onsets resulting from initial consonant mutation in Welsh, the second the representation of the various contrasting stops in Arrernte.

3.4.1 Welsh Nasal Mutation

The Welsh language is well-known for its initial consonant mutations, a set of processes that alter the initial consonant of an underlying form under certain phonology-external conditions (see Ball & Müller 1992 for an overview). One of these patterns, triggered (among others) by the first singular possessive /və/ ‘my’, is Nasal Mutation (NM). Under NM all of the Welsh stops are turned into nasals of the same place, retaining their laryngeal specification. The process applies equally to non-branching and genuinely branching onsets, as well as to the (marginally phonemic) affricates /tʃ, dʒ/;[14] this is illustrated in (10), where (10a) shows NM applying to singleton consonants and the affricate /tʃ/, and (10b) shows NM applying to branching onsets.

(10) *Welsh*

	UR	*NM*	*Translation*
a.	/pʰʊɬ/	[və m̥ʰʊɬ]	‘my pool’
	/baχgen/	[və maχgen]	‘my boy’
	/tʰir/	[və n̥ʰir]	‘my land’
	/gʷaɬt/	[və ŋʷaɬt]	‘my hair’
	/tʃips/	[və n̥ʃips]	‘my chips’
b.	/tr̥ɛvn/	[və n̥r̥ɛvn]	‘my system’
	/djaul/	[və njaul]	‘my devil’
	/blɔdɨn/	[və mlɔdɨn]	‘my flower’
	/pr̥iv varn/	[və m̥r̥iv varn]	‘my main opinion’

Since the nasal-initial clusters in (10b) are derived from genuine branching onsets, the argument here is that the resultant nasal clusters are also genuine branching onsets of the type in (9c) above, in line with Kaye et al.’s (1990) Projection Principle.[15] Two arguments are commonly made in order to reject the Welsh data in (10).

First, the Welsh first singular possessive /və/ is often realised as a proclitic, so that it could be argued that the phrase possessive + target counts as a single phonological domain and the nasal is consequently no longer domain-initial. There are numerous reasons why this argument is not sufficient to reject NM forms as phonological domains. On the one

[14] Welsh traditionally does not have affricates in its inventory, but they have become marginally attested due to large English loan vocabulary in modern colloquial Welsh (where they alternate with simplified versions depending on the speaker, e.g. /tʃips/~/ʃips/ ‘chips’).

[15] The Projection Principle states that government relations (between constituents) are established at the lexical level and remain constant throughout phonological alteration, i.e. constituent structure remains unaltered (Kaye et al. 1990: 221).

hand mutations generally (though not NM) can not only be triggered by string-adjacent lexical items, but also by other morphosyntactic environments, such as Soft Mutation (which turns fortis into lenis sounds) following a syntactic maximal projection (the XP trigger hypothesis, see e.g. Borsley & Tallerman 1996). On the other hand, some possessives in Welsh, such as the third singular /i/ 'his/her' are realised as enclitics of the preceeding word when they are preceded by a vowel, yet they continue to trigger mutations on the lexical item they dominate syntactically (e.g. /a i kiː hi/ 'and her dog REFL' → [a = i χiː hi]). It is also not clear whether other triggers of NM can necessarily be counted as proclitics. For instance the NM trigger /ən/ 'in' generally seems to resist cliticisation, while the homophonous imperfective marker /ən/ is realised as an enclitic following vowel-final items. There are also instances where string-adjacency between a lexical trigger and an NM target can be violated, namely when expletives such as *fucking* and *bloody* are inserted, e.g. in [və fʊkɪn ŋ̊ʰiː] (< /kʰiː/) 'my fucking dog' (cf. Breit 2012).[16]

Second, the nasal-initial branching onsets resulting from NM are always derived. Thus while other arguments would have to be made about how they survive derivation, the weaker argument can be made that—at least at the lexical level—they never present a problem. In other words, the argument is that a structure such as (9c) is never stored in the lexicon and hence somehow less problematic. Again there are good reasons to reject this argument. Although most traditional accounts of Welsh mutations are derivational in nature, almost all recent work has argued that mutation environments are subcategorisation frames which simply select the appropriate (already mutated) form (e.g. Green 2003, 2007; Hannahs 2013a, b) in a suppletion-type process. Although I am not certain that this approach is correct, such proposals are obviously challenging for the position that these forms are not problematic precisely because they only ever occur as derived forms. There are also a few cases where the nasal mutated form of a word with a branching onset has been lexicalised. For instance in the form /mləneð/, the variant of /bləneð/ 'year' selected after numerals from five and above (the same holds true for /bluið/ ~ /mluið/ 'year [of age]' and /djurnɔd/ ~ /njurnɔd/ 'day'). Importantly, the numerals themselves do not trigger Nasal Mutation, so that, as shown in (11a), there is no NM taking place following the numeral *seven* for any other lexical item (here /tʰɨdalen/), but as (11b) shows the root for *year* selects the form /mləneð/ and not the form /bləneð/.

(11) a. [saiθ tʰɨdalen] *[saiθ n̥ʰɨdalen] 'seven pages'
b. [saiθ mləneð] *[saiθ bləneð] 'seven years'

Such lexicalised mutation forms are reasonably common in Welsh, and a large number of function words have been reanalysed with their mutated form now serving as the underlying lexical representation. The case of Welsh fossilised NM forms such as /mləneð/, in addition to the other arguments above, then provides good evidence that Welsh nasal-initial complex onsets are a counterexample to the proposed ban on nasal-headed branching onsets and have to be accepted as examples of the structure in (9c). They cannot be dismissed either on the basis of phonological domains or on the basis that such nasal-initial branching onsets supposedly only occur as derived forms.

3.4.2 Arrernte onsets

Let us now turn to Arrernte, which is of interest to us because of its various contrasting stops, especially the occurrence both of prenasalised stops and prestopped nasals.

[16] Stenson (1990) observes a similar case of non-adjacent initial consonant mutation with an intervening expletive in Irish.

Under the assumption that prenasalised stops and prestopped nasals are both attached to a single unary-branching ×-slot, it is a consequence of the reduced set of elemental primes and the SOHC that the number of representations that can be generated is very limited, and we will presently see that the stop inventory of Arrernte seems to be more expansive than what is compatible with the number of representations we can so generate.

According to Maddieson & Ladefoged (1993) and Ladefoged & Maddieson (1996), Arrernte contrasts plain stops with nasal stops, prenasalised stops and prestopped nasals. Each of these occur in a rounded and in an unrounded version, and in six places of articulation, as illustrated in Table 2. For instance in alveolar place we have /t, tʷ; n, nʷ; ᵗn, ᵗnʷ; ⁿd, ⁿdʷ/. Neglecting the representation of place of articulation for now, we need all three of the elements |U, ʔ, L| to represent rounding, stopness and nasality, respectively. The rounded series contains |U| while the unrounded series does not. So let us stipulate that the simple stops, e.g. /t, tʷ/, are represented by |ʔ| and |ʔ, U| (plus place elements) respectively. Although nasal stops would typically contain both |ʔ| and |L|, it has been proposed that some primary nasal consonants can be successfully characterised simply by the presence of |L| even in the absence of |ʔ| (Cyran 2010; though this may not do justice to primary nasals which actively pattern with other stops in a given system). If we adopt this proposal for Arrernte we have |L| and |L, U| to represent /n, nʷ/, respectively. We are left with the prenasalised series and prestopped series to still define. Since they are both characterised by full oral occlusion and suppression of the carrier signal at some point, let us stipulate that they contain |ʔ|, but because we need to somehow distinguish the two and stopness is more salient in the prenasalised stop than in the prestopped nasals, in that the total suppression of the carrier signal is longer and more abrupt, let us assign |ʔ̲, L| and |ʔ̲, L, U| to the pair /ⁿd, ⁿdʷ/. While it is not clear whether it is appropriate to characterise the distinction in this way, this argument would generally be in line with that of Backley & Nasukawa (2009), who argue that ejectives have headed |ʔ̲| because their suppression of the carrier signal is more pronounced than that of non-ejective stops.[17] We are left with but one option for /ᵗn, ᵗnʷ/, namely the unheaded representations |ʔ, L| and |ʔ, L, U|, respectively. Alternatively to headed |ʔ̲|, we could use headed |L̲| and unheaded |L|, or a complementary combination of both. The important thing is that in order to make all the necessary differentiations, even though there is no voicing contrast in Arrernte, we still need to make use of headedness to account for the contrast in manner alone. In summary, we have the representations in (12) (again, omitting place of articulation).

Table 2: The inventory of stops in Arrernte.

	Bilabial		***Velar***		***Palatal***		***Dental***		***Alveolar***		***Retroflex***	
Plain	p	pʷ	k	kʷ	c	cʷ	t̪	t̪ʷ	t	tʷ	ʈ	ʈʷ
Nasal	m	mʷ	ŋ	ŋʷ	ɲ	ɲʷ	n̪	n̪ʷ	n	nʷ	ɳ	ɳʷ
Prenasalised	ᵐb	ᵐbʷ	ᵑg	ᵑgʷ	ᶮɟ	ᶮɟw	ⁿ̪d̪	ⁿ̪d̪ʷ	ⁿd	ⁿdʷ	ɳɖ	ɳɖʷ
Prestopped	ᵖm	ᵖmʷ	ᵏŋ	ᵏŋʷ	ᶜɲ	ᶜɲʷ	ᵗ̪n̪	ᵗ̪n̪ʷ	ᵗn	ᵗnʷ	ᵗɳ	ᵗɳʷ

[17] It is notable though that if this were to be accepted, it would minimally require us to acknlowledge that neither the interpretation of |ʔ̲| nor the representation of prenasalised stops are universal across languages, which is contrary to the universalist view of Backley (2011).

(12)	/t/	|ʔ|	/n/	|L|	/^{t}n/	|ʔ, L|	/^{n}d/	|$\underline{\text{ʔ}}$, L|
	/t^{w}/	|ʔ, U|	/n^{w}/	|L, U|	/$^{t}n^{w}$/	|ʔ, L, U|	/$^{n}d^{w}$/	|$\underline{\text{ʔ}}$, L, U|

Because we have to rely on headedness to encode the prenasalised–prestopped contrast (whether via |L| or via |ʔ|), when we turn to representing the place of articulation, we cannot avail ourselves of headedness since the SOHC doesn't permit more than one head. Since |U| and |$\underline{\text{U}}$| thus cannot be in contrast to encode labialization with bilabial place, we are forced to assume that bilabial is the default place in Arrernte (similarly to how it is often assumed that alveolars or velars in some languages don't have a place element). In fact, because unheaded |U| is already used, it cannot function in composite place specifications with the other two place elements |A| and |I|, either. We are left with only four combinatorial possibilities for place specification: | | (bilabial), |A| (velar), |I| (palatal), |A, I| (dental). At this point, we run out of place distinctions, but still have to account for retroflex and alveolar place. It is absolutely clear at this point that, given the toolbox of conventional Element Theory, the hypothesis that prenasalised stops and prestopped nasals in Arrernte consist of a singular melodic representation attached to a non-branching ×-slot as in (9a) has to be rejected. Consequently we have good reasons to assume that prenasalised stops and prestopped nasals in at least some languages, such as Arrernte, are either contour segments attached to a branching ×-slot as in (9b), or clusters attached to a branching onset as in (9c). The most likely candidate on theory-internal grounds here would appear to be a branching onset structure, as in (9c). The reason for this is that it is generally assumed in Government Phonology that the contour structure in (9b) does not have any explicit subsegmental ordering relation, but rather that the ordering of the unfused expression in that configuration is determined by external factors; this comes with the prediction that any one language should either only show one type of contour segment, i.e. either prestopped nasals or prenasalised stops, or that if it does show both they must be in complementary distribution (for instance one occurring domain-initially, the other elsewhere). In Arrernte however both types occur in the same environment, thus militating against treatment as an instance of the classic contour segment.

Of course it must be noted that some sources, e.g. Breen & Pensalfini (1999) and Breen & Dobson (2005), do not analyse the prenasalised series of stops as single constituents at all, but rather propose that they are among the highly restricted set of heterorganic clusters permitted in the language. They can do this only because they analyse Arrernte as a language that does not allow any word-initial onset consonants whatsoever. In line with their analysis of Arrernte as a "VC syllable" language, they posit that there is an initial schwa preceding all of the prenasalised stops in what otherwise looks like word-initial position. Maddieson & Ladefoged (1993: 291f) and Ladefoged & Maddieson (1996: 129) however argue that this initial vowel has been lost in many words, leading the "NC clusters" to be left stranded in word-initial position. They also submit that these must be regarded as single constituents since they occupy a position in which Arrernte does not allow any other types of clusters, e.g. heterorganic plosive-plosive or liquid-stop clusters. Nevins & Topintzi (2014; in press) also provide several counterarguments to Breen & Pensalfini's (1999) "strict VC" analysis, and they provide evidence which lends further support to the analysis of prenasalised stops as single constituents in Arrernte (evidence actually already discussed by Breen & Dobson 2005), namely that they cannot be split up in the language game Rabbit Talk, which moves word final material (the last VC(C)) to the front of the word—evidence that the targeted material forms a constituent. This "resilience" of the prenasalised stops against being broken up is straight-forward under the assumptions made by Maddieson & Ladefoged (1993) and Ladefoged & Maddieson (1996), which I have adopted above, and an analysis of these segments as branching constituents of the type (9c) as I have consequentially proposed here.[18]

In summary, we have seen from the Welsh Nasal Mutation data, and especially the example /mləneð/ 'year (after high numerals)', that there are reasons to believe that even if they are comparatively rare, nasal-initial clusters are not necessarily ruled out as a matter of design of the phonological component, either at the lexical level or as the result of derivation. An attempt at finding a set of singular representations that can capture the many contrasting stops in Arrernte has shown this is not viable given the SOHC and the set of elements currently used in ET. Both examples make it clear that when we are confronted with what looks like prenasalised stops, we cannot simply assume that they are represented by a single melodic representation of the type in (9a); instead we must also consider an analysis where they are analysed as contour segments made up of two unfused melodic representations attached to a single ×-slot, or NC clusters constituting a genuine branching onset with a nasal governor, of the type in (9c), which I have argued best fits the cases of Welsh and Arrernte.

3.5 Typological evidence

A second argument for the universality of the CI, advanced by Nasukawa (2005) and Backley & Nasukawa (2009) is based on the typological distribution of nasality and true voicing.[19] They argue that the status of truly voiced segments as headed |$\underline{\text{L}}$| and that of nasals as dependent |L| gives rise to an implicational universal, namely that whenever a language has truly voiced segments it will also have nasals while the presence of nasals does not necessitate the presence of true voicing. I will argue here that the typological arguments they present are both empirically and conceptually mistaken.

Nasukawa (2005) and Backley & Nasukawa (2009) back up their claim with the typological data in Table 3, which shows that all the possible combinations of nasality and true voicing are attested except for a language that has true voicing but no nasals (Nasukawa 2005: 26). They derive this apparent implicational universal by reasoning that, given the CI, if a language allows headed |$\underline{\text{L}}$| (voicing) this would imply that it will also allow dependent |L| (nasality), while the presence of dependent |L| would not necessarily imply the presence of headed |$\underline{\text{L}}$|. There are two principal arguments against this view.

Table 3: Typology of nasals and truly voiced stops, from Backley & Nasukawa (2009: 68).

Languages	*Nasals*	*Voicing*
Quileute	×	×
Finnish, English	✓	×
(none)	×	✓
Dutch, French, Thai	✓	✓

[18] An anonymous reviewer suggests that labialisation on consonants in Arrernte may not be encoded segmentally but rather be a word-level prosody or even an analytical artefact. If it can be conclusively shown that this is indeed the case this would allow us to generate all the place contrasts, though GP would not traditionally allow attaching |U| at a different level of projection and this would raise additional questions as to how the novel coincidence of two |U|'s (one segmental, one prosodic) were to be treated. If labialisation is simply not a property of Arrernte consonants at all then the point is clearly moot; however, I'm not aware of any anlyses of either type at present and other Australian aboriginal languages' consonant inventories may still present similar representational challenges (cf. Butcher 2006).

[19] Or *long-lead voicing*, in their terms.

First, the typological facts on which they base their argument are inaccurate. There are a few languages which do show true voicing but which have no primary nasal consonants. Sylak-Glassman (2013a, b) shows that Ditidath (Wakashan), which has had a historic system-wide loss of nasals,[20] has a series of truly voiced plosives with prevoicing in the same range as many other true voicing languages (Sylak-Glassman 2013b: 17). WALS gives Lushootseed (Salish) as another language with voiced plosives but no primary nasals (Maddieson 2013), and Sylak-Glassman (2013b) discusses Lushootseed as a candidate for comparison with Ditidath, where we might expect to find the same pattern of true voicing in the absence of any primary nasal consonants. We have already discussed the case of Rotokas in Section 3.2, which has one dialectal variant that employs nasals where the other has fully voiced plosives (Firchow & Firchow 1969), thus providing a singular example for the possibility of both a voicing-free nasal and a nasal-free voicing system. In addition to the phonetic evidence, the fact that there is occasional ambiguity and potential for e.g. Rotokas Proper speakers to use nasals in place of the voiced series of stops for paralinguistic effect, as well as the historic development of voiced stops from nasals, suggests that these are phonological voicing, i.e. |L|-based, systems. Once we amend the typological distribution to include these, as in Table 4, the asymmetry motivating Nasukawa (2005) and Backley & Nasukawa's (2009) typological implication disappears.

Second, even if we were to still somehow accept that the typological evidence suggested a tendential preponderance of voicing-free nasal systems at the expense of nasal-free voicing systems, the technical motivation that headed |$\underline{\text{L}}$| implies the availability of dependent |L| is mistaken. Constraints of the type "X must be head" are quite common in the GP literature (see Ploch 1998, 1999 for an overview), for instance Charette & Göksel (1996, 1998) propose the constraint "|A| must be head" for Turkish. Even under the CI view we would thus expect there to be systems such as Ditidath and Rotokas Proper, which could arise from an analogous constraint "|L| must be head". Consequently, there is no conceptual implication in GP that the presence of an element as a head implies its occurrence as a dependent element or vice versa.

Lastly, consider that the voiced series of plosives in nasal-free languages such as Ditidath, Lushootseed and Rotokas Proper all derive from historic primary nasals. If the argument that |$\underline{\text{L}}$| implies |L| were to be upheld, then this seems much more plausible under the AI, where it can be analysed as a system-wide loss of |$\underline{\text{L}}$|-heads, leaving behind dependent |L|'s in their wake. Conversely, under the CI we have to assume that there was a system-wide promotion of dependent |L| to headed |$\underline{\text{L}}$|, perhaps caused by the spontaneous adoption of a constraint that |L| must be head.[21] Alternatively, if we allow languages a choice

Table 4: Typology of nasals and truly voiced stops, amended.

Languages	***Nasals***	***Voicing***
Quileute	×	×
Finnish, English	✓	×
Ditidath, Rotokas P	×	✓
Dutch, French, Thai	✓	✓

[20] According to Sylak-Glassman (2013b: 9) there is very limited use of nasals in Ditidath for paralinguistic functions and in loans, similar to the situation in Rotokas Proper.

[21] Of course, even the spontaneous adoption of such a constraint would not necessarily ensure the promotion of all |L|'s to headhood. Rather, we would expect that system-wide loss of all dependent |L|'s is another possible path to satisfying a newly adopted constraint militating against dependent |L|'s.

between the CI and the AI, such system-wide changes find another explanation in the simple switch of a parameter.

4 Nasals are more salient

In Section 2 on the notion of headship in Element Theory, one of the properties of heads under discussion was saliency, the idea that a head distributes asymmetrically over its dependents. In Backley & Nasukawa's (2009: 54) words:

> "[The] headship relation [...] permits a situation in which one element (i.e. the head) dominates all others (i.e. dependents) in an expression, allowing this dominant element to manifest a stronger set of acoustic cues and thus predominate in the physical interpretation of the resulting melodic expression."

(See also Lindsey & Harris 1990: 362; Backley 1995: 402; Harris & Lindsey 1995: 57, 58; Backley 2011: 41 for similar arguments).

With the exception of perhaps Backley & Nasukawa (2009), the saliency argument has been developed and illustrated mostly through the study of vocalic nuclei, but as Backley & Nasukawa (2009) rightly point out, it should in principle extend to all the other elements and onset positions—no argument has been advanced in the ET literature to preclude this. With regards to the unified |L| prime then, we might ask which one incarnation maximally expresses the salient properties of the prime, voicing or nasality? In terms of the effect on the spectrum both voicing and nasality are reflected in an increase of low frequency energy. Voicing in consonants is associated foremost with F0 perturbations (Kingston et al. 2008; Winn et al. 2013; Kirby & Ladd 2015), lowering of F1 (Stevens & Klatt 1974; Summers 1988; Kluender et al. 1995; Kingston et al. 2008), and an increase in the intensity of spectral low frequency energy (Kluender et al. 1995). Similarly, nasality is manifested acoustically by the introduction and prominence of low frequency energy, and the dampening of higher frequency amplitude peaks (Kurowski & Blumstein 1993). As can be seen from Figure 2, showing a spectral slice averaged across the mid-section of a number of intervocalic stops, the effect of modal voicing on the signal during oral occlusion is an increase of low frequency and F1 intensity (in comparison to the virtually

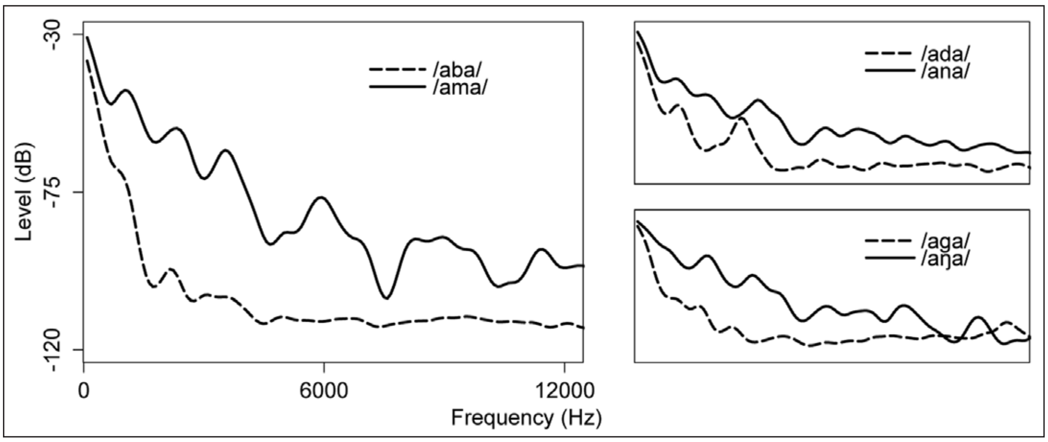


Figure 2: Spectral slices of the hold phase mid-section of a voiced (dashed) and nasal (solid) stop at bilabial, alveolar and velar place.[22]

[22] The recording is of a 29 year old male native speaker of German, obtained under controlled conditions in a recording booth at UCL.

silent hold phase of a voiceless stop), while the nasal stop shows again an increase in low frequency energy over the voiced oral stop. Given Backley & Nasukawa's (2009) view that elemental saliency finds its expression in acoustic preponderance in the signal, saliency in a prime such as |L| can be understood in terms of the intensity of the changes it effects in the signal. Given that both voicing and nasality introduce and/or amplify low frequency energy, but that the intensity of nasal low frequency energy is much greater, we can conclude that the version of the prime responsible for nasality is the maximally salient expression of that prime, i.e. the greater intensity of signal modification by nasality as compared to voicing speaks for the view that nasality is represented by headed |$\underline{\text{L}}$| and voicing by dependent |L|.

Although lowered F1 and the higher intensity of low frequency energy are important components of the manifestation of voicing, it is the regular pulsing of the signal introduced by vocal fold vibration and the measure of VOT derived from it that is commonly seen as the primary acoustic cue for the voicing contrast (see e.g. Howell et al. 1992 for discussion). From a purely articulatory point of view it may well seem plausible to say that this pulsing is solely due to the setting of laryngeal tension and not in any way connected to control of the velopharyngeal port; one might then argue that since nasalization does not introduce pulsing into the signal while voicing does, voicing is the maximal expression of the unified |L| in that only voicing exhibits the maximal modification of the signal by introducing regular pulsing. There is however good evidence that this divide between the two articulatory settings involved is not reflected in the cognitive representation of voicing and nasality in such a way. Instead, the typological and phonetic evidence speaks for the fact that glottal pulsing is an inherent component of nasality which cannot be divorced from it. The typological evidence for this comes from the fact that it is an exceptionless implicational universal that languages with a series of voiceless or breathy nasals also always have a series of fully voiced nasals (cf. Ferguson's 1966 universals 6–9). This universal is unsurprising if we accept that voicing is inseparably tied to nasality in such a way that breathy or voiceless nasals can only be conceived as modified versions of otherwise *inherently voiced* nasal segments, for instance by addition of an element |H|. This is in turn reflected in the phonetic realisation of (phonologically) breathy or voiceless nasals: all the cases of such nasals which have been studied show that the breathy or voiceless series of nasals still retains phonetic voicing (with the typical glottal pulsing) for a significant portion of their duration, while nasal segments completely devoid of vocal fold vibration appear to be entirely absent from the world's languages (Bhaskararao & Ladefoged 1991; Maddieson & Ladefoged 1993). This is illustrated in Figure 3, which shows a "voiceless" nasal in Welsh, including a laryngograph track and nasal airflow measurement. It can be seen clearly from this that the first half of the nasal is actually fully voiced with regular vocal fold vibration and glottal pulsing as found in an ordinary voiced nasal, while the second half of the nasal features a more breathy phonation with wide spacing of glottal pulses and the introduction of some high frequency frication noise. Such laryngeally modified nasals thus still clearly exhibit all the characteristics of (phonetic) voicing in addition to the (phonetic) nasality component. In conclusion, it is clear from the typological distribution and phonetic realisation of laryngeally modified nasals that voicing is an inseparable, inherent property of nasality. The facts surrounding laryngeal activity in the unified |L| prime are then entirely consistent with the view that nasality is the maximal expression of that prime, which includes both phonetic voicing and maximal modulation of the spectrum in the low frequency energy band, while the dependent prime shows a weaker exhibition of the same characteristics.

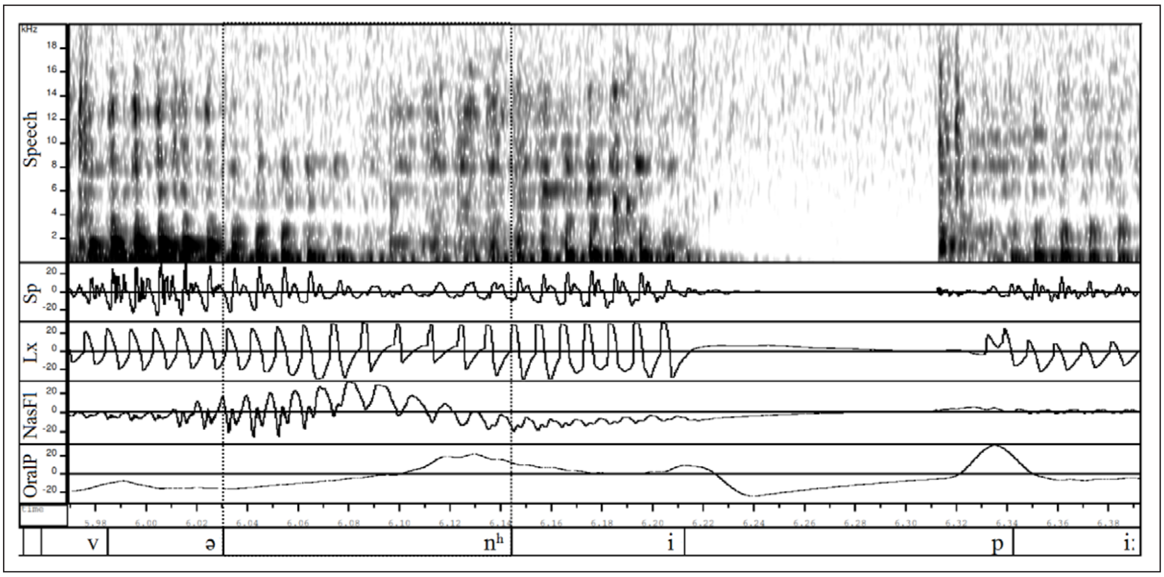


Figure 3: Part of the phrase /edrəχ ar və n̥ʰip iː/ ‘look at my tip’ with a fortis alveolar nasal produced by a male adult speaker of North Welsh.[23]

Finally, let us consider the behaviour of nasals in whispered speech. It is well-known that nasality persists in whispered speech while phonetic voicing is, for obvious physiological reasons, lost. On its own, this may not seem like a relevant criterion for asserting that nasality is the more salient expression of the two, however there is telling evidence from the way in which the two types of segments are adjusted in whispered speech. Osfar (2011) shows that underlyingly voiced stops undergo a significant degree of temporal lengthening in whispered speech to make them categorically match the inherently phonetically longer underlyingly voiceless segments, while whispered nasals are not lengthened in this way. This suggests that even though phonetic voicing is not possible under these conditions, the nasals are still treated as though they were categorically distinct (i.e. “L-type”) segments, further corroborating the hypothesis that nasality is the most salient expression of the unified prime and that cognitively voicing is an inseparable subordinate property of nasality that comes with the AI.

5 Nasals are stronger

When we look at the relative strength of voicing and nasality, we might first look at contexts in which segments regularly undergo weakening processes (i.e. lenition). Indo-European languages such as German, Catalan and Polish are well-known for the occurrence of final obstruent devoicing, although this process is of course also found in many non-Indo-European languages, such as Georgian, Wolof, and Turkish (see Mascaró 1987; Lombardi 1994; Wetzels & Mascaró 2001 for a typological overview).

[23] The recording shown is part of a larger corpus of controlled Welsh speech currently being collected and analysed. The speaker is a 61 year old male native speaker, originally from Ruthin (Denbigh) now living in Llainfairpwll (Anglesey). The recording was made in a sound proof cabin at Bangor University’s School of Linguistics & English Language. Sp = speech signal, Lx = laryngograph/EGG signal, NasFl = nasal airflow, OralP = oral air pressure; note that the speech signal is somewhat muffled due to the speaker wearing an oronasal mask for airflow measurement.

As is well-known, word-final devoicing does not apply to nasals. Note that in Element Theory, there is no a priori reason why nasals should not pattern with other obstruents here, e.g. under the UVNH both voiced oral and nasal stops contain place elements, |ʔ|, and |L|. If we follow the conventional analysis which sees word-final devoicing as loss of |L| (Brockhaus 1990), the CI analysis is that domain-finally headed |L̲| (in voiced obstruents) cannot be licensed, but dependent |L| (in nasals) is supported. Further stipulation is then necessary, however, in order to explain why |L| is lost altogether, rather than simply being demoted to dependent status and so turning the weakened final obstruents into nasals (rather than voiceless segments), as Nasukawa (1999) argues is the case for the diachronic shift from intervocalic voiced stops to prenasalised stops in Northern Tohoku Japanese. If we attempt to account for this by assuming that dependent |L| is not supported in obstruents in this position (and so demotion is not a viable strategy), then should nasals not be devoiced and/or denasalised, too? If we take heads to be stronger than dependents and assume the AI, the situation is explained straight-forwardly in that weak dependent |L| (voicing in obstruents) is eradicated in this position due to the weak licensing inherited from the final empty nucleus, while headed |L̲| is strong and licenses its own dependents, so showing robustness against eviction.

We see the same robustness of nasals in other lenition environments. Consider the data in (13) through (16), which show postvocalic spirantisation in Spanish (González 2006), intervocalic lenition in Estruary English and Liverpool English (Lindsey & Harris 1990) and inter-continuant lenition in Gaalpu (Chong 2011: 474, 482).

(13) *Spanish*
/la bota/ [la β̞ota] 'the boot'
/la nota/ [la nota] 'the note'

(14) *Estruary English*
/bɪt/ [bɪʔ] 'bit'
/bɪn/ [bɪn] 'bin'

(15) *Liverpool English*
/bæk/ [bæx] 'back'
/bæn/ [bæn] 'ban'

(16) *Gaalpu*
/t̪akaj-ku/ [t̪akajwu] 'taste-DAT'
/puɻwu-n̪a/ [puɻwun̪a] 'fruit-ACC'

Again the data in (13) to (16) show that nasals are exceptionally robust against lenition compared to other stops. However, even in the face of such common nasal exceptionality, it is possible to argue that nasals simply do not form part of the natural class targeted by such processes—even given all the difficulty of excluding dependent |L| while explicitly referring to a natural class formed by headed |L̲|. We would thus ideally want to see them exhibit this robustness in a leniting process that targets both nasals and other stops. Such a case may exist in Bemba, where the causative can be expressed either by suffixation of /-iʃ/ or by leniting the final consonant of the stem. As is apparent from the data in (17), the leniting variant has three effects: spirantisation, devoicing, and palatalisation.

(17)	*Bemba* (Kula 2000: 237)[24]		
	Intransitive	*Causative*	*Translation*
	/lub-a/	[lufʲ-a]	‘(cause) to be lost’
	/leep-a/	[leefʲ-a]	‘(cause) to be long’
	/end-a/	[enʃ-a	‘(cause) to walk/move’
	/pit-a/	[piʃ-a]	‘(cause) to pass’
	/lung-a/	[lunʃ-a]	‘(cause) to hunt’
	/kul-a/	[kuʃ-a]	‘(cause) to grow’
	/kos-a/	[koʃ-a]	‘(cause) to become hard’
	/pon-a/	[poɲ-a]	‘(cause) to fall’
	/kom-a/	[komʲ-a]	‘(cause) to be deaf’

While the process is of course not purely one of lenition in that palatalisation must be due to the introduction of an element |I|, we can still see that the leniting causative clearly affects both oral stops (regardless of voicing) and nasal stops. However, while oral stops lose both voicing and oral occlusion in addition to being palatalised, in nasals both nasality *and* voicing are robust, so that the only effect of the leniting causative on nasals is to palatalise them. Clearly then the prime encoding nasality in Bemba is stronger than the one encoding voicing, which is consistent only with the AI.

There are however a few cases where nasals either do undergo lenition processes or have done so diachronically. When this happens, nasality is generally preserved, either on a persisting weakened consonant, or if the consonant is eradicated on the adjacent vowel. This is so common in fact that Ferguson (1966) derived his universal 14 from it: “Nasal vowels, apart from borrowing and analogical formations, always result from loss of a primary nasal consonant” (Ferguson 1966: 59). Examples (18) to (20) show three such weakening processes targeting nasal consonants: the (perhaps historic) loss of final nasals in French, Polish nasal weakening, and stop lenition in Maxakalí.

(18)	*French*		
	Fem.	*Masc.*	*Translation*
	[bɔn]	[bɔ̃]	‘well’
	[fin]	[fɛ̃]	‘fine’
	[øʁɔpeɛn]	[øʁɔpeɛ̃]	‘european’

(19)	*Polish* (Gussmann 2007: 2)		
	UR	*SF*	*Translation*
	/instɨŋkt/	[iw̃stɨŋkt]	‘instinct’
	/tramvaj/	[traw̃vaj]	‘tram’
	/kunʃt/	[kuw̃ʃt]	‘artistry’

(20)	*Maxakalí* (Nevins & da Silva 2015)		
	/nãhãn/	[nãhãɜ̯̃]	‘annatto’
	/ɯ̃ɲiɣ̯̃m/	[ɯ̃ɲiɣ̯̃]	‘arm’, ‘hand’
	/ɯĩɲĩtʃõŋ/	[ɯĩɲĩtʃõ]	‘tongue’

The French case in (18), loss of a historical nasal consonant after nasal sharing spreads it onto the preceding vowel, followed by the loss of final vowels and denasalisation before remaining nasals (Ploch 1999), is relatively well known and diachronically typical for the development of primary nasal vowels (Rochet 1976; Sampson 1999). The Polish nasal

[24] I have adapted Kula’s (2000) transcription to show <y> as [ʲ], <sh> as [ʃ], and <ny, my> as [ɲ, mʲ].

weakening data in (19) show that even when both place of articulation and stopness are lost nasality remains as a feature of the resulting approximant. This is similar to the data from Maxakalí in (20), where primary nasal consonants in coda position are lenited to approximants. Again, nasality necessarily stays behind and is not deleted. Note that following da Silva & Nevins (2014) and Nevins & da Silva (2015) in Maxakalí /m, ŋ/ lenite to [ɣ̃, ɰ̃] respectively, and the apparent total loss in the latter two forms can be accounted for by the coalescence of the resultant sequential identical segments. This robustness of nasality even when almost all the other melodic material is eroded away from their segmental position again speaks for the phonological strength of the nasal prime.

Finally, let us consider the interplay of voicing and nasality in fortition processes. Based on the example of Northern Tohoku Japanese in (4) above, Nasukawa (1999) argued that prenasalisation may be the result of lenition in weak contexts, so that we find dependent |L| in weak environments and headed |L̲| in strong environments in Northern Tohoku Japanese. Backley & Nasukawa (2009) extend this argument and propose that headedness generally aligns with strong environments, and that this explains why maximal contrast is often found predominantly in domain-initial positions. They again see data such as that from Northern Tohoku as evidence for the CI, since there we find voicing in word-initial environment and prenasalisation elsewhere. When we look at languages more widely however, there does not seem to be any skew in the direction that their analysis would imply; in fact we find alternations in which domain-initial strengthening of voiced stops results in nasalisation, the exact opposite to what Backley & Nasukawa (2009) predict. Iverson & Salmons (1996) argue that prenasalised word-initial stops in Mixtec are the result of what they call "hypervoicing", an amplification of the voicing porperties of these stops in the strong domain-initial environment, contiguous with the saliency arguments made in Section 4. This is illustrated in (21) below.

(21) *Mixtec* (Iverson & Salmons 1996: 166f)

UR	*SF*	*Translation*
/bàʔà/	[ᵐbàʔà]	'good'
/báʔù/	[ᵐbáʔù]	'coyote'
/daʔa/	[ⁿdaʔa]	'hand'
/diʒi/	[ⁿdiʒi]	'dead person'

If Iverson & Salmons (1996) are correct in asserting that the Mixtec situation is one of fortition, this is only compatible with the AI where dependent |L| in domain-initial position is promoted to |L̲|; under the CI the data in (21) would indeed have to be analysed as typologically very rare word-initial lenition (though I will shortly discuss one such case), and would in any case be incompatible with the "head alignment" proposal of Backley & Nasukawa (2009).

Pirahã, a language which has been argued to lack any underlying primary nasal consonants as we have already briefly discussed, in fact provides a second mirror image to the Northern Tohoku Japanese data of Nasukawa (1999). In Pirahã, Sandalo & Abaurre (2010: 9) argue, voiced /b, g/ surface as nasal [m, n] whenever they occur either at the beginning of an utterance or after a hesitation pause, but voiced stops never surface as nasals elsewhere, even if they are flanked by nasal vowels either side.[25] This distribution is illustrated by the data in (22) below.

[25] Everett (1986) and Heinrichs (1964) make very similar remarks about the distribution of nasals in Pirahã.

(22) *Pirahã* (Sandalo 1989: 38f)

[mege kaobée]	'to fall on the floor'
[kapeega bege kaobée]	'the notebook fell on the floor'
[kapeega ‖ mege kaobée]	'the notebook (pause) fell on the floor'

If we compare (22) with (4) it is clear that Pirahã is the mirror image of Northern Tohoku Japanese, with nasals clearly aligning with the strong domains. Similar to the Mixtec account, this is best analysed as domain-initial strengthening, and as such compatible with the AI, while the CI again would have to propose that Pirahã has domain-initial lenition. The situation is similar in Skiri Pawnee, another example of a language lacking a primary nasal consonant where we find nasal variants in strong environments. As Parks & Pratt (2008: 13f) write: "Apico-alveolar ***r*** is usually a tap like its counterpart in Spanish, as in *pero* 'but'. However, in word-initial position many speakers frequently pronounce the sound as a nasal [n] and some speakers even pronounce it occasionally as a lateral [l]." Again, such variation must be ascribed to domain-initial lenition under the CI view.[26]

Let us now turn to some cases which might indeed look like they show domain-initial lenition of underlying nasals. The first comes from the Welsh initial consonant mutations already touched on in section 3.4.1. While we have briefly discussed the pattern of Nasal Mutation, which turns oral into nasal stops, there is another mutation pattern known as Soft Mutation. Soft Mutation turns voiceless oral stops into their voiced counterparts and turns voiced stops and /m/ into voiced fricatives (though /g/ is deleted, arguably because Welsh has no voiced velar fricative), as illustrated in (23a) and (23b), respectively. Notably the other two nasal stops, /n/ and /ŋ/, remain unaffected.

(23) *Welsh*

	UR	*SM*	*Translation*
a.	/pʰʊɬ/	[də bʊɬ]	'your pool'
	/tʰir/	[də dir]	'your land'
	/kʰisan/	[də gisan]	'your kiss'
b.	/baχgen/	[də vaχgen]	'your boy'
	/djaul/	[də ðjaul]	'your devil'
	/gʷaɬt/	[də waɬt]	'your hair'
	/mɔrʊr/	[də vɔrʊr]	'your sailor'

While this may then look like a case of nasal spirantisation if we look only at the nasal /m/ (as in the last example in (23b)), it is clear from the overall pattern that the process is neither purely one of phonological lenition (it is morphosyntactically conditioned, different segments undergo different changes, as we have seen with Nasal Mutation before not all changes involve loss of melodic material) nor one purely of fortition (SM here is of a general lenition characteristic, while NM is of a forition characteristic; see Green (2007) for more detailed arguments why Celtic mutations are not true cases of lenition). Given the fact that whether such mutations are even synchronically phonologically active processes is very much under debate, as we have already discussed in Section 3.4.1, and that the process applies to stops regardless of their voicing or nasality, this does not provide any evidence against the hypothesis that nasals are stronger than voiced segments.

[26] Rodrigues (1986, 2003) proposes that "nasal" is the articulatory default setting in languages such as Pirahã, which would explain domain-initial affinity of nasality. However the fact that such domain-initial nasalisation is far from universal cross-linguistically, and contrasts e.g. with the Northern Tohoku Japanese case, means that this "preference" for domain-initial nasalisation must still be encoded phonologically in these languages in some way.

Clearly the targeting of a single nasal (while others are left in tact) in Celtic mutations is not a case of phonological lenition targeted at nasals; though there is perhaps an implication here that if nasal stops are the targets of lenition this implies that oral stops are also targeted.

Another case of what looks like a leniting denasalising process is found in Kashaya (Pomo). Buckley (1992: 50) suggests that in Kashaya the voiced stops [b, d, g] are derived from underlying glottalised nasals /m̰, n̰, ŋ̰/ in a process he calls "desonorization" and which essentially amounts to denasalisation and deglottalisation of the respective segments. He shows that two groups are in (almost perfect) complementary distribution with the stops found in onsets and the glottalised nasals in final position. There is morpheme based alternation between [d] and [n̰], as illustrated in the examples in (24).

(24) *Kashaya* (Buckley 1992: 50)

a. [cadú] 'look!'
[cán̰pʰí] 'if he sees'

b. [duhludí·biʔ] 'start to pick off'
[duhlún̰ba] 'having picked it off'

c. [mahsadún] 'while taking it away'
[mahsán̰qʰ] 'must have taken it away'

Note however that Oswalt (1961) proposes the exact opposite analysis, where the glottalised nasals in Kashaya are derived from the voiced stops, and a further complication with the proposal is that only the glottalised nasals are affected, while the plain voiced nasal series is found in the same (strong) environment as the voiced stops. Even so, if we accept the proposal that these voiced oral stops are underlyingly nasal, Buckley (1992: 53) notes himself that since Kashaya (under his analysis) does not have voicing contrast, the situation amounts essentially to variance in the phonetic interpretation of the prime responsible for that contrast. The situation then is ultimately similar to that in Rotokas already discussed, and need not necessarily be ascribed to a case of denasalisation due to change in headship.

The final case I want to turn to concerns denasalisation of domain-initial segments in Korean (Lee & Kim 2007; Yoshida 2008; Kim 2011). This process primarily denasalises word-initial consonants, as illustrated in (25).

(25) *Korean*

UR	*SF*	*Translation*
/mul/	[pul]	'water'
/ne/	[te]	'my'

Word-initial oral stops do not seem to be affected by any similar process. What is important to note regarding the case of Korean is that, as Kim (2011) shows through extensive experimental work, the resultant stop is of the neutral series (Korean has a three-way contrast between neutral, tense and aspirated plosives). This means that regardless of whether we adopt the CI or the AI, in both cases we have to deal with a process targeting nasals and obliterating nasality together with any laryngeal specification. This is difficult to account for in any way other than admitting it as a case of domain-initial lenition. We see strong segments even in the strongest prosodic position are not universally immune, but whether the obliterated element in Korean denasalisation is headed or not does not bear on the matter.

In summary, we have seen from the discussion of various phenomena in this section that nasality is a disproportionately strong phonological trait when compared to voicing. I have argued that this is best accounted for by assuming an AI where nasality is encoded by headed $|\underline{\mathrm{L}}|$, under the assumption that heads are phonologically stronger and more resilient against weakening processes. Following Backley & Nasukawa's (2009) argument that melodic heads align with prosodic heads, I have also shown data from a variety of languages that provide the mirror-image to Nasukawa's (1999) prenasalisation data. I argued that nasality does in fact often align with the prosodically strong domain-initial position, providing evidence under Backley & Nasukawa's (2009) criteria that they are headed, whereas the voiced series in the same languages should be regarded as unheaded, in line with the AI.

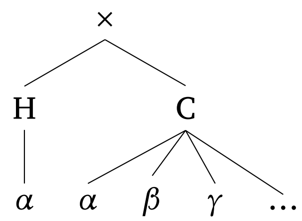
6 Interpretation and why nasals are voiced

In Section 4, I have shown that given acoustic criteria the most salient expression of the unified prime |L| is nasality. In this section I want to show how, assuming the specific set-theoretic implementation of Element Theory in Breit (2013), this can be derived from a cyclic evaluation of elemental melodic expressions at phonetic interpretation. The model in Breit (2013) takes it that the head–dependent relation in melodic expressions is encoded structurally, following Harris (1994: 149), who writes:

> "*Head* [...] is not a categorial term but rather refers to a phonological function or *relation*, specifically one that is contracted *between positions*."

Similarly to how syntactic work employs a form of Kuratowski's (1921) notation for ordered sets—$\{\alpha, \{\alpha, \beta\}\}$ where α is the head—to encode phrase structure (cf. Chomsky 1995), so Breit (2013) proposes that melodic expressions can be expressed in the form of partially ordered sets of the type $\{\{\alpha\}, \{\alpha, \beta, \gamma, \ldots\}\}$, where α is the head and $\{\beta, \gamma, \ldots\}$ are the dependents.[27] This is illustrated graphically in (26), with the additional labels H and C for Head and Complement positions.

(26)



One way of deriving the observation that a headed element, say α in (26) is more preponderant in the acoustic signal than the dependents is to propose that the operation which amalgamates the elements in an expression into an acoustic target is entirely symmetric, but applies cyclically.

For argument's sake, let us assume that the function $\mathrm{i}(\kappa, \varsigma)$ generating the acoustic target at interpretation is one which expects as its input a carrier signal κ and a set of elements ς and then simply averages the spectral patterns associated with each target and the carrier (cf. Figure 1),[28] say:

[27] The form $\{\{\alpha\}, \{\alpha, \beta\}\}$ is preferential to the abbreviated form $\{\alpha, \{\alpha, \beta\}\}$ because it avoids collapsing of the set's structure when there is no head, i.e. the head in such structures is seen as *empty*.

[28] Of course matters are in reality much more complicated, and much further work is needed to work out a specific model implementation of such an interpretation function. Though see Williams (1998) for a computational implementation of the recognition component of interpretation in the framework of GP.

(27) $$\mathrm{i}(\kappa,\varsigma) = \frac{\kappa + \sum\limits_{e \in \varsigma} e}{\mathrm{n}(\varsigma) + 1}.$$

Now let us assume for example a melodic expression |$\underline{\text{I}}$, U, A| = {{I}, {I, U, A}}. If we now first apply i() to the structural complement, we get some intermediate spectral pattern x = i(κ, {I, U, A}), and i() is then applied to the melodic expression as a whole, so that |$\underline{\text{I}}$, U, A| evaluates to i(I, x) = i(I, i(κ, {I, U, A})). Because the spectral pattern of |I| is compounded into the expression twice, first as part of the complement, and then in merger with the resultant complement pattern, it has predominant influence on the final spectral target of the entire melodic expression. Thus, a view of the interpretive component where the function merging the elements applies cyclically from the inside out, first merging the elements in the complement, then the complement and the head, automatically derives the acoustic saliency of headed primes.

By way of a simple illustration of this idea, suppose that we characterise the carrier signal K, the element |ʔ| and the element |L| as a simple sequence of target amplitude values along a frequency spectrum as follows:

(28) K = ⟨–85, –65, –85, –65, –85, –65, –85, –65, –85, –65⟩,
ʔ = ⟨–165, –165, –165, –165, –165, –165, –165, –165, –165, –165⟩,
L = ⟨0, –30, –60, –80, –100, –100, –100, –100, –100, –100⟩.

Following the set notation introduced above, we can now define a placeless voiced oral stop T with the representation |L, ʔ| as a set T = {Ø, {L, ʔ}} and a placeless nasal stop N of the form |$\underline{\text{L}}$, ʔ| as a set N = {{L}, {L, ʔ}}. If we now cyclicly apply the interpretation function i() to these sets as proposed above, we derive the following evaluations for T and N (note that the first application of i() adds the carrier signal K, whereas the further cycles add the result of the previous cycle as their carrier signal):

(29) $$T = \mathrm{i}(\mathrm{K}, \{\mathrm{L}, \text{ʔ}\}) = \frac{\mathrm{L} + \text{ʔ} + \mathrm{K}}{3} = \langle -87, -83, -107, -100, \ldots \rangle,$$

$$N = \mathrm{i}(\mathrm{L}, \mathrm{i}(\mathrm{K}, \{\mathrm{L}, \text{ʔ}\})) = \frac{\mathrm{L} + \frac{\mathrm{L} + \text{ʔ} + \mathrm{K}}{3}}{2} = \langle -43, -57, -83, -90, \ldots \rangle.$$

The resultant spectral targets T and N calculated according to (29) are shown visually in Figure 4. As is clearly apparent, the intensity of signal modulation by headed |$\underline{\text{L}}$| in the derivation of N is much greater than that of dependent |L| alone in the derivation of T, and this is solely due to the recurrence of |L| in the cyclic application of i().

Another, perhaps crucial, implication of this proposal is that since a headed representation always incorporates the dependent version of the head in its interpretation, a headed element can *never* dispose of a property that its dependent version has. That is to say, if a given element |e| has as a dependent element the property of inducing voicing, then so must the headed version |$\underline{e}$|, since the headed version is also always incorporated as a dependent. For the unified prime |L| this would mean that under the AI we correctly predict that nasals with headed |$\underline{\text{L}}$| are always inherently voiced precisely because this is what they do as dependent |L|.

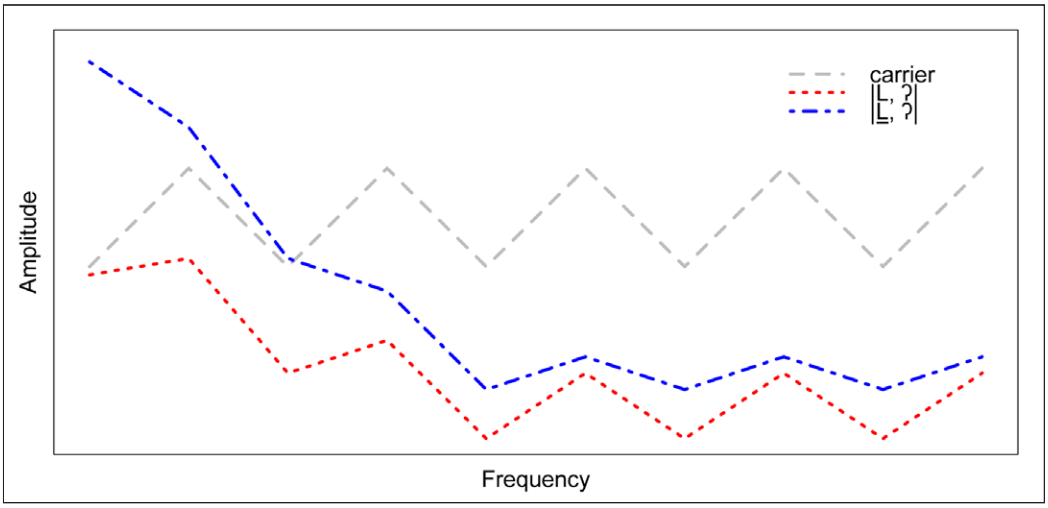


Figure 4: Simulated derivation of a spectral target for the representations |L, ʔ| and |L̲, ʔ| by cyclic application of the interpretation function i().

That heads can introduce additional properties into the signal that are not part of the dependent (such as dampening of higher frequency energy) can be accounted for if we allow that the interpretation function i() has access to the information whether it is merging a complement position or a maximal melodic expression (i.e. head and complement), similarly to how it must have access to the information what category (onset, rhyme, nucleus) dominates the melodic expression it is merging in order to allow for the different interpretation elements receive in nuclear versus onset position. Notably, even if we allow this, it is clear that the headed element in this view is still present as a dependent at interpretation, and thus will have both the properties it has as a dependent and any additional properties only its headed version may exhibit. Under this view, it follows from the AI that nasals are inherently voiced, but the CI is clearly incompatible with such a cyclical model of interpretation.

7 Conclusion

In this paper I have summarised the main arguments for the Unified Voicing and Nasality Hypothesis leading to the proposal of a unified prime, with the CI of a headed |L̲| encoding voicing and dependent |L| encoding nasality. I have briefly revisited the two major arguments made in defence of this proposal, nasals as governors and implicational typology, and shown that the situation is not as clear cut as it might perhaps appear, so that we should also consider an AI where headed |L̲| encodes nasality and dependent |L| encodes voicing. I have then proceeded to show that this alternative proposal is in harmony with the common ET argument that phonological heads are more salient in the acoustic signal by showing that voicing can be understood as a less intensive version of producing the main characteristics also produced by nasality; conversely, the CI was argued to be incompatible with the saliency argument for heads. Following this I showed that nasality in consonants behaves as a phonologically extremely robust trait, which I argued can be accounted for by the inherent strength associated with being a head under the AI, while the CI had no such explanatory power for this behaviour and would even incorrectly predict voicing to be more robust when it is not. Finally, I put forward the sketch of a cyclical model of the interpretation component, which can derive the relative saliency of melodic heads from a purely symmetrical implementation of elemental fusion, and additionally correctly predicts that nasals should be inherently voiced if and only if we assume an AI where nasality is encoded by headed |L̲| and voicing by dependent |L|, while the CI was again largely incompatible with this model.

Assuming that the UVNH itself stands solid, there are two types of conclusion that can be drawn from this. The strongest possible conclusion, especially from a universalist stance, is that the CI stands in conflict with the properties we would expect the headed version of the unified prime to exhibit, and so we must either reject the CI or the saliency and strength arguments as incorrect; we then have the option of universally assuming the AI or re-evaluating what we take as evidence for headedness, and what we assume the phonological consequences of headedness to be. Obviously a universal adoption of the AI would require the re-evaluation of the vast body of work that has been successfully carried out under the assumption of the CI thus far, to wit Ploch (1999) and Nasukawa (1997, 1999, 2000, 2005); whether this is feasible and we would not run into other problems on the way is essentially an open question, but one would surely expect there to be complicated knock-on effects given the effect of creating competition for the head slot by switching headedness with a limitation of melodic expressions to a single head. The softer conclusion is to adopt a relativist stance and say that languages have a choice as to how they encode voicing and nasality, loosely in line with arguments made by Cyran (1996, 2011) about the parametrisation of individual elements and laryngeal relativism, the idea that an underlying |H| system may look on the surface like an |L| system or vice-versa. This could take either the stance of a parametric choice between the CI and the AI, or an even freer, more emergentist stance where headed or dependent |L| can be assigned duty to encode nasality, perhaps even varied by context as under the CI view that while in onsets dependent |L| encodes nasality in nuclei it is headed |L| that encodes nasality, and also broadly in line with Botma's (2004, 2009) element-based dependency phonology approach where |L| is interpreted as nasality or voicing dependent on whether it forms part of an obstruent or a sonorant. In the end, the current view of a universal CI of a unified prime is clearly difficult to uphold without the discovery of alternative mechanisms that could explain the effects and problems discussed here, and the AI merits serious consideration as an option if we take seriously the saliency and strength arguments for heads not only in nuclei but also in onsets.

Abbreviations

ACC = accusative, AI = Alternative Implementation, ASP = aspect, BEN = benefactive, CI = Conventional Implementation, DAT = dative, ET = Element Theory, GER = gerund, GP = Government Phonology, IND = indicative, NM = Nasal Mutation, PRES = present, PST = past, REFL = reflexive, SBJ = subject, SBJV = subjunctive, SF = Surface Form, SM = Soft Mutation, SOHC = Single Optional Headedness Condition, UR = Underlying Representation, UVNH = Unified Voicing and Nasality Hypothesis. 3PL = third person plural, 3SG = third person singular.

Acknowledgements

For discussion and helpful comments I thank Andrew Nevins, John Harris, Bert Botma, Connor Youngberg, Tobias Scheer, Shanti Ulfsbjorninn, Monik Charette, Doragon Bôru, three anonymous reviewers, and audiences at the 23rd Manchester Phonology Meeting, the 2015 Elements Fest and the 45th Poznań Linguistic Meeting. Charlotte Liu spotted many typos. This work was supported by the Arts and Humanities Research Council [grant number 1458926].

Competing Interests

The author has no competing interests to declare.

References

Anderson, John M. & Charles Jones. 1974. Three theses concerning phonological representations. *Journal of Linguistics* 10(1). 1–26. DOI: https://doi.org/10.1017/S0022226700003972

Anderson, John M. & Colin J. Ewen. 1987. *Principles of Dependency Phonology*. Cambridge: Cambridge University Press. DOI: https://doi.org/10.1017/CBO9780511753442

Backley, Phillip. 1995. A tier geometry for vowel systems. *UCL Working Papers in Linguistics* 7. 399–436. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/95papers/BACKLEY.

Backley, Phillip. 2011. *An introduction to Element Theory*. Edinburgh: Edinburgh University Press.

Backley, Phillip & Kuniya Nasukawa. 2009. Headship as melodic strength. In Kuniya Nasukawa & Phillip Backley (eds.), *Strength relations in phonology*, 47–78. Berlin: Mouton de Gruyter. DOI: https://doi.org/10.1515/9783110218596.1.47

Backley, Phillip & Toyomi Takahashi. 1996. Activate alpha: harmony without spreading. *UCL Working Papers in Linguistics* 8. 487–518. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/96papers/backley.

Ball, Martin J. & Briony Williams. 2000. *Welsh phonetics*. Edwin Mellen Press.

Ball, Martin J. & Nicole Müller. 1992. *Mutation in Welsh*. London: Routledge. DOI: https://doi.org/10.4324/9780203192764

Bhaskararao, Peri & Peter Ladefoged. 1991. Two types of voiceless nasals. *Journal of the International Phonetic Association* 21(2). 80–88. DOI: https://doi.org/10.1017/S0025100300004424

Borsley, Robert D. & Maggie Tallerman. 1996. Phrases and Soft Mutation in Welsh. *Journal of Celtic Linguistics* 5. 1–49.

Botma, Bert. 2004. *Phonological aspects of nasality*. Utrecht: LOT. http://www.lotpublications.nl/Documents/90_fulltext.pdf.

Botma, Bert. 2009. Transparency in nasal harmony and the limits of reductionism. In K. Nasukawa & P. Backley (eds.), *Strength relations in phonology*. Berlin: Mouton de Gruyter. DOI: https://doi.org/10.1515/9783110218596.1.79

Breen, Gavan & Rob Pensalfini. 1999. Arrernte: A language with no syllable onsets. *Linguistic Inquiry* 30(1). 1–25. DOI: https://doi.org/10.1162/002438999553940

Breen, Gavan & Veronica Dobson. 2005. Central Arrernte. *Journal of the International Phonetic Association* 35. 249–254. DOI: https://doi.org/10.1017/S0025100305002185

Breit, Florian. 2012. Coping with borrowed swearwords: Anomalies in Welsh mutation patterns. *Poster presented at the 2012 Bangor Summer School in Bilingualism*, 25 Jul 2015, Bangor University.

Breit, Florian. 2013. *Formal aspects of Element Theory*. London: University College London MRes dissertation. http://ling.auf.net/lingbuzz/001928.

Brockhaus, Wiebke. 1990. Colourful leagues: A Government Phonology approach to final obstruent devoicing in German. *UCL Working Papers in Linguistics* 2. 270–297. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/90papers/UCLWPL2_14_Brockhaus.

Buckley, Eugene Lorenz III. 1992. *Theoretical aspects of Kashaya phonology and morphology*: University of California at Berkeley dissertation. http://escholarship.org/uc/item/2m2435db.

Butcher, Andrew R. 2006. Australian aboriginal languages: Consonantsalient phonologies and the 'place-of-articulation' imperative. In *Speech production: Models, phonetic processes, and techniques*, 187–210. New York, NY: Psychology Press.

Carr, Philip. 2005. Salience, headhood and analogies. In Philip Carr, Jacques Durand & Colin J. Ewen (eds.), *Headhood, elements, specification and contrastivity: Phonological papers in honour of John Anderson* (Amsterdam Studies in the Theory and History of Linguistic Science. Series IV: Current Issues in Linguistic Theory), 15–30. Amsterdam: John Benjamins. DOI: https://doi.org/10.1075/cilt.259.05car

Charette, Monik & A. Göksel. 1996. Switching and vowel harmony in Turkic languages. In B. H. Kardela (ed.), *A festschrift for Edmund Gussmann*, 29–57. Lublin: Wydawnictwo KUL.

Charette, Monik & A. Göksel. 1998. Licensing constraints and vowel harmony in Turkic languages. In Eugeniusz Cyran (ed.), *Structure and interpretation: Studies in phonology* (PASE Studies and Monographs), 65–89. Lublin: Folium.

Chomsky, Noam. 1995. *The minimalist program*. Cambridge, MA: MIT Press.

Chong, Adam J. 2011. Lenition in Gaalpu: An Optimality Theoretic analysis. *Australian Journal of Linguistics* 31(4). 473–490. DOI: https://doi.org/10.1080/07268602.2011.625601

Cobb, Margaret. 1997. *Conditions on nuclear expressions in phonology*: SOAS, University of London dissertation.

Crothers, John. 1978. Typology and universals of vowel systems. In Joseph Greenberg (ed.), *Universals of human language* 2. 99–152. Stanford, CA: Stanford University Press.

Cyran, E. 1996. The parametric occurence of elements in phonological systems. In Henryk Kardela & Bogdan Szymanek (eds.), *A festschrift for Edmund Gussmann from his friends and colleagues*, 75–98. Lublin: Redakcja Wydawnictw KUL.

Cyran, Eugeniusz. 2010. *Complexity scales and licensing in phonology*. Berlin: De Gruyter Mouton. DOI: https://doi.org/10.1515/9783110221503

Cyran, Eugeniusz. 2011. Laryngeal realism and laryngeal relativism: Two voicing systems in Polish? *Studies in Polish Linguistics* 6. 45–80. http://www.ejournals.eu/SPL/2011/SPL-vol-6-2011/art/1174/.

Cyran, Eugeniusz. 2014. *Between phonology and phonetics: Polish voicing*. Berlin: De Gruyter Mouton. DOI: https://doi.org/10.1515/9781614515135

da Silva, Marcó Coelho & Andrew Nevins. 2014. Ethnosociophonology and consonant lenition in Maxakalí. *Revista Linguíʃtica* 10(2). https://revistas.ufrj.br/index.php/rl/article/view/4603. DOI: https://doi.org/10.17074/linguistica.v10i2.407.

Everett, Daniel. 1986. Pirahã. In *Handbook of Amazonian languages* 1. 200–326. Berlin: Mouton de Gruyter.

Ferguson, Charles A. 1966. Assumptions about nasals: A sample study in phonological unversals. In Joseph Harold Greenberg (ed.), *Universals of language: Report of a conference held at dobbs ferry, new york, april 13–15, 1961*, 53–60. Cambrdige, MA: The MIT Press 2nd edn.

Firchow, Irwin & Jaqueline Firchow. 1969. An abbreviated phoneme inventory. *Anthropological Linguistics* 11(9). 271–276. http://www.jstor.org/stable/30029468.

González, Carolina. 2006. The phonetics and phonology of spirantization in North-Central Peninsular Spanish. *Anuario del Seminario de Filología Vasca "Julio de Urquijo"—International Journal of Basque Linguistics and Philology* 40(1). 409–436. http://www.ehu.eus/ojs/index.php/ASJU/article/view/4398.

Green, Anthony Dubach. 2003. The independence of phonology and morphology: The celtic mutations. *ZAS Papers in Linguistics* 32. 47–86. http://publikationen.ub.uni-frankfurt.de/frontdoor/index/index/docId/30862.

Green, Anthony Dubach. 2007. *Phonology limited*, 27. (Linguistics in Potsdam). Potsdam: Unversitätsverlag Potsdam. https://publishup.unipotsdam.de/opus4-ubp/frontdoor/index/index/docId/1433.

Gussmann, Edmund. 2007. *The phonology of Polish*. Oxford: Oxford University Press.
Halle, Morris & Kenneth Stevens. 1971. A note on laryngeal features. *Quarterly Progress Report* 101. Research Laboratory of Electronics, MIT.
Hannahs, S. J. 2013a. Celtic initial mutation: pattern extraction and subcategorisation. *Word Structure* 6(1). 1–20. DOI: https://doi.org/10.3366/word.2013.0033
Hannahs, S. J. 2013b. *The phonology of Welsh* (The Phonology of the World's Languages). Oxford: Oxford University Press.
Harris, John. 1992. Licensing inheritance. *UCL Working Papers in Linguistics* 4. 359–406. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/92papers/UCLWPL4_17_Harris.
Harris, John. 1994. *English sound structure*. Oxford: Blackwell.
Harris, John. 1998. Licensing inheritance: an integrated theory of neutralisation. *Phonology* 14(3). 315–370. DOI: https://doi.org/10.1017/S0952675798003479
Harris, John. 2005. Vowel reduction as information loss. In Philip Carr, Jacques Durand & Colin J. Ewen (eds.), *Headhood, elements, specification and contrastivity: Phonological papers in honour of John Anderson* (Amsterdam Studies in the Theory and History of Linguistic Science. Series IV: Current Issues in Linguistic Theory), 119–132. Amsterdam: John Benjamins. DOI: https://doi.org/10.1075/cilt.259.10har
Harris, John & Geoff Lindsey. 1995. The elements of phonological representation. In J. Durand & F. Katamba (eds.), *Frontiers of phonology: atoms, structures, derivations*, 34–79. Harlow, Essex: Longman.
Hayes, Bruce P. 1999. Phonetically-driven phonology: The role of Optimality Theory and inductive grounding. In Michael Darnell, Edith Moravscik, Frederick Newmeyer, Michael Noonan & Kathleen Wheatly (eds.), *Functionalism and formalism in linguistics. Volume I: General papers*, 243–285. Amsterdam: John Benjamins.
Hayes, Bruce P. & Tanya Stivers. 1995. The phonetics of post-nasal voicing. Ms., UCLA.
Hayes, Bruce P. & Tanya Stivers. 2000. Postnasal voicing. Manuscript, UCLA. http://www.linguistics.ucla.edu/people/hayes/phonet/ncphonet.pdf.
Heinrichs, Arlo L. 1964. *Os fonemas do Mura-Pirahã* (Boletim do Museu Paraense Emílio Goeldi 21). Belém.
Honeybone, Patrick. 2005. Diachronic evidence in segmental phonology: the case of obstruent laryngeal specifications. In M. van Oostendorp & J. van de Weijer (eds.), *The internal organization of phonological segments*, 319–354. Berlin: Mouton de Gruyter. DOI: https://doi.org/10.1515/9783110890402.317
Howell, Peter, Stuart Rosen, Harriet Lang & Stevie Sackin. 1992. The role of f1 transitions in the perception of voicing in initial plosives. *Speech, Hearing and Language: Work in Progress* 6. 118–126. http://www.phon.ucl.ac.uk/home/stuart/pubs/Howell%201992%20The%20role%20of%20F1%20transitions%20in%20the%20perception%20of%20voicing%20in%20intial%20plosives_fixed.pdf.
Hyman, Larry. 2001. On the limits of phonetic determinism in phonology: *NC revisited. In Elizabeth Hume & Keith Johnson (eds.), *The role of speech perception in phonology*, 141–185. New York, NY: Academic Press.
Itô, Junko & R. Armin Mester. 1986. The phonology of voicing in Japanese: Theoretical consequences of morphological accessibility. *Linguistic Inquiry* 17. 49–73.
Iverson, Gregory K. & Joseph C. Salmons. 1995. Aspiration and laryngeal representation in Germanic. *Phonology* 12. 369–396. DOI: https://doi.org/10.1017/S0952675700002566
Iverson, Gregory K. & Joseph C. Salmons. 1996. Mixtec prenasalization as hypervoicing. *International Journal of American Linguistics* 62(2). 165–175. DOI: https://doi.org/10.1086/466284

Kaye, Jonathan. 1989. *Phonology: A cognitive view*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Kaye, Jonathan. 1990. 'Coda' licensing. *Phonology* 7(2). 301–330. DOI: https://doi.org/10.1017/S0952675700001214

Kaye, Jonathan. 1995. Derivations and interfaces. In J. Durand & F. Katamba (eds.), *Frotniers of phonology: Atoms, structures, derivations*, 289–332. London: Pearson Education.

Kaye, Jonathan. 2000. A users' guide to Government Phonology. Ms., University of Ulster. http://lolita.unice.fr/%7Escheer/scan/Kaye00guideGP.pdf.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud. 1985. The internal structure of phonological elements: a theory of charm and government. *Phonology* 2. 305–328. DOI: https://doi.org/10.1017/S0952675700000476

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud. 1990. Constituent structure and government in phonology. *Phonology Yearbook* 7. 193–231. DOI: https://doi.org/10.1017/S0952675700001184

Kim, Young Shin. 2011. *An acoustic, aerodynamic and perceptual investigation of word-initial denasalization in Korean*. London: University College London PhD thesis. http://discovery.ucl.ac.uk/1324541/.

Kingston, John, Randy L. Diehl, Cecilia J. Kirk & Wendy A. Castleman. 2008. On the internal perceptual structure of distinctive features: The [voice] contrast. *Journal of Phonetics* 36(1). 28–54. DOI: https://doi.org/10.1016/j.wocn.2007.02.001

Kirby, J. P. & R. D. Ladd. 2015. Stop voicing and F0 perturbations: Evidence from French and Italian. In *Proceedings of the 18th international congress of phonetic sciences*. Glasgow. https://www.internationalphoneticassociation.org/icphsproceedings/ICPhS2015/Papers/ICPHS0740.pdf.

Kluender, Keith R., Andrew J. Lotto & Rick J. Jenison. 1995. Perception of voicing for syllable-initial stops at different intensities: Does synchrony capture signal voiceless stop consonants? *Journal of the Acoustical Society of America* 97(4). 2552–2567. DOI: https://doi.org/10.1121/1.411975

Kula, Nancy Chongo. 2000. Spirantization in morphologically driven phonology: The causative in Bemba. In Christine Czinglar, Katharina Köhler, Erica Thrift, Jan van der Torre & Malte Zimmermann (eds.), *Proceedings of console VIII*. 233–248. http://citeseerx.ist.psu.edu/viewdoc/download?doi = 10.1.1.136.5056&rep = rep1&type = pdf. DOI: https://doi.org/10.1.1.136.5056

Kuratowski, Casimir. 1921. Sur la notion de l'ordre dans la théorie des ensembles. *Fundamenta Mathematicæ* 2(1). 161–171.

Kurowski, Kathleen M. & Sheila E. Blumstein. 1993. Acoustic properties for the perception of nasal consonants. In Marie K. Huffman & Rena A. Krakow (eds.), *Nasals, nasalization and the velum* 5. 197–222. (Phonetics and Phonology), San Diego, CA: Academic Press. DOI: https://doi.org/10.1016/B978-0-12-360380-7.50012-0

Ladefoged, Peter & Ian Maddieson. 1996. *The sounds of the world's languages*. Oxford: Blackwell.

Lee, Duck-Young. 1996. Vowel harmony in Korean: A-head alignment. In *Proceedings of 3rd government phonology workshop*. University of Vienna.

Lee, Duck-Young & Shohei Yoshida. 1998. A-head alignment in Korean. In E. Cyran (ed.), *Structure and interpretation: Studies in phonology*, 195–204. Lublin: Folium.

Lee, Sang-Do & Soo-Jeong Kim. 2007. Gong-gi-yeog-hag-ja-lyo-leul iyong-han han-gug-eo-wa yeong-eo bi-eum-e dae-han eum-seong-hagjeog yeon-gu [Aerodynamic approach to nasals in Korean and English]. *Sae-han-yeong-eo-yeong-mun-hag [The New Korean Journal of English Language and Literature]* 49(3). 85–100.

Lindblom, Björn. 1986. Phonetic universals in vowel systems. In John Ohala & J. J. Jaeger (eds.), *Experimental phonology*, 13–44. Orlando, FL: Academic Press.
Lindsey, Geoff & John Harris. 1990. Phonetic interpretation in generative grammar. *UCL Working Papers in Linguistics* 2. 355–369. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/90papers/UCLWPL2_18_LindseyHarris.
Locke, John. 1983. *Phonological acquisition and change*. New York: Academic Press.
Lombardi, Linda. 1994. *Laryngeal features and laryngeal neutralization* (Outstanding Dissertations in Linguistics). New York, NY: Garland Publishing.
Lowenstamm, Jean. 1996. CV as the only syllable type. In Jacques Durand & Bernard Laks (eds.), *Current trends in phonology: Models and methods*, 419–441. Salford: ESRI.
Lyman, Benjamin Smith. 1894. Change from surd to sonant in Japanese compounds. In *Oriental studies: A selection of papers read before the Oriental Club of Philadelphia 1888–1894*, 160–176. Boston, MA: Ginn & Company. https://archive.org/details/orientalstudiess00orierich.
Maddieson, Ian. 2013. Absence of common consonants. In Matthew S. Dryer & Martin Haspelmath (eds.), *The world atlas of language structures online*, Leipzig: Max Planck Institute for Evolutionary Anthropology. http://wals.info/chapter/18.
Maddieson, Ian & Peter Ladefoged. 1993. Phonetics of partially nasal consonants. In M. K. Huffman & R. A. Krakow (eds.), *Nasals, nasalization and the velum*, 251–301. San Diego, CA: Academic Press. DOI: https://doi.org/10.1016/B978-0-12-360380-7.50014-4
Mascaró, Joan. 1987. A reduction and spreading theory of voicing and other sound effects. Published 1995 in Catalan Working Papers in Linguistics, 4(2). 267–328. Manuscript, Universitat Autònoma de Barcelona. http://ddd.uab.cat/record/21191.
Nasukawa, Kuniya. 1997. Melodic structure in a nasal–voice paradox. *UCL Working Papers in Linguistics* 9. 403–423. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/97papers/nasukawa.
Nasukawa, Kuniya. 1999. Prenasalisation and melodic complexity. *UCL Working Papers in Linguistics* 11. 53–70. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/99papers/nasukawa.
Nasukawa, Kuniya. 2000. Nasal harmony as prosody-driven agreement. *UCL Working Papers in Linguistics* 12. 257–285. https://www.ucl.ac.uk/pals/research/linguistics/research/uclwpl/wpl/0papers/nasukawa.
Nasukawa, Kuniya. 2005. *A unified approach to nasality and voicing*. Berlin: Mouton de Gruyter. DOI: https://doi.org/10.1515/9783110910490
Nasukawa, Kuniya & Phillip Backley. 2015. Heads and complements in phonology: a case of role reversal? *Phonological Studies* 18. 67–74.
Nevins, Andrew & Marcó Coelho da Silva. 2015. Consonant lenition in Maxakalí and ethnosociophonology. *Paper presented at the 2015 Elements Fest*, University College London.
Nevins, Andrew & Nina Topintzi. 2014. Moraic onsets and cross-anchoring in Arrernte. *Paper presented at the 22nd Manchester Phonology Meeting*, 29–31 May 2014, Manchester.
Nevins, Andrew & Nina Topintzi. in press. Moraic onsets in Arrernte. *Phonology*.
Osfar, Megan Jo. 2011. *Articulation of whispered alveolar consonants*. Urbana, IL: University of Illinois MA dissertation. https://www.ideals.illinois.edu/bitstream/handle/2142/26173/Osfar_Megan.pdf?sequence=1.
Oswalt, Robert L. 1961. *A Kashaya grammar (Southwestern Pomo)*. Berkeley, CA: University of California at Berkeley PhD thesis.
Parks, Douglas R. & Lula Nora Pratt. 2008. *A dictionary of Skiri Pawnee* (Studies in the Anthropology of North American Indians). Omaha, NE: University of Nebraska Press.

Pater, Joe. 1996. *NC. In K. Kusumoto (ed.), *Proceedings of nels26*.
Ploch, Stefan. 1993. *The vocalic systems of Standard German and Augsburg Swabian and rhotic effects on the internal structure of vowels*: SOAS, University of London MA dissertation.
Ploch, Stefan. 1997. The nasal fallacy. *SOAS Working Papers in Linguistics and Phonetics* 6. 221–273.
Ploch, Stefan. 1998. Non-switch harmony in Yawelmani (and Turkish and Sakha). *SOAS Working Papers in Linguistics and Phonetics* 8. 209–238.
Ploch, Stefan. 1999. *Nasals on my mind: The phonetic and the cognitive approach to the phonology of nasality*: SOAS, University of London dissertation.
Rochet, Bernhard L. 1976. *The formation and evolution of the French nasal vowels*. Tübingen: Max Niemeyer Verlag. DOI: https://doi.org/10.1515/9783111328287
Rodrigues, Aryon D. 1986. Silêncio, pausa e nasalização. *Anais do Encontro Nacional de Linguística* 8. 153–159.
Rodrigues, Aryon D. 2003. Silêncio, nasalidade e laringalidade em línguas indígenas brasileiras. *Letras de Hoje* 38(4). 11–24.
Sampson, Rodney. 1999. *Nasal vowel evolution in Romance*. Oxford: Oxford University Press.
Sandalo, Filomena. 1989. *Aspectos da língua Pirahã*: Universidade Estadual de Campinas MA thesis.
Sandalo, Filomena & Maria Bernadete Abaurre. 2010. Orality spreading in Pirahã. *LIAMES: Línguas Indígenas Americanas* 10. 7–19. DOI: https://doi.org/10.20396/liames.v10i1.1506
Schane, Sanford A. 1984. The fundamentals of Particle Phonology. *Phonology Yearbook* 1. 129–155. DOI: https://doi.org/10.1017/S0952675700000324
Schane, Sanford A. 1995. Diphthongization in Particle Phonology. In John A. Goldsmith (ed.), *Handbook of Phonological Theory*, Oxford: Blackwell. DOI: https://doi.org/10.1111/b.9780631201267.1996.00020.x
Scheer, Tobias. 1998. Governing domains are head-final. In Eugeniusz Cyran (ed.), *Structure and Interpretation: Studies in phonology*, 261–285. Lublin: Folium.
Scheer, Tobias. 2004. *A lateral theory of phonology. volume 1: What is CVCV, and why should it be?* Berlin: Mouton de Gruyter.
Solé, Maria-Josep, Larry M. Hyman & Kemmonye C. Monaka. 2009. More on post-nasal devoicing: The case of Shekgalagari. *UC Berkeley Phonology Lab Annual Report*, 299–320. http://linguistics.berkeley.edu/phonlab/annual_report/documents/2009/Shekgalagari_USletter_PLAR.pdf.
Stenson, N. 1990. Phrase structure congruence, government, and Irish–English code-switching. In R. Hendrick (ed.), *Syntax and semantics: The syntax of the modern celtic languages* 23. 167–197. San Diego, CA: Academic Press.
Stevens, Kenneth N. & Dennis H. Klatt. 1974. Role of formant transitions in the voiced–voiceless distinction for stops. *Journal of the Acoustical Society of America* 55(653). 653–659. DOI: https://doi.org/10.1121/1.1914578
Summers, W. Van. 1988. F1 structure provides information for finalconsonant voicing. *Journal of the Acoustical Society of America* 84(485). 485–492. DOI: https://doi.org/10.1121/1.396826
Sylak-Glassman, John. 2013a. The phonetic properties of voiced stops descended from nasals in Ditidaht. *Paper presented at the 87th Annual Meeting of the Linguistic Society of America*. http://linguistics.berkeley.edu/~sylak/cv/papers/Sylak-Glassman%20 2013%20-%20The%20Phonetic%20Properties%20of%20Voiced%20Stops%20 Descended%20from%20Nasals%20in%20Ditidaht.pdf.

Sylak-Glassman, John. 2013b. The phonetic properties of voiced stops descended from nasals in Ditidaht. Manuscript under preparation, University of California at Berkeley.

Trubetzkoy, Nikolai Sergeyevich. 1939. *Grundzüge der Phonologie* (Travaux du Cercle Linguistique de Prague 7). Reprinted 3rd impression by Vandenhoeck & Ruprecht, Göttingen, 1962.

Ulfsbjorninn, Shanti. in press. Bogus clusters and lenition in Tuscan Italian: Implications for the theory of sonority. In Geoff Lindsey & Andrew Nevins (eds.), *Sonic signatures*, Amsterdam: John Benjamins. https://ling.auf.net/lingbuzz/003267. DOI: https://doi.org/10.1075/lfab.14.c16

Wetzels, Leo & Joan Mascaró. 2001. The typology of voicing and devoicing. *Language* 77(2). 207–244. DOI: https://doi.org/10.1353/lan.2001.0123

Williams, Geoff. 1998. *The phonological basis of speech recognition*. London: SOAS, University of London PhD thesis.

Winn, Matthew B., Monita Chatterjee & William J. Idsardi. 2013. Roles of Voice Onset Time and F0 in stop consonant voicing perception: Effects of masking noise and low-pass filtering. *Journal of Speech, Language and Hearing Research* 56. 1097–1107. DOI: https://doi.org/10.1044/1092-4388(2012/12-0086)

Yoshida, Kenji. 2008. Phonetic implementation of Korean "denasalization" and its variation related to prosody. *IULC Working Papers Online* 8(1). https://www.indiana.edu/~iulcwp/wp/article/view/08-01.

How to cite this article: Breit, Florian. 2017. Melodic heads, saliency, and strength in voicing and nasality. *Glossa: a journal of general linguistics* 2(1): 85.1–35, DOI: https://doi.org/10.5334/gjgl.462

Submitted: 23 Mar 2016 **Accepted:** 22 Jun 2017 **Published:** 29 September 2017

]u[*Glossa: a journal of general linguistics* is a peer-reviewed open access journal published by Ubiquity Press. OPEN ACCESS