Metrical influences on fortition and lenition

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1. Introduction[1]

There is considerable tacit agreement among phonologists and phoneticians about the prototypical uses of the terms 'lenition' and 'fortition'. However, in the phonetic dimension the terms do not refer to a single unified phenomenon, but instead to manipulations of two independent parameters: duration and magnitude (degree of consonantal stricture) (Lavoie 2001). In phonology, 'lenition/fortition' refers to the categorical effects of such adjustments in duration and magnitude once they have been phonologized. The coherence of the terms is thus essentially diachronic; synchronically, many different formally unrelated processes may implement the phonologization.

On the synchronic phonological level, then, 'fortition' and 'lenition' are no more than taxonomic labels that provide little insight into the cognitive processes involved. The processes covered by the terms are not formally unified (at least given standard representational assumptions; for a contrasting view according to which phonological representations are phonetically detailed, see Kirchner 1998). Both terms may refer to a range of distinct processes, including changes in phonological segment weight (gemination/ degemination through insertion/ deletion of moras), sonority or continuancy (occlusion/ spirantization through change in the value of the feature [continuant], and so on), and voicing. The last of these may be connected to the observation that decreases in duration in obstruents may give rise to voiced percepts (Cole & Cooper 1975); accordingly, some languages have phonologized decrease in obstruent closure duration as a

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phonological voicing rule, and in other languages lenition processes reflect the combined effect of voicing and spirantization. Lenition additionally subsumes changes in place (debuccalization) as well as outright deletion. While there are a number of proposals that aim to bring some representational coherence to these phenomena (e.g. Gnanadesikan 1997), none have met with general acceptance.

If one wishes to adopt an approach that attempts to derive phonological constraints/ rules from pressures of perception and articulation, it becomes clear there is also no functional unity in the processes either. We shall show that the motivations for lenition and fortition are just as diverse as the processes, perhaps even more so.

We will argue that there is no single constraint that motivates every process called 'fortition', and the same for 'lenition'. In fact, even for the prototypical fortition process of metrically conditioned consonant gemination, there is no unique motivation; we identify three, outlined under (1).

(1) *Metrical motivations for consonant gemination*
   a. Main stress weighting: PrWd heads must have two moras.
   b. Coda maximization: increase coda segments in foot heads.
   c. Syntagmatic restrictions: e.g. avoidance of clash.

Furthermore, consonant gemination is only one in a class of possible repairs. As we shall see, others include vowel lengthening, epenthesis, and metathesis.

§3 focuses on (1a,b), which are both types of 'head enhancement' – the pressure to increase structure in heads of a certain type. We argue that there is a constraint which requires the heads of prosodic words (PrWds) to be bimoraic (MAIN-TO-WEIGHT) (also see McGarrity 2003:30, 119); amongst other things, this constraint can force gemination, e.g. /paka/ → [pá$_{\mu}$k$_{\mu}$.ka$_{\mu}$]. We also show that there is no evidence for a constraint that requires stressed syllables to be bimoraic *generally* (i.e. no STRESS-TO-WEIGHT) (cf. McGarrity 2003, Mellander 2003, and references cited therein). Indeed, including generalized STRESS-TO-WEIGHT in CON makes several unattested predictions. One is 'trochaic lengthening' (e.g. /CVCVCVCV/ → [(CV́ːCV)(CV̀ːCV)]), which we argue does not exist, in agreement with Prince (1990) and Hayes (1995). Another false prediction is that the pressure for iambic heads to be enhanced should be met by a variety of responses (Hayes 1995:82f). For example, /patakataka/ could become [(paták)(katák)ka], with gemination. However, we argue that the only possible response to iambic enhancement is vowel lengthening. So, while main-stressed syllables may be enhanced by gemination, lengthening of the vowel, epenthesis, and so on, iambic lengthening invariably affects the vowel in the stressed syllable. The domains of the two processes are therefore different: MAIN-TO-WEIGHT is a requirement on syllable *Rhymes*, whereas the constraint driving iambic lengthening is a requirement on syllable *Nuclei*. To our knowledge, this asymmetry has so far escaped notice in the literature and cannot be derived from existing accounts based on constraints on foot-form, which merely favour bimoraic heads in iambic feet (e.g. those based on the Iambic-Trochaic Law, see Prince 1990, Hayes 1995, Baković 1999).

We argue that head enhancement through mora insertion is to be distinguished from head enhancement that maximizes the segmental content of metrically prominent syllables. Head enhancement by mora insertion may only target the heads of PrWds (or larger domains), while the kind that maximizes *segmental* content (since it does not entail mora insertion) may target the heads of metrical feet.

§4 illustrates the role of syntagmatic metrical restrictions. For example, the avoidance of adjacent prominent moras (‘clash’) can motivate augmentation. §5 identifies constraint types that must not exist in order to account for the lack of certain gemination patterns. §6 examines the influence of metrical structure on lenition. We argue that lenition is in fact never motivated by metrical conditions, but may be blocked by faithfulness to prominent positions. Finally, §7 lays out our conclusions.

2. Lenition and fortition in phonetics, phonology and morphology

Like any phonological process, those covered by the terms ‘lenition’ and ‘fortition’ may turn up in embryonic form as part of phonetic implementation. They are also subject to various degrees of morphologization and, in some cases, have evolved into morphological markers.

An example of purely phonetic fortition is found in Korean. Jun (1993) shows that both plain and aspirated stops have relatively longer VOT at the beginning of prosodic phrases than medially or finally. There is no phonological process involved – stops in Korean contrast phonologically for aspiration. Cross-linguistically, domain-initial position correlates with articulations that are longer in duration or tenser (greater in magnitude, greater degree of stricture, greater area of contact between articulators).

For work on phonetic fortition, see Krakow (1989), Turk (1992, 1993), Pierrehumbert & Talkin (1992), Dilley *et al.* (1996), Smith (2002:section.4.2.2.1) and Cho & Keating (2001). We know of no cases in which domain-initial strengthening is phonologized.

Interestingly, though, there are quite clear cases where the effects of domain-initial strengthening have become morphologized. One example is Initial Consonant Mutation in the Celtic languages (e.g. Willis 1982; Pyatt 1997). According to Jackson (1967) and Sommerfelt (1954), both the Brythonic and Goidelic branches of Celtic had allophony between 'fortis' (long and tense) and 'lenis' (short and lax) consonants. The distribution of the fortes was taken to be a disjunction of absolute initial or post-consonantal position, the distribution of the lenes following a proclitic ending in a vowel. This picture may be simplified. The fortes were found initially in a domain as the result of domain-initial strengthening, and the lenes elsewhere (after both vowels and consonants). Following a vowel (but not following a consonant), lenis consonants underwent intervocalic voicing or spirantization, and these changes were subsequently morphologized as the markers of certain morphosyntactic categories or lexicalized with certain proclitics. Another case may be Njébbana (Gunwingguan, Australian, cf. McKay 2000).

Lavoie (2001) is the most extensive study of phonetic lenition. In relation to stress. Lavoie observes that "while consonant [phonetic] realization is significantly influenced by the presence or absence of stress, the stress-conditioned patterns are seldom phonologized". In particular, foot-medial position is frequently cited as a prime site for lenition (Prince 1980). As we shall see, foot-medial position may also serve as a site for fortition, as in many varieties of Saami (see §3.2). We show that these two apparently contradictory phenomena may be united under a single rubric. There is a pressing need for a theory of just which implementation rules are *phonologizable* and which are not. Another example of a common and salient phonetic effect with no known phonological counterpart is the raising of fundamental frequency after voiceless (stiff) obstruents (David Odden p.c.) (cf. ubiquitous tone *lowering* after voiced obstruents as described in Bradshaw 1999).

The influence of phonetic stress on consonant realization – and phonetic lenition and fortition – is covered in the work cited above. As our focus is phonological, we merely make some methodological observations here. In particular, it can be difficult to determine whether a phenomenon is purely phonetic or phonological. One useful diagnostic, however, is that phonological processes can condition other phonological processes. For example, a mora-insertion process like /ika/ → [ík.ka] creates a closed syllable, which may in turn trigger vowel allophony: e.g. [ík.ka] (assuming that this allophony is phonological!). Mora insertion may also occur because of (morpho-)phonological restrictions, such as minimal word size: e.g. /ta/ → [taː]. Phonetic lenition and fortition can also be gradient, affecting the degree of realization of some phonetic property rather than altering a contrastive specification (as for Korean VOT).

The literature is replete with examples of languages in which fortition and lenition are morphological processes. Consider for example the Initial Consonant Mutation systems of Celtic (see contributions in Ball & Fife 1993), Atlantic languages like Fula, or Consonant Gradation in the Uralic languages (see contributions in Abondolo 1998). For example, the plural morpheme in Fula is a [-continuant] prefix. When it attaches to a root-initial consonant, the effect is fortition-like: [fɛrlo] 'hill' cf. [pɛrle] 'hills' (Gamble 1958, Arnott 1970). Another example is the object focus morpheme in Keley-I which is an affixal mora causing gemination of a medial consonant: [pi.li] 'choose' cf. [pil.li] 'choose+object focus'; [du.jaɣ] 'pour' cf. [duj.jaɣ] 'pour+object focus' (Hohulin & Kenstowicz 1979, Samek-Lodovici 1992).

Methodologically, it is usually not difficult in practice to distinguish morphological lenition/ fortition from the phonological kind. Morphological lenition/ fortition is found in individual languages only in specific morphological environments. In contrast, phonological lenition/ fortition occurs whenever the relevant phonological environment occurs, regardless of morphological composition. Frequency of occurrence is not a guide to whether lenition/ fortition is phonological; some languages have several morphemes that have fortition-/ lenition-like effects (e.g. Irish Gaelic, see Pullman 2004).

3. Head enhancement

Our focus in this and the following section is fortition, and specifically the prototypical fortition process of consonant gemination. Our aim is to show that consonant gemination is not a unified process. There is no single constraint (e.g. FORTITE!) that motivates all gemination; there are many different motivations. Conversely, fortition is not the unique response to a particular constraint or set of constraints; the same motivations may induce vowel lengthening, diphthongization, splitting, and other processes.

Major motivators of gemination are those constraints that serve to 'enhance' prosodic heads by increasing the amount of material in them. Here we identify two distinct sub-types of prosodic head enhancement: increase in the moraic content of the syllable Rhyme in PrWd heads (§3.1), and increase in the segmental content of the Coda in foot heads (§3.2).

3.1. Heads, moras, and gemination

Hayes (1995:83f) and McGarrity (2003) propose that there is a mechanism that requires the head (main-stressed) syllable of a PrWd to be bimoraic. We adapt this proposal, and express it through the constraint MAIN-TO-WEIGHT, under (2).

(2) MAIN-TO-WEIGHT Assign a violation for every head syllable of the head foot of the PrWd that contains one mora. ('Main-stressed syllables must be bimoraic').

§3.1.1 provides evidence for MAIN-TO-WEIGHT: there are languages that require bimoraic main-stressed syllables, but not bimoraic secondary stressed ones. Lengthening under stress is never driven rhythmically in trochaic languages.

§3.1.2 shows that MAIN-TO-WEIGHT causes a variety of responses. Apart from consonant gemination – i.e. fortition – the constraint also causes lenghthening (South Greenlandic), epenthesis (Mabalay Atayal), and diphthong formation (Tukang Besi).

MAIN-TO-WEIGHT contrasts with the two most common proposals about stress and moraic quantity. One is that all foot heads aim to be bimoraic – 'STRESS-TO-WEIGHT' (e.g. Hammond 1986, Riad 1992, Rice 1992, 2006, van de Vijver 1998, McGarrity 2003). The other is that there is pressure on heads of iambic feet to be bimoraic, due to the Iambic-Trochaic Law (Hayes 1995), or Prince's (1990) principles as implemented in Baković's (1999) FTHARM constraint. We argue in §3.1.3 that neither STRESS-TO-WEIGHT nor FTHARM should be granted entry to the universal constraint set CON, since their inclusion predicts unattested systems.

3.1.1. Main head enhancement

Hayes (1995:84) and McGarrity (2003:29ff) identify Wargamay (Dyirbalic, Queensland Australia) as a language in which the effects of MAIN-TO-WEIGHT are distinct from STRESS-TO-WEIGHT. In Wargamay, main-stressed syllables lengthen but secondary stressed syllables do not: e.g. [ɟuɽáˑgajmìri] 'Niagara-Vale-from', *[ɟuɽáˑgajmìˑri] (Dixon 1981). The same is found for consonant gemination in Kuuku-Yaʔu (Thompson 1976, McGarrity 2003), and South Greenlandic Inuit (Ulving 1953).

Kuuku-Yaʔu (Pama-Nyungan, Cape York, Australia) has a default-to-opposite-edge system; main stress falls on the rightmost long vowel if there is one, otherwise the initial syllable, e.g. [wíːmumu] 'large number of ants', [mùːmáːɲa] 'rub', [pújŋaṯiɲa] 'shut'. In addition, a secondary stress falls on the initial syllable of every word, e.g. [mìjáːŋina] 'show himself'. A consonant is geminated following a short Nucleus bearing the *main* stress (3a). In contrast, the consonant following a Nucleus bearing secondary stress is not geminated (3b).

(3) *Kuuku-Yaʔu main-stress gemination*

a.	/pama/	→ [pámma]	'Aboriginal person'
	/waliʔi/	→ [wálliʔi]	'spotted lizard'
	/wukuṯuru/	→ [wúkkuṯuru]	'coral cod'
	/kacinpinta/	→ [káccinpinta]	'female'
	/maʔupimana/	→ [máʔʔupimana]	'build, make'
b.	[mìjáːŋina]	*[mìjjáːŋina]	'show himself'

In South Greenlandic Inuktitut (Inuit, South Greenland) stress interacts with both fortition (mora insertion) and qualitative lenition of consonants (Ulving 1953). Ulving does not explicitly mark stress in his examples, but his description is clear: (a) main stress falls within a two-syllable window at the right edge of the Prosodic Word, (b) within the window the position of main stress is morphologically or lexically determined, and (c) the initial syllable of the word always bears secondary stress.

Consonants geminate following a penultimate Nucleus bearing main stress (4a). However, no gemination takes place in secondary stressed syllables (4b).

(4) *South Greenlandic Inuktitut main-stress gemination*

a.	/awata-t/	→ [àwáttat]		‘kayak bladder {pl}’
	/nuka-t/	→ [núkkat]		‘sibling {pl}’
	/ami-t/	→ [ámmit]		‘skin {pl}’
b.	/amiq/	→ [àmíq]	*[àmmíq]	‘skin’
	/nukaq/	→ [nùkáq]	*[nùkkáq]	‘sibling’
	/iqalukat/	→ [ìqalúkkat]	*[ìqqalúkkat]	‘polar cod {pl}’

It is of course crucial under (4) to show that the secondary stressed syllable is truly a phonological foot head. Evidence for this claim is found in lenition. Lenition applies to stops only after an unstressed Nucleus: e.g. /k/ lenites to [ɣ] in [ìsiɣáq] ‘foot-sg.’ cf. [ìsíkkat] ‘foot-pl.’. However, lenition does not occur after an initial syllable: e.g. [àkípput] ‘they answer’, *[àɣípput]. Similarly, /q/ lenites to [ʁ] after an unstressed Nucleus, but not after the secondary stressed [ì] in [ìqaluwáq] ‘polar cod’.

We will not discuss how main stress is restricted to the final two syllables. Instead, our focus is on gemination. MAIN-TO-WEIGHT forces gemination by requiring a main-foot head with more than one mora. Because it has no jurisdiction over secondary stress, there is no pressure for gemination to occur in this environment; in fact, singletons and geminates contrast after secondary stress (e.g. [ìɣɣiáq] ‘gullet’, [nìɣáq] ‘snare’). DEP-μ is violated by output moras that are not present in the input, a situation that occurs in gemination.

(5) *Gemination after main stress only*

		/a-kipi-ut/	MAIN-TO-WEIGHT	DEP-μ
	a.	(à)(kí.put)	*!	
☞	b.	(à)(kíp.put)		*
	c.	(àk)(kíp.put)		* *!

While the Codas of penultimate stressed syllables geminate, word-final stressed Codas apparently do not: e.g. [àmíq], *[àmíqː]. However, in word-final position MAIN-TO-WEIGHT can be satisfied by making the Coda moraic: e.g. [à.mí$_{\mu}$q$_{\mu}$], [nì.ɣá$_{\mu}$q$_{\mu}$] ‘snare’.

MAIN-TO-WEIGHT is essential in accounting for Wargamay, Kuuku Yaʔu, and South Greenlandic. The alternative is that there is only a constraint STRESS-TO-WEIGHT that requires that *all* foot heads be heavy and that other constraints block gemination from occurring in secondary stressed syllables.

But what would block STRESS-TO-WEIGHT from applying to secondary stressed syllables in these systems? There are two possible accounts, one which takes its lead from faithfulness, the other from markedness. Neither of them are attractive. The faithfulness-based approach is to have a constraint σ̀-WTIDENT which preserves length only in secondary stressed syllables. However, σ̀-WTIDENT must refer directly to the heads of *non*-head feet, and so does not fit into positional faithfulness theory which allows reference to PrWd heads and all foot heads, but not to syllables with secondary stress alone. The possibility of prosodic faithfulness constraints that make direct reference to *secondary* stress also makes the prediction, incorrect as far as we know, that secondary stressed syllables may have richer subinventories than main-stressed ones.

The markedness-based alternative is to say that STRESS-TO-WEIGHT can be blocked by a markedness constraint that specifically bans geminates in secondary stressed syllables: *SECONDARY/GEMINATE. For South Greenlandic, *SECONDARY/GEMINATE would outrank STRESS-TO-WEIGHT, blocking gemination from applying in secondary stressed syllables. However, this approach fails because South Greenlandic does in fact permit geminates contrastively after secondary stress. The reasoning is as follows. To get main-stress gemination STRESS-TO-WEIGHT must outrank WTIDENT; to allow contrastive geminates after secondary stress, WTIDENT must outrank *SECONDARY/GEMINATE. It follows from the transitivity of dominance that STRESS-TO-WEIGHT must outrank *SECONDARY/ GEMINATE, but this ranking appears incompatible with the *blocking* of gemination in *secondary* stressed syllables, which requires that *SECONDARY/ GEMINATE outrank STRESS-TO-WEIGHT, a contradiction.

3.1.2. Other responses to MAIN-TO-WEIGHT

Consonant gemination is not the sole possible response to MAIN-TO-WEIGHT. Occasionally more than one method is employed in the same language. A striking case is found in Tukang Besi (Malayo-Polynesian, Tukang Besi archipelago off Southeast Sulawesi). The following discussion relies on Donohue's (1999) description.

Tukang Besi has the surface consonants [p t̪ k ʔ g s h ɓ ɗ̪ m n̪ ŋ r l β] ([β] functions as a sonorant) and pre-nasalized versions of the obstruents [ᵐp ⁿt̪ ᵑk ᵐb ⁿɗ̪ ᵑg ⁿs]. The language has right-to-left trochees, with main stress assigned to the rightmost foot: [ku.(pà.mo).(rò.ʔu).(kkɛ́.mo)] ‘I made her/ him drink’, [(nò.βa).(ndɛ́.ho)] ‘it’s still raining’ (Donohue 1999:31).

Syllables generally have the shape (C)V. However, there is an optional process whereby main-stressed syllables become bimoraic. For example, /ɛka/ → [ɛ́$_{\mu}$k$_{\mu}$.ka$_{\mu}$] ‘climb’ and /kapi/ → [ká$_{\mu}$p$_{\mu}$.pi$_{\mu}$] ‘wing’ show Coda gemination, a familiar response to MAIN-TO-WEIGHT. However, Coda gemination is not the preferred response to MAIN-TO-WEIGHT in Tukang Besi. In fact, it is the last resort; the default response is to geminate the *pre-stress* consonant.

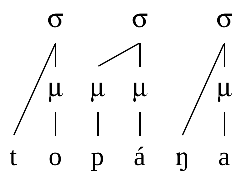
(6) *Tukang Besi pre-stress gemination*

/to-paŋa/	→	[topːáŋa]	‘cut-branch’
		[mɛlːái]	‘far’
		[ponːóʔe]	‘suck it’
		[mòtɯtːɯ́rɯ]	‘sleepy’
		[mòʔomːɯ́rɯ]	‘hungry’

Pre-stress gemination is typologically rare. However, it is not unique to Tukang Besi: Urubu-Kaapor (Tupi, Brazil) uses it for main-stressed syllables too, e.g. [kattú] ‘it is a good’, [nu.pã̀.ttá] ‘he will hit’ (Kakumasu 1986, González 2003:48).

So what is ‘pre-stress gemination’? At first glance, it looks like it may create a standard heterosyllabic geminate: i.e. [to$_{\mu}$p$_{\mu}$.pá$_{\mu}$.ŋa$_{\mu}$]. However, as an attempt to satisfy MAIN-TO-WEIGHT, this structure is useless, since it is the *unstressed*, *foot-external* syllable [top] that becomes heavy here, while the main-stressed syllable [pa] remains light. Neither is it clear what other constraint would motivate such a mapping, given this structure. We propose instead that MAIN-TO-WEIGHT is satisfied by making the *Onset* of the stressed syllable moraic. The structure for [topːáŋa] then becomes as shown under (7).

(7) *Syllable structure of [to.ppá.ŋa]*



Other options fail for a variety of reasons. NOCODA prevents both gemination (e.g. *[to.páŋ.ŋa]) and Coda attraction (*[to.páŋ$_{\mu}$.a]). Long vowels are banned absolutely in the language, ruling out *[to.páː.ŋa], and DEP bans epenthesis (*[to.páʔ.ŋa]). Consequently, moraification of the Onset is the only available response.

Tableau (8) summarizes. Each candidate gives a phonological representation and the square brackets enclose its phonetic interpretation. The constraint *ONS/μ bans moraic Onsets.

(8) *Moraic Onsets in Tukang Besi*

		/to-paŋa/	M-T-W	NOCODA	*ONS/μ
	a.	to.pá.ŋa [topáŋa]	*!		
	b.	to.páŋ$_{\mu}$.a [topáŋŋa]		*!	
	c.	to.páŋ$_{\mu}$.ŋa [topáŋŋa]		*!	
☞	d.	to.p$_{\mu}$á.ŋa [toppáŋa]			*

In line with our claim that only main-stressed syllables may be subject to the bimoraic requirement, Donohue (1999:34) states that only main-stressed syllables undergo this kind of augmentation in Tukang Besi, although he gives no transcribed examples. Therefore, 'I made her/ him drink' must be [ku.pà.mo.rò.ʔu.kkɛ́.mo], and not, for example, *[ku.ppà.mo.rò.ʔu.kkɛ́.mo].

The structure under (7) is uncommon, and may provoke surprise and consternation in our readers. However, moraic Onsets are attested in a variety of languages (Davis 1999, Hajek & Goedemans 2003 and references cited therein, Topintzi 2006).[2]

[2] There is a variety of evidence for moraic onsets. Some languages furnish a contrast between word-initial singletons and geminates. An example is Pattani Malay (Hajek & Goedemans 2003, Topintzi 2006), e.g. /buwɔ́h/ 'fruit' vs. /bːuwɔ́h/ 'to bear fruit', /ɟalɛ́/ 'street, path' vs. /ɟːalɛ́/ 'to walk'. In certain languages, weight assignment to onsets is a strategy for satisfying word minimality requirements (Bella Coola, cf. Bagemihl 1998, Trukese, cf. Curtis 2003). In Bella Coola, minimal words may have any of the shapes CV, VV, or VC, but V is subminimal. Topintzi (2006) proposes that voiceless onsets in Arabela (Za-

In disyllabic words, it is the initial syllable that receives the main stress. Word-initially, moraic Onsets appear to be subject to special licensing conditions. When the Onset of the initial syllable is an oral stop, it cannot be moraic (LICONS-μ). In this situation, the language has recourse to an alternative strategy for satisfying MAIN-TO-WEIGHT: geminating the consonant following the main-stressed Nucleus as shown under (9).

(9) [ká$_\mu$p$_\mu$.pi$_\mu$] ‘wing’ [gɯ́$_\mu$n$_\mu$.nɯ$_\mu$] ‘mountain’
[pó$_\mu$n$_\mu$.no$_\mu$] ‘suck’

Under the assumption that this introduces a weight-bearing Coda into the main-stressed syllable, then MAIN-TO-WEIGHT is satisfied.

(10) *Moraic Onsets in Tukang Besi*

		/kapi/	M-T-W	LICONS-μ	NOCODA	*ONS/μ
	a.	ka.pi [kápi]	*!			
☞	b.	káp$_\mu$.pi [káppi]			*!	
	c.	k$_\mu$ápi [kkápi]		*!		*

Coda gemination is also found in disyllables beginning with a vowel. In the complete absence of a suitable Onset, the post-tonic consonant geminates instead, as shown under (11).

(11) [ɛ́$_\mu$k$_\mu$.ka$_\mu$] ‘climb’ [ɛ́$_\mu$l$_\mu$.la$_\mu$] ‘tongue’

To summarize, Tukang Besi presents a striking example of how MAIN-TO-WEIGHT can motivate more than one type of response, and how fortition is only one of many possible responses. MAIN-TO-WEIGHT is satisfied

paroan, Peru) are moraic, making them subject to the WEIGHT-TO-STRESS PRINCIPLE (WSP, Prince 1990). Arabela parses trochees from left to right and assigns main stress to the final foot, e.g. [(tè.na).(ká.ri)] ‘afternoon’, [(sà.ma).(rú)] ‘spirit’, [(hù.wa).(hà.ni).(já)] ‘peaceful’. Being heavy, CV syllables disrupt the rhythmic alternation, e.g. [(nò.wa).(ʃì).(ʃá.no)] ‘brightened’, [(sà.po).(hò).(sá.no)] ‘deceived’, [(mwè.ra).(tì).(tjé.nu)] ‘cause to be seen’.

through moraic Onsets, and where those are impossible, by consonant gemination to give a Coda.[3]

Vowel lengthening and epenthesis

Other possible responses to MAIN-TO-WEIGHT include vowel lengthening and epenthesis. We will illustrate these with a couple of cases here.

We have already mentioned Wargamay, a language that has vowel lengthening as the sole response to MAIN-TO-WEIGHT. A more striking case is Guelavía Zapotec (Otomanguean, Mexico, Jones & Knudson 1977, González 2003), which uses both vowel lengthening and gemination as a response to MAIN-TO-WEIGHT. Main stress is assigned to the penultimate syllable. The consonants are divided into a fortis series /p t t͡s t͡ʃ t͡ʂ k s ʃ ʂ m̄ n̄ l̄/ (fortis sonorants are marked with a macron) and a lenis series /b d d͡z d͡ʒ g z ʒ ʐ m n l r/. Fortis consonants undergo gemination following the main-stressed Nucleus, e.g. /rapaˀ/ → [ráppaˀ] 'I have', /ʃpakaˀ/ → [ʃpákkaˀ] 'my tadpole'; /naʃɨn/ → [náʃʃɨŋ] 'it is sweet', but before a lenis consonant it is the vowel that is lengthened, e.g. /rkwabede/ → [rkwaβéːðe] 'it is spicy'; /ragoˀ/ → [ráːɣoˀ] 'you bite'; /gozmɨ/ → [góːzmɨ]

3 As is so often the case, there are subtleties in the data that we cannot hope to do justice to here. There are two caveats to the account that we have presented here. The first has to do with the behaviour of disyllabic words with initial sonorants. Consider the following examples: [máŋa] 'eat', [lóno] 'cloud', [βíla] 'go'. Donohue (1999) transcribes the initial sonorant of these words as short. One phonological interpretation of this is that the initial sonorant does not bear a mora: [má$_\mu$.ŋa$_\mu$] 'eat', [ló$_\mu$.no$_\mu$] 'cloud', [βí$_\mu$.la$_\mu$] 'go'. If this is correct, then MAIN-TO-WEIGHT cannot be satisfied in these forms, since the main-stress syllable lacks a heavy Rhyme. In order for our account to work, the initial sonorant must be moraic: [m$_{\underline{\mu}}$á$_\mu$.ŋa$_\mu$] 'eat', [l$_{\underline{\mu}}$ó$_\mu$.no$_\mu$] 'cloud', [β$_{\underline{\mu}}$í$_\mu$.la$_\mu$] 'go'. This raises the question why they are not transcribed double. We can only venture a speculation here, but one possible reason is that adjustments in the duration of oral stops are enhanced by adjustments in magnitude (stiffness), a common situation in languages (Ladefoged & Maddieson 1996). This additional enhancement would make the increase in the duration of the stop more salient, in turn making it more likely to be recorded in the transcription. The second caveat concerns the approximants [β r h ʔ], implosives [ɓ ɗ̪] and prenasalized obstruents. These are never transcribed as double, even in positions we would expect. Consequently, /maʔɛka/ 'afraid, fear' surfaces as [ma.ʔɛ́.ka], not *[maʔ.ʔɛ́.ka] or *[ma.ʔɛ́k.ka], and /mondilu/ 'sour' as [mo.ndí.lu].

'sickle'. In this case, a phonotactic restriction banning geminate lenis consonants blocks gemination as a response to MAIN-TO-WEIGHT, forcing vowel lengthening instead. The core ranking is: MAIN-TO-WEIGHT, *GEMINATE/LENIS » NOLONGV » *GEMINATE.

It is possible that MAIN-TO-WEIGHT accounts for at least some of the *Raddoppiamento Sintattico* patterns of various Italian dialects. In Italian, main stress may fall on any of the last three syllables of the word (Lepschy & Lepschy 1988). Inside this window, stress is lexically determined. Main-stressed syllables are always heavy, and open main-stressed syllables in penultimate and antepenultimate position evince vowel lengthening, e.g. /fjorentína/ → [fjorentíːna] 'Florentine', /pád͡ʒine/ → [páːd͡ʒine] 'pages'. Italian also has a class of words ending in a stressed final vowel, and these cause gemination of a following consonant, e.g. /d͡ʒá finíto/ → [d͡ʒáffiníːto] 'already finished', /andó vía/ → [andóvvíːa] 'he went away' /sot͡ʃietá t͡ʃivíle/ → [sot͡ʃietátt͡ʃivíːle]. Why doesn't Italian use the same strategy for satisfying MAIN-TO-WEIGHT word-finally as medially? Word-medially, Italian has contrastive geminates, e.g. /fato/ 'fate' vs. /fatto/ 'made'. Satisfying MAIN-TO-WEIGHT word-medially through gemination of the post-tonic consonant would neutralize the geminate contrast, and so WTIDENT(C) must outrank WTIDENT(V). As Buckley (1998) observes, many languages have a ban on long vowels in word-final position (e.g. $*\text{V}ː]_{\text{Wd}}$). In Italian, the high rank of $*\text{V}ː]_{\text{Wd}}$ and MAIN-TO-WEIGHT forces gemination rather than vowel lengthening.[4]

Latvian (Indo-European, Latvia, Holst 2001) provides an interesting contrast. Following a short main-stressed Nucleus, only obstruents undergo gemination, e.g. *likums* [líkkums] 'law'; *desā* [dǽssɑː] 'in the sausage'; *miza* [mízzɑ] 'bark'. Other segment types do not lengthen: e.g. *ala* [ɑlɑ], *zināt* [zinɑːt] 'to know'; *pļava* [pʎɑʊɑ] 'meadow'. In this case, a constraint bans sonorant geminates, and there is no back-up response: i.e. NOLONGV » MAIN-TO-WEIGHT, *GEMINATE/SONORANT » *GEMINATE.

4 The kind of *raddoppiamento sintatico* that we have addressed here is purely phonological. However, the term is also used to refer to morphologized alternations triggered by certain proclitics that do not end in a stressed vowel, e.g. *a casa* [akkáːsa] 'at home', *qualche virus* [kwálkevvíːrus] 'some virus or other'. We may also note that phonological *raddoppiamento* unexpectedly applies or fails to apply in certain religious phrases, e.g. *Gesù Cristo* is [d͡ʒezú krísto], not *[d͡ʒezú kkrísto], and *Spirito Santo* is [spíːrito ssánto], not *[spíːrito sánto].

Mabalay Atayal (Formosan, Taiwan, Lambert 1999:86) responds to MAIN-TO-WEIGHT by epenthesis of [ʔ], as shown under (12). Stress is not explicitly marked by Lambert, but her description (p.183ff) is clear; the data is from Lambert (1999:83). (‘trans.loc.’ stands for ‘transitive locative’).

(12) *Mabalay Atayal MAIN-TO-WEIGHT consonant epenthesis*

a.	/an-βakħa/	→ [βa.nak.ˈħɐʔ̲]	‘break+{perfective}’
		cf. [βak.ħɐ-.ˈun]	‘break+{trans.loc.}’
		*[βak.ħɐ-.ˈʔun]	
b.	/m-paŋa/	→ [ma.pa.ŋaʔ̲]	‘carry on back+{intransitive}’
		cf. [pa.ŋa-.ˈan]	‘carry on back+{trans.loc.}’
c.	/am-sβu/	→ [sa.ma.ˈβuʔ̲]	‘shoot+{intrans.}’
		cf. [βu-.ˈan]	‘shoot+{trans.loc.}’

The underlined glottal stops cannot be present underlyingly. If, for example, [sa.ma.ˈβuʔ̲] ‘shoot+{intrans.}’ has an underlying /ʔ/, there would have to be a process of intervocalic ʔ-deletion to account for [βu-an], *[βuʔan]. However, [ʔ] is̲ allowed intervocalically: e.g. [pak.ni.ˈʔi] ‘{cause}+eat+{jussive}’ (p.83).

3.1.3. Foot optimization and its irrelevance to fortition

One of the most important results in metrical phonology is the fundamental asymmetry of the foot inventory. In particular, HL trochees (consisting of a heavy followed by a light syllable) and LH iambs are not simply mirror images of each other. If STRESS-TO-WEIGHT was in CON, however, we would predict that trochees and iambs behaved symmetrically. As argued cogently by Prince (1990) and Hayes (1995), however, HL trochees are universally dispreferred, so we do not expect to find languages with rhythmic lengthening of trochaic foot heads. In iambic languages, on the other hand, there is a rhythmic pressure to maximize the quantity difference between the head and dependent. For example, in Kashaya every foot head must be bimoraic CV: or CVC (Buckley 1994:172), as shown under (13) below.[5]

[5] Iambic Pressure often fails to apply word-finally: e.g. Kashaya [(ʃi.má)] ‘ear’, *[(ʃi.máː)], [(mo.mácʰ).(me.là)] ‘I ran in’ (Buckley 1994:175ff).

(13)	[(mo.mú:).(lic'è:).(ducè:).du]	'keep running all the way around (sg)'
	[(da.mácʰ).(qa.wà:).(c'i.jìc').(meʔ)]	'keep coming in here!'

This 'Iambic Pressure' has been formalized in a variety of ways (Prince 1990, Kager 1993, Hayes 1995, Baković 1999, van der Vijver 1998, Revithiadou 2004). Here, the Iambic-Trochaic Asymmetry is guaranteed partly by eliminating STRESS-TO-WEIGHT and limiting the effects of mora insertion under stress to *main-stressed* syllables through MAIN-TO-WEIGHT. In this section, we argue that the Iambic-Trochaic Asymmetry in fact goes even deeper than this. As we have seen, MAIN-TO-WEIGHT is associated with a variety of responses, including vowel lengthening and consonant gemination. *Iambic Pressure only results in vowel lengthening, never consonant gemination*. Thus, an input like /patakataka/ may only ever map to [(pa.tà:).(ka.tá:).ka]), never [(pa.tàk).(ka.ták).ka]. While MAIN-TO-WEIGHT is a requirement on main-stressed *Rhymes*, Iambic Lengthening is a requirement on the *Nuclei* of iambic heads.

Because Iambic Pressure does not motivate gemination/ fortition, it falls outside the scope of the current chapter. Here we merely emphasize its distinctness from the pressure that creates geminates: i.e. MAIN-TO-WEIGHT. We also note that theories that regard Iambic Pressure as increasing mora quantity in iambic head syllables face the difficulty of explaining why it only ever seems to motivate vowel lengthening.

A challenge to our claim is Hayes' (1995:83) citation of six languages as having 'iambic gemination'. However, further examination of these languages raises a number of difficulties.

The sources for Menomini gemination are not adequately detailed to be sure that there is iambic gemination. Bloomfield (1939, 1962) and Hockett (1981) report iambic vowel lengthening: /ahsama:w/ → [(ah.sá:).(má:w)] 'he is fed', *[(ah.sám).(má:w)]. However, they also report that between short vowels where the first receives (secondary?) stress, an [n] is "often lengthened" /nekɛhkenanan/ → [(ne.kɛ́:).(hke.nán).nan] 'I don't know' (a similar case is reported for Gundidj, cf. Hercus 1986:159–160, González 2003:53). A possibility is that the vowel preceding the [n] is nasalized and lengthens, producing what sounds like a Coda nasal (akin to 'nasal glides', see Trigo 1988). This is pure conjecture; the sources available to us do not provide detailed phonetic analysis. We mention this case only because it has been cited as having gemination; field research would resolve this issue.

Unami/ Munsee is reported as having gemination after a stressed vowel, but it is probably limited to main stressed syllables – the source does not mark gemination, and secondary stress is not reported (Hayes 1995:§6.3.3).

A variety of Yupik languages are reported to have iambic lengthening: [(pi.súː).qu.(ta.qúː).ni] 'if he (refl.) is going to hunt'. However, gemination only ever occurs to ensure that roots are stressed /√aŋ-uq/ → [(áŋ).ŋuk] 'it is big' (cf. [(áŋ).lu.ni] '(it) being big' (Jacobson 1984, Ketner 2007, Hayes 1995:§8.8). The alternatives *[(á).ŋuk] and *[(a.ŋúk)] lose, the first because the foot is not iambic, the second because the suffix ends up receiving stress instead of the root.

Central Alaskan Yupik has iambic vowel lengthening: /qajani/ → [(qa.jáː).ni] 'in his own kayak'. A consonant geminates if it precedes a vowel that is underlyingly long: /qajaːni/ → [(qáj).(jáː).ni] 'in his (another's) kayak'. Baković (1999) proposes that this process is driven by a need for harmonic feet, however it is not clear why head enhancement would be satisfied by vowel lengthening in the second syllable but gemination in the first: i.e. why not *[(qáː).(jáː).ni]? Whatever the motivation behind the gemination, we suspect that it is not metrical; this suspicion is also expressed in Hayes' (1995:245) analysis which appeals to a rule of 'pre-long strengthening' that inserts a mora before an underlying long vowel.

Southern Paiute is cited by Hayes (1995:83) as having iambic gemination. However, in post-stress position geminates contrast with singletons: [muβípːi̥] 'nose-NOM.', cf. [nɨβáɸi̥] 'snow-NOM.', *[nɨβápːi̥] (/p/ spirantizes intervocalically) (Sapir 1930).

Hayes (1995:83) also cites Seward Peninsula Inupiaq as having iambic consonant gemination, but the situation is far from straightforward. Kaplan (1985:202) argues that the process is phonological (not morphological), but observes that Consonant Gradation (i.e. gemination) applies independently of stress: "word stress is assigned after CG applies, with no consideration of whether a given syllable has or has not been altered by CG. …[W]ord stress is assigned individually to syllables practically regardless of what precedes or follows" (p.193). He cites examples of degemination after unstressed syllables (e.g. /tutːutːuq/ → [tútːutúq] 'he killed a caribou'), and comments that "where CG predicts a short *t* after a weak syllable […] there is no lengthening possible" (p. 194). In contrast, he notes that "where consonant length is governed by CG and thus [is] non-distinctive, those segments which are subject to lengthening are not always truly long […] actual lengthening is in practice optional.” Gemination seems therefore to be optional and independent of stress.

One potential counter-example to the claim above is found in Norton Sound-Unaliq Yupik; this language has iambic vowel lengthening (e.g. /qajapixkani/ → [(qa.jáː).(pix.káː).ni] ‘his own future authentic kayak’), but if the stressed vowel is [ə] the following consonant is geminated: e.g. [(a.tə́p).pik] ‘real name’ (Jacobson 1985:29ff, van de Vijver 1998). However, there are no cited examples showing that gemination happens in secondary stressed syllables. This case requires further investigation.

3.2. Coda maximization

The previous section examined a number of cases in which main-stressed syllables were enhanced through the insertion of a mora. A far less common process is the enhancement of heavy stressed Rhymes through the attraction of consonantal material into the Rhyme. To date, this kind of ‘Coda maximization’ is only attested in dialects of Northwest Saamic (Bye 2005), Fenno-Swedish (Kiparsky 2004) and apparently also Seward Peninsula Inupiaq (Kaplan 1985:194).

Kiparsky (2004) explores the spread of Coda maximization (his ‘fortition’) in Fenno-Swedish. The function of Coda maximization in Fenno-Swedish, according to Kiparsky, is to ‘enhance heavy syllables’ (p. 12). Its application, however, ‘was avoided wherever it would have merged a contrast between heavy and superheavy syllables’. In dialects where the contrast between heavy and superheavy is preserved, as in General Fenno-Swedish and South Ostrobothnian, Coda maximization is limited to applying in post-consonantal position since post-vocalic application would neutralize the contrast. Thus, in these dialects, /venta/ undergoes Coda maximization to *ventta*, with geminate /t/ post-consonantally, but /ruupa/ ‘call’ remains unmodified as *ruupa*. However, where the distinction between heavy and superheavy has been neutralized, as it has in the varieties of the Southwest, Helsinki and Brändö, Coda maximization applies both post-consonantally and post-vocalically, giving *ventta* and *ruuppa*. The tableau below adapts Kiparsky’s own table of the Fenno-Swedish dialects. We have ranged the dialects from left to right in a scale of increasing quantitative innovation. Borgå in Nyland is thus the most conservative dialect in quantitative terms, and Brändö the most innovative. Innovations are shown in italics.

(14) Fenno-Swedish quantity (Kiparsky 2004)

orth.	Borgå	Gen.	S.Ostrob	Southw	Hels.	Brändö	
baka	baka	baka	baka	baka	*baakka*	baakka	'bake'
mina	mina	mina	mina	mina	mina	*minna*	'my'
gått	goott	goott	goott	*gott*	gott	gott	'gone'
vända	vennda	vennda	vennda	vennda	vennda	vɛnnda	'turn'
vänta	vennta	*ventta*	ventta	ventta	ventta	vɛntta	'wait'
ropa	ruupa	ruupa	ruupa	*ruuppa*	ruuppa	ruuppa	'call'
råg	rog	rog	*roog*	roog	roog	roog	'rye'

The quantitative system of Borgå is essentially unchanged since Old Norse. Borgå retains in full the Old Norse contrast between light (CV), heavy (CVV/ CVC) and superheavy syllables (CVVC). General Fenno-Swedish has innovated by maximizing the Coda of a closed heavy syllable (/venta/ → *ventta*). South Ostrobothnian apparently represents the third stage of quantitative evolution. In this dialect, the final C of a monosyllabic word does not count for weight, and the Nucleus lengthens under the minimal bimoraic requirement (/rog/ → *roog*). Despite the lengthening, the distinction between heavy and superheavy syllables is still maintained due to the possibility of final geminates, as evidenced by the prosodic minimal pair *roog* vs. *goott*. Southwest Fenno-Swedish neutralizes /CVVCC/ to *CVCC* (/goott/ → [gott]) and, in doing so, eliminates the contrast between heavy and superheavy syllables. Once the distinction is gone, Coda maximization may (and does) apply to *any* heavy syllable, without compromising the heavy vs. superheavy contrast, as in *ruuppa*, 'call'.

Coda maximization is also known from the Northwest Saamic (Lapponic) languages spoken in northern Norway, Sweden and Finland (Bye 2005). These languages are striking in terms of the complexity of their syllable structure. The stressed syllable of a foot may contain one, two or three moras and consonants have a three-way length contrast foot-medially, e.g. West Finnmark Saami /kaaruu/ 'by consenting', /kaarruu/ 'he/ she consents', /kaarːruu/ 'consenting'. Any combination of short/ long vowel and short/ geminate/ overlong geminate consonant is permitted. On top of all this, complex Codas are permitted. Consider the following examples from the Jukkasjärvi dialect of Lule Saami (Collinder 1949). Following a stressed Nucleus and at least one consonant, a consonant before an unstressed Nucleus undergoes gemination (shown underlined). Feet are rightward iterative syllabic trochees. Coda maximization is rhythmic and applies to the head syllable of every foot, not just the main-stressed one (15b).

(15) *Coda maximization in Jukkasjärvi Lule Saami*

a.	/saavnee + ht/	→	[(sáavn.neeht)]	‘seams, joints’
	/kaajsee/	→	[(káajs.see)]	‘steep mountain {acc/gen.sg}’
	/haaŋkas/	→	[(háaŋk.kas)]	‘reindeer fence {nom.sg}’
	/luspee + ht/	→	[(lúsp.peeh)]	‘lake outflow {nom.pl}’
	/naaskeer/	→	[(náask.keer)]	‘awl’
	/tææptee + n/	→	[(tǽæpt.teen)]	‘spleen {inessive-elative sg}’
b.	/pɛɛtnaki-j-taa/	→	[(pɛ́ɛt.na).(kìjt.taa)]	‘dog {plural + illative}’
	/lohka-pæhtee/	→	[(lóh.ka).(pǽht.tee)]	‘read {2dual.present}’
	/mujːhtala-ihtʃu-lejmee/	→	[(múj:.hta).(lìhtʃu).(lèjm.mee)]	‘narrate {conditional + 1plural}’

Gemination occurs even if more than one consonant intervenes between the stressed Nucleus and the target, e.g. /aajhtee + ht/ → [(áajht.teeht)] ‘larder (nom.pl)’.

There is language-internal evidence from Saami to indicate that Coda maximization does not increase the number of moras in the syllable. In *sáavn.neeht* ‘seams, joints’, for example, the second mora of the first syllable, dubbed the ‘weak’ mora by Zec (1995), is shared by both the /v/ and the /n/ of the Coda, as well as the second half of the vowel /a/. Space limitations prevent repetition of the arguments here; we instead refer the reader to Bye (2005). Suffice it to say that the first syllable of each of the preceding examples is demonstrably bimoraic. Given this, Coda maximization is not a counterexample to our claim that mora insertion on trochaic heads may only apply to the main-stressed syllable.

4. Clash-driven fortition

In some languages consonant gemination is motivated by the avoidance of clash at the moraic level: i.e. adjacent stressed moras are avoided (Kager 1992a,b).

A clear case is Kayardild (Evans 1995). Main stress falls on the initial syllable. In addition, bimoraic trochees are arrayed from right to left; all syllables are parsed into feet. In words with an odd number of moras, this footing would result in a clash at the moraic level: i.e. /CVCVCV/ →

[(CV́)(CV́CV)]. To avoid this situation, Kayardild employs gemination. For example, underlying /kalat̪a/ ‘cut’ surfaces as [(kál)(lɐ̀t̪)] (with an incidental apocope process); by doing so, [(ká$_{\mu}$l$_{\mu}$)(lɐ̀$_{\mu}$t̪)] avoids having adjacent stressed moras, while its competitor *[(ká$_{\mu}$)(lɐ̀$_{\mu}$t̪)] does not. Evidence that ‘cut’ lacks an underlying geminate is found in words where mora clash does not occur: e.g. /kalat̪a-ri/ → [(kálɐ)(t̪ɐ̀ri)] ‘didn’t cut’. Another example is /malaa/ → [(mál)(làa)] ‘sea’.

A more complex case involves Finnish dialects. These do not avoid adjacent *stressed* moras, but rather adjacent *head* moras. Kager (1992b) argues that head moras in this case are (a) stressed moras of light syllables and (b) the leftmost mora of heavy (stressed or unstressed) syllables. Finnish dialects avoid clash of head moras, i.e. a stressed light syllable (CV) followed by a heavy syllable (CVC).

Finnish has rightward syllabic trochees: e.g. [(ló.pe).(tè.ta)] ‘finish (negative)’, [(ló.pe).(tèt.ta).va] ‘to be finished’, [(púo.lus).(tèt.ta).(vìs.sa)] ‘defensible’. To avoid adjacent head moras, though, different dialects adopt different strategies. In the dialect described by Kiparsky (1991) and Kager (1992b), feet are ‘moved’ resulting in local ternarity: e.g. [(ló.pe).te.(tàan)] ‘one finishes’, not *[(ló.pe)(tè.taan)], where the head mora [è] is adjacent to the head mora of the heavy syllable; also [(rá.kas).tu.(nèi.ta)] ‘infatuated lovers’, [(lú.e).(tùt.te).lu.(tèl.la)] ‘to gradually cause to have been read’. In contrast, other dialects (Central and North Pohjanmaa, Savo) and other Balto-Fennic languages (South Estonian, Ingrian, and Votic) pre-empt the mora clash through gemination, making the light syllable heavy (Kettunen 1930, Laanest 1966, Paunonen 1973, Gordon 1997, Harrikari 2000): e.g. Central and North Pohjanmaa [(kál̲.laa)] (standard: [kalaa]) ‘fish (part.sg)’; [(ás̲.suu)] (standard: [asuu]) ‘he lives’; [(kú.mar).(tèl.lee)] (standard: [kumartelee]) ‘he keeps nodding’. In [(kál̲.laa)], clash between the stressed syllable and the head mora of the long vowel is avoided by inserting a non-head mora between them: i.e. [(ká̲$_{\mu}$l$_{\mu}$.la̲$_{\mu}$a$_{\mu}$)], *[ká̲$_{\mu}$.la̲$_{\mu}$a$_{\mu}$].

5. Non-motivations for fortition

The preceding sections have argued that fortition and its relation to stress are not unified. There is no single constraint that motivates consonant gemination. Instead, there are several motivations: MAIN-TO-WEIGHT (§3.1), Coda maximization (§3.2), and mora-clash avoidance (§4). Consequently, there is no simple answer to the question of how fortition and prosodic heads interact.

Fortition/ gemination is also not a unified response in the sense that it is never the *only* response to a particular pressure. MAIN-TO-WEIGHT can force gemination, but also vowel lengthening, consonant epenthesis, moraic Onsets, and potentially other responses not discussed here (e.g. deletion/ syncope: /CVCV/ → [CV́C], metathesis /CVCV/ → [CVVC]).

However, in broad terms, it is reasonable to say that gemination is often motivated by conditions on prosodic heads. Since gemination introduces a mora, it will often perturb the foot structure of a word; similarly, since there are many conditions on head well-formedness and these often demand increase in moraic content, gemination is a viable option.

Before moving on to lenition, however, it is equally important to identify constraint types that cannot exist in relation to gemination. §3.1.3 argued that there is no constraint that forces bimoraicity in the heads of iambs (cf. Baković's 1999 FTHARM). Similarly, there cannot be constraints that (a) promote bimoraicity in all stressed syllables (usually called 'STRESS-TO-WEIGHT' – Hammond 1986, Riad 1992, Rice 1992, van de Vijver 1998, McGarrity 2003), (b) force contrastive augmentation, or (c) force multiple enhancement.

Coupled with a requirement of foot disyllabicity (FTBIN-σ, cf. Elías 2005), STRESS-TO-WEIGHT predicts that there could be trochaic languages in which all stressed syllables are bimoraic, giving iterating uneven trochees: e.g. /LLLLLLL/ → [(H́L)(H́L)(H́L)L]. There have indeed been reports of such 'trochaic lengthening' in the literature. However, Hayes (1995:84) claims that some of these cases are phonetic and not phonological (e.g. Swedish, cf. Bruce 1984). Of the others, almost all turn out to have lengthening in the main-stressed syllable only. Examples are Icelandic (Hayes 1995:sec.6.2.2.3), Mohawk (Michelson 1988, Mellander 2003), Selayarese (Mithun & Basri 1986, Mellander 2003), Guelavía Zapotec (Jones & Knudson 1977, González 2003), Popoloca (Veerman-Leichsenring 1991, González 2003), and Kambera (Klamer 2004, van der Hulst & Klamer 1996).

Gouskova (2003) uses STRESS-TO-WEIGHT to derive rhythmic syncope in Tonkawa, e.g. /ke-we-jamaxa-oo-ka/ → [(kèw).(jàm).(xóo.ka)] 'you paint our faces'. While would-be CVCV trochees are clearly reduced to CVC in Tonkawa, there are alternative motivations. One derives from independently attested conditions on sonority. De Lacy (2006) and references cited therein show the need for constraints against high sonority segments in the non-head part of a foot; one of these constraints bans everything of vocalic sonority in this position. This constraint may be used to derive the right footings for Tonkawa (e.g. [(kèw).(jàm).(xóo).ka]). Importantly, however, it does not promote footings like /LL/ → [(H́L)]. [(H́L)] fares just as badly as [(ĹL)] in markedness as both have footed non-head Nuclei; however, [(ĹL)] fares better on faithfulness (see de Lacy 2006:§8.7.3 for further discussion).

The most cited putative challenge to the claim that there is no STRESS-TO-WEIGHT is Chimalapa Zoque. Knudson (1975) reports that this language assigns main stress to the penult and secondary stress to the initial syllable (see Gordon 2002 on other dual stress systems). Both stressed syllables must be either CVː or CVC (e.g. [hùːkúːti] 'fire', [wìːtuʔpajnɨ́ksɨ] 'he is coming and going', [ʔòːtoŋŋɨ́ːpiʔtʰ] 'if he had spoken'). However, Johnson (2000:§3.2.1), writing on San Miguel Chimalapa Zoque, does not report a secondary stress on the initial syllable. Further investigation is needed to account for this descriptive disparity.

6. Lenition and feet

We focus in this section on the relation of metrical structure to typical cases of lenition, namely those that involve an increase in consonantal sonority. We argue that constraints on metrical structure do not condition qualitative alterations in segments, whether fortition or lenition. This is in keeping with Honeybone's (2003) proposals that lenition is never *favoured* in specific environments, but it may be blocked in certain positions, such as metrically prominent constituents. This also accords with Lavoie's (2001) observation that "while consonant [phonetic] realization is significantly influenced by the presence or absence of stress, the stress-conditioned patterns are seldom phonologized."

While foot-medial position may be a prime site for lenition, we argue here that it is only incidentally so: the flapping of t/d in English can be understood in terms of the interaction of stress-based syllabification, segmental context, and position within the syllable. Of prime importance are positional faithfulness constraints that block lenition in prosodically prominent environments.

There are at least two motivations for increasing consonant sonority. One is that moras favour higher sonority segments over lower sonority ones (Zec 1995, Morén 1999). Consequently, moraic coda consonants can be forced to lenite. For example, Squliq Atayal /z/ becomes [j] in Codas and /ɡ/ becomes [w]: /ʔubuz/ → [ʔubuj] 'continue', cf. [bu.z-an] {passive}; /htuɡ/ → [hətuw] 'come out', cf. [hət.ɡ-an] {passive} (Huang 2004). These patterns provide evidence for a constraint that militates against obstruents in Coda position, e.g. *CODAOBSTRUENT. For further discussion and analysis of this and related cases, see de Lacy (2006).

A second and far more common motivation is the 'assimilation' in which a segment increases in sonority between two highly sonorous segments such as vowels, approximants, or sonorants (e.g. /aba/ → [aβa], /ata/ → [aɾa]).

However, the constraints that motivate these two kinds of lenition do not require reference to foot structure in any language. We are not aware of a case like Squliq Atayal's except that only stressed Codas must become more sonorous. For the assimilation type of lenition, we are not aware of any cases that are demonstrably motivated by constraints which refer to foot structure or prosodic heads. Instead, we will argue that lenition is influenced by foot form indirectly, through blocking by positional faithfulness constraints: the constraints ONSIDENT[Feature] may block lenition in Onsets, and σ́-IDENT [Feature] may block it in stressed syllables.

The claim that lenition is not motivated by constraints on feet disagrees with the majority of the lenition literature. In particular, English flapping is often argued to require rules or constraints that refer to prosodic heads and/ or foot boundaries. Consequently, we examine data from two registers of New Zealand English (NZE) below, and show how the positional faithfulness constraints may create an apparent foot-sensitivity in lenition. We acknowledge the vast amount of literature on flapping in dialects of English (e.g. Kahn 1976, Kiparsky 1981, Nespor & Vogel 1986, Hammond 1996); we regret that space limitations prevent us from doing justice to the many dialect variations and theories proposed, so a single dialect and theoretical proposal is our focus here.[6]

The NZE Basilect (NZE-B) is the register used in casual social situations (at least by younger speakers). /t/ and /d/ lenite to [ɾ] between vowels except in the Onsets of stressed syllables (before nasal Nuclei they become [ʔ] – [bæʔn̩] 'batten', and there are no liquid Codas or Nuclei – [ɫ] in other English dialects corresponds to NZE [ʊw]).

6 The New Zealand English data was elicited from two native speakers: Catherine Kitto and one of the authors (de Lacy).

(16) NZE Basilect flapping

a. flapping intervocalically and in unstressed syllables

[hǽɾə]	'hatter'	[báːɾə]	'barter'
[báɪɾəŋ]	'biting'	[hɔ́spəɾʊw]	'hospital'
[ɾəpɛ́ɾəɾəv]	'repetitive'	[ɡrəmæ̀ɾəkǽləɾi]	'grammaticality'

b. no flapping before or after a consonant

[wíntə]	'winter'	[sístə]	'sister'
[ʔǽktə]	'actor'	[tʃʌ́tni]	'chutney'
[ʔǽtləs]	'atlas'	[tʰɛ́ntəɾəv]	'tentative'

c. no flapping intervocalically in a stressed syllable Onset

[ʔətʰǽk]	'attack'	[ʔətʰɛ̀njuwéɪʃn̩]	'attenuation'

Flapping in NZE-B is 'assimilative' lenition: the constraints that motivate it ban low sonority elements intervocalically (called FLAPPING for short). FLAPPING does not mention heads; it does not have the form *V́tV, for example. What prevents it from applying everywhere is positional faithfulness: after Beckman (1998), its effects are blocked by σ́-IDENT[manner], a constraint that preserves manner of articulation in foot heads.

(17)

		/ɹətɔːt-əd/	σ́-IDENT [manner]	FLAPPING	IDENT [manner]
☞	a.	ɹə.tɔ́ː.ɾ-əd		*	*
	b.	ɹə.tɔ́ː.t-əd		* *!	
	c.	ɹə.ɾɔ́ː.ɾ-əd	*!		* *

Only /t/ and /d/ undergo lenition because only they have a corresponding high sonority stop, i.e. [ɾ]. There are no corresponding high sonority stops equivalents of /p b k ɡ/ that are adequately faithful, so they remain unchanged, i.e. blocked by faithfulness to place, continuancy, and nasality.

Flapping does not apply before or after a consonant or word-finally because FLAPPING only applies intervocalically.

The NZE Acrolect (NZE-A) is the register used in formal situations. The flapping situation differs from NZE-B significantly. /t/ and /d/ lenite to [ɾ] only when they follow a short stressed vowel and precede another vowel.

(18) NZE Acrolect flapping

a. Flapping after a short stressed vowel and before a vowel

[hǽɾə]	'hatter'	[kǽɾi]	'catty'
[ɹəgǽɾə]	'regatta'	[tʰæ̀ɾəməgútʃi]	'Tatamagouchee'

b. No flapping after a stressed long vowel or stressed diphthong

[báːtə]	'barter'	[míːtə]	'metre'
[kəmpjúːtə]	'computer'	[ɹáɪtə]	'writer'
[páʊtə]	'pouter'		

c. No flapping after unstressed vowels

[hɔ́spətəl]	'hospital'	[tʰɛ́ɹətən]	'Terreton'

We propose that NZE-A is assimilative lenition, just like NZE-B. The difference between the two registers is twofold. In NZE-A, lenition is blocked in *Onsets* by ONSIDENT[manner]. Lenition therefore happens everywhere else, i.e. to intervocalic Codas. How do intervocalic Codas arise? After Kahn (1976), Hammond (1996) and others, we propose that in NZE-A post-stress consonants are incorporated into the Coda of the preceding syllable if they are in the same foot. So, 'hatter' is [(hǽɾ.ə)], not *[(hǽ.tə)]. Such Coda-incorporation does not occur in [(míː).tə] 'metre' because the heavy syllable forms its own foot, excluding the following [t].

Harris (2003) identifies support for this view in word clusters like [(gɛ́ɾ).(ɔ́n)] 'get on'. NZE requires word-to-syllable alignment, preventing resyllabification like *[gɛ.(tɔ́n)]. The result is an intervocalic coda consonant, which flaps. This proposal has its roots in Kahn's (1976) ambisyllabicity proposal (also see Hammond 1996).

We propose that the motivation for post-stress Coda incorporation is a manifestation of a general pressure to reduce foot-internal material outside the head syllable ('foot non-head reduction'). This pressure has a variety of manifestations, including vowel shortening (i.e. /CVCVː/ → [CV́CV]), Coda deletion (/CVCVC/) → [CV́CV]), metathesis (/CVCV/ → [CVVC]), and so on; in NZE-A these other options are blocked by faithfulness, so it forces 'Coda attraction' instead: /CVCV/ → [(CV́C.V)] (also see proposals that are equally compatible with our central point here, e.g. Hammond 1996, Beckman 1998:ch.5).

The net effect is that post-stress lenition is motivated by a 'general' constraint – it applies to all intervocalic segments. However, Onset-faithfulness limits its scope to coda segments, and coda segments only arise in one of two ways: (a) word-syllable alignment, and (b) foot non-head reduction. There is no need for constraints that promote lenition to refer directly to foot structure: i.e. there is no constraint *V́tV. Instead, lenition in NZE-A occurs wherever it can, i.e. intervocalically outside Onsets.

NZE-A is not alone. Harris & Urua (2001) report that lenition in Ibibio targets intervocalic consonants only within a foot. Examples (with tones suppressed) include: [(dɨp)] 'hide' cf. [(dɨβe)] 'hide oneself', [(koot)] 'call' cf. [(kooɾo)] 'not calling'. Elsewhere, intervocalic stops do not lenite: foot-initially, e.g. [u(taŋ)] 'plaiting', [i(batta)] '(s)he is not counting', and at the beginning of an unfooted syllable, as in [(dappa)ke] 'not dream', not *[(dappa)ɣa]. The solution developed for NZE above extends unproblematically to Ibibio. In [(dɨβ.e)] the [β] may be taken to be syllabified into the Coda to maximize the segmental content of the head of the foot. In [(dappa)ke], on the other hand, the /k/ is outside the range of attraction into the foot head and so there will be no pressure to undergo sonorization.

7. Conclusions

As we stated at the outset, lenition and fortition are not phonologically unified. Even when attention is restricted to a single typical fortition process – consonant gemination – we discover that there are several motivations, and gemination is only one of many possible responses to each of those motivations. The same is true for lenition.

In terms of typical fortition and lenition processes, we argued that their relation to metrical structure, as mediated by constraints, is complex. In general terms, markedness constraints that motivate qualitative alternations in segments (whether fortition or lenition) do not ever seem to mention metrical structure. For example, there seems to be no need for constraints that specifically require lenition in foot-medial position but not elsewhere (cf. Harris & Urua 2001). When metrical structure does seem relevant, its influence is indirect, as the result of a combination of pressures on post-stress syllabification (as in NZE-A) or faithfulness to stressed syllables (as in NZE-B).

In contrast, there is considerable evidence that constraints that motivate *quantitative* fortition do directly mention prosodic structure. Consonant gemination can result from pressures for PrWd heads to be bimoraic, for the maximization of segmental content in the Codas of stressed syllables, and the avoidance of adjacent stressed moras. However, the same constraints may trigger other responses, including epenthesis and vowel lengthening. Thus, while constraints driving quantitative fortition do seem to require direct reference to metrical structure, those driving lenition do not.

The theoretical contribution of this chapter is that we have identified a range of constraints that can force foot-head augmentation: MAIN-TO-WEIGHT, Coda maximization, and syntagmatic constraints like *CLASH. Augmentation of stressed syllables through the insertion of a mora is only found in main-stressed syllables in trochaic languages, never secondary stressed syllables. The pressure to have light-heavy (LH) iambs is fundamentally different from comparable pressures favouring bimoraic stressed syllables in trochaic languages. Another major difference is that LH iambic pressure is only ever resolved by *vowel* lengthening, while MAIN-TO-WEIGHT can be met by a variety of different responses.

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