CHAPTER 3

AUGMENTATION OF PHONETICALLY STRONG POSITIONS

3.1 Introduction

This chapter presents a number of examples of positional augmentation in phonetically strong positions. As defined in Chapter 1 (following Beckman 1998), phonetically strong positions are those that characteristically contain salient cues to the perception of certain phonological contrasts; they are distinguished from psycholinguistically strong positions, which are examined in the following chapter. The phonetically strong positions for which augmentation effects are documented here are the positions stressed syllable (§3.2), long vowel (§3.3), and syllable onset or released consonant (§3.4).

The examples discussed in this chapter show that there are a variety of positional augmentation constraints that make reference to these three positions, including constraints calling for such properties as syllable weight, high-sonority nuclei, low-sonority onsets, high tone, and supralaryngeal place features. These properties have all been shown to enhance perceptual prominence (§2.3.2), so constraints that require the presence of these properties are all legitimate **M/str** constraints according to the Prominence Condition.

After the language examples have been presented in §§3.2-4, a summary of the **M/str** constraints discussed in this chapter is given in §3.5. As noted in §2.3.3 above, the typology of attested **M/str** constraints for phonetically strong positions matches the predicted typology of such constraints as restricted only by the Prominence Condition.[1]

3.2 Positional augmentation in stressed syllables

A special relationship between stress and perceptual prominence is frequently recognized. For one thing, the phonetic realization of stress often involves one or more prominent properties, including pitch, duration, and amplitude (Lehiste 1970). Other perceptually prominent properties that stressed syllables are sometimes altered in order to manifest include low-sonority onsets (de Lacy 2000, to appear) or onsets in general. Furthermore, there are languages with what are traditionally called "unbounded stress systems," in which stress is attracted to a syllable that is intrinsically associated with a prominent property such as high tone, syllable weight, or vowel sonority (for recent discussion see Kenstowicz 1994, Hayes 1995, Walker 1996, and de Lacy 1999); attraction of stress to syllables with onsets or with low-sonority onsets has also been documented (Strehlow 1942; Davis 1988; Everett & Everett 1984ab, Everett 1988).

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[1]The situation is different with psycholinguistically strong positions (considered in Chapter 4), because an additional filter, the Segmental Contrast Condition, is relevant for these positions.

The stressed syllable is a strong position, as evidenced by the resistance of stressed syllables to positional neutralization effects (Trubetzkoy 1939; Steriade 1993; Beckman 1998). The theory developed here thus predicts that there should be augmentation constraints — prominence-enhancing markedness constraints — relativized to this position. Moreover, stressed syllables, being syllables, are large enough to encompass consonants, vowels, and prosodic features such as tone. Therefore, augmentation constraints that require a particular prominent property to hold of consonants or vowels, or that manipulate tone, can potentially be relativized to stressed syllables. In accordance with this prediction, there are indeed a wide range of augmentation effects observed in stressed syllables. For example, they are required to be heavy (Mohawk, West Germanic, Aguacatec; §3.2.1.1), to bear high tone (Slave, Golin, Serbo-Croatian; §3.2.1.2), to have high-sonority nuclei (Slovene, Mokshan Mordwin; §3.2.1.3), to have onsets (Dutch, Western Arrernte; §3.2.2.1), or to have specifically low-sonority onsets (Niuafo'ou, Pirahã; §3.2.2.2).

The observed affinity of stressed syllables for prominent properties is thus accounted for by **M/**σ́ constraints, prominence-enhancing markedness constraints relativized to stressed syllables. Under this approach, it is no accident that the kinds of properties involved in stress attraction (as in unbounded stress systems) are also those involved in stressed-syllable alteration effects (when syllables, independently designated to bear stress either by lexical specification or through the interaction of metrical constraints, are also required to have particular prominent properties). The same inventory of **M/**σ́ constraints is responsible for both classes of phenomena.

This section is structured as follows. First, in §3.2.1, familiar cases of stress/prominence interaction involving syllable weight, high tone, and nuclear sonority are briefly reviewed, and the **M/**σ́ constraints responsible for such effects are introduced and exemplified. The relationship between stressed-syllable alteration and stress attraction phenomena is also discussed in this section (see especially §3.2.1.1). §3.2.2 then examines onset-related phenomena specific to stressed syllables. Interactions between stress and onsets or onset sonority levels are less common than the kinds of stress/prominence interactions discussed in §3.2.1, so the languages introduced in §3.2.2 are discussed in somewhat greater depth. Crucially, the addition of an onset and the reduction of onset sonority are also ways to enhance perceptual prominence (as argued in §2.3.2.3), so positional versions of markedness constraints calling for these properties are correctly predicted to exist. The results of the section are summarized in §3.2.3.

3.2.1 Familiar stress/prominence interactions through M/σ́ constraints

This section reviews a number of interactions between the strong position stressed syllable and several properties that are traditionally regarded as perceptually prominent: syllable weight (§3.2.1.1), high tone (§3.2.1.2), and high-sonority syllable nuclei (§3.2.1.3). The constraints responsible for these effects are all given formulations as **M/**σ́ constraints. The connection between stressed-syllable alteration and stress attraction effects is also examined.

3.2.1.1 Weight requirements for stressed syllables: HEAVYσ/σ́

One of the most familiar examples of a requirement that holds of the strong position stressed syllable is seen in the special relationship between stress and heavy syllables, frequently discussed in the context of metrical stress theory. In some languages, such as Mohawk (Michelson 1988) or West Germanic (Murray & Vennemann 1983), stressed syllables are required to be or become heavy, through vowel lengthening or consonant gemination. In other languages, with what are traditionally known as unbounded stress systems, including for example Aguacatec (McArthur & McArthur 1956; Walker 1996), stress is attracted to already existing heavy syllables.

Both of these patterns represent ways in which a language can satisfy a single positional augmentation constraint on stressed syllables, HEAVYσ/σ́.

(1) HEAVYσ/σ́ For all syllables *x*, if x is a σ́, then *x* dominates >1 mora

As discussed in Chapter 2, this constraint is a positional version, relativized to stressed syllables, of a constraint that requires syllables in general to be heavy. The formulation of HEAVYσ/σ́, as for any positional augmentation constraint, is compositional; it is predictable given the formulations of the **C**/*str* schema and the general constraint HEAVYσ.[2]

(2) **C**/*str* For all *y*, if *y* is a *str*, then **C** holds of *y*
where *y* is an element in the focus of the constraint **C** (Crowhurst & Hewitt 1997; see §2.2.2)

HEAVYσ For all syllables *x*, *x* dominates >1 mora

HEAVYσ/σ́ is high-ranking and active in both stressed-syllable alteration languages like Mohawk or West Germanic and stress-attraction languages like Aguacatec. The difference between the two kinds of languages stems from the relative ranking of two other types of constraints. If the constraints that determine the location of stress (which may, depending on the language, be alignment constraints, faithfulness constraints, or both) outrank the faithfulness constraints regulating syllable weight, then faithfulness is what is violated, so stressed-syllable alteration occurs. But if the weight-related faithfulness constraints outrank the stress-location constraints, then the location constraints are violated, and the actual location of the syllable that bears stress will be determined by the location of any pre-existing heavy syllables in the prosodic word.

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[2]See §2.3.2.1 on the status of HEAVYσ as an independently attested general (i.e., non-positional) constraint.

For example, consider the case of a language with an unbounded stress system that prefers to stress bimoraic syllables over monomoraic syllables when possible. One example of such a language is Aguacatec, given an OT analysis by Walker (1996) based on the original data and description in McArthur & McArthur (1956) and analyses by Hayes (1981, 1995).

In Aguacatec, when a word has only light syllables, stress falls on the rightmost syllable. (CV and CVC syllables are light; CVː syllables are heavy.)

(3) Rightmost stress in Aguacatec (McArthur & McArthur 1956:73-4)

wuqán	'my foot'
taʔál	'its juice'
ŋkʃk’aʔtʃán	'(someone) fed you'
ʔawéʃ	'your trousers'
bijól	'butcher'
ʔalk’óm	'thief'
paʔtbíl	'raincape'
tʃinhojlíh-ts	'they search for me'
ʔat’új	'your small earthen jug'

However, if there is a heavy syllable, it receives stress, even when it is not the rightmost syllable in the word.

(4) Heavy syllables preferentially stressed (McArthur & McArthur 1956:73-4)

(a)	ʔintáː	'my father'	(b)	ʔáːk’ah	'new'
	ʔatʂíːʔ	'your dog'		ʔáːts’um	'salt'
	ʔatʂúːtʃ	'your milk'		ŋqéːrats	'that isn't it'
				ʔéːq’um	'carrier'
				tʃíː’bah	'meat'
				míːtuʔ	'cat'

Previous OT treatments of unbounded stress systems, such as Kenstowicz (1994), Walker (1996), and Baković (1998), have demonstrated that the essential constraint interaction is one in which an alignment constraint requiring stress to fall at the left or right edge of the word is dominated by a constraint requiring stressed syllables to be heavy,[3] which under the constraint

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[3]In default-to-opposite-side unbounded stress systems (where the heavy syllable nearest one edge is stressed, but in the absence of heavy syllables a light syllable at the *other* edge is stressed), additional constraints are involved. Zoll (1996, 1997a) develops an account of default-to-opposite stress in which COINCIDE constraints are used to locate light stressed syllables (as marked structures) at specified edges. Gordon (2000) argues that the only true cases of default-

nomenclature conventions adopted here is the positional augmentation constraint HEAVYσ/σ́. As a result of this ranking, stress will fall on a heavy syllable when one is available, even if it is not the rightmost syllable in the word. (The effect of the alignment constraint, although it is dominated, is still seen when there are no heavy syllables in the word and stress is final, or when there is more than one heavy syllable in a word and the rightmost of them is chosen.[4] See Walker (1996) for detailed discussion.)

(5) HEAVYσ/σ́ For all syllables *x*, if *x* is a σ́, then *x* dominates >1 mora

ALIGN-R(σ́, PrWd) ∀ σ́ ∃ PrWd such that the Right edges of σ́ and PrWd are aligned (McCarthy & Prince 1993a)
('Stress is rightmost in the prosodic word')

(6) Heavy syllable chosen over rightmost syllable

/miːtuʔ/	HEAVYσ/σ́	ALIGN-R(σ́, PrWd)
a. miːtúʔ	*!	
☞ b. míːtuʔ		*

Another ranking relationship must also hold to produce a stress system like that in Aguacatec: FAITH(μ), the faithfulness constraint that prohibits lengthening of an underlying short vowel, must also dominate the alignment constraint. Otherwise, final stress could be achieved without violating HEAVYσ/σ́ simply by lengthening the final vowel of the word.

(7) Misalignment preferred over vowel lengthening in Aguacatec

/miːtuʔ/	HEAVYσ/σ́	FAITH(μ)	ALIGN-R(σ́, PrWd)
a. miːtúːʔ		*!	
☞ b. míːtuʔ			*

to-opposite systems are those of the "rightmost heavy, else leftmost" variety, and that intonational factors are responsible for the appearance of initial stress in words with only light syllables.

[4]McArthur & McArthur (1956) do not provide any actual examples of words with two long vowels, but their description of the stress-assignment pattern is explicit.

However, it is not logically necessary that FAITH(μ) dominate ALIGN-R(σ́, PrWd) in every language. The two constraints are completely independent, so the factorial typology of possible language systems includes a ranking in which these two constraints are reversed. Such a language would lengthen an underlyingly short final vowel in order to perfectly satisfy both the augmentation constraint HEAVYσ/σ́ and the stress-location constraint ALIGN-R(σ́, PrWd).

(8) Vowel lengthening preferred over misalignment (hypothetical language)

/miːtuʔ/	HEAVYσ/σ́	ALIGN-R(σ́, PrWd)	FAITH(μ)
☞ a. miːtúːʔ			*
b. míːtuʔ		*!	

Indeed, there are languages that require stressed syllables to be heavy. One example of such a language is Mohawk (Iroquoian; Michelson 1988), in which long vowels are not generally permitted, but stressed open syllables are realized as long.[5]

(9) Stressed-syllable lengthening in Mohawk (Michelson 1988:53)

/atirut/	k-atirút-haʔ	1A-*pull*-HAB	'I pull'
	ʌ-k-atirúː.t-ʌʔ	FUT-1A-*pull*-PUNC	'I'll pull'
/ohar/	k-ohár-haʔ	1A-*attach*-HAB	'I attach it'
	ʌ-k-oháː.r-ʌʔ	FUT-1A-*attach*-PUNC	'I'll attach it'
/awak/	yo-tewey-awák-ht-haʔ	NP-*fan-shake*-INST-HAB	'fan'
	wak-atewey-awáː.k-u	1P-*fan-shake*-STAT	'I'm fanning myself'
/hyatu/	ye-hyatú-hkhwaʔ	FA-*write*-INST.HAB	'pencil'
	k-hyáː.tu-s	1A-*write*-HAB	'I write'

[5]In Mohawk, regular penultimate stress assignment is disrupted by epenthesis; an epenthetic vowel in an open penult is ignored for stress assignment, giving rise to stress on the antepenult (or an even further leftward syllable if there are multiple epenthetic vowels). If the epenthetic vowel is the morphologically mandated "joiner vowel" [a], then the vowel in a stressed open antepenult will also be long, just as for regular penultimate stress. However, in the case of phonologically, rather than morphologically, determined epenthesis, the epenthetic vowel is realized as [e] and the vowel in a stressed open antepenult will, exceptionally, not be long. See Michelson (1988), especially chapters 5 and 6, for discussion.

Proto-Lake-Iroquoian, from which Mohawk has developed, had predictably long vowels in all stressed open syllables, whether penult or antepenult and whether epenthetic or underlying, except when the onset of the following syllable was a laryngeal consonant (Michelson 1988:52).

Another example of a system in which the satisfaction of HEAVYσ/σ́ affects not stress location, but syllable shape, can be found in the history of Germanic (Murray & Vennemann 1983:525-526). Reconstructed syllable structure for Proto-Germanic includes forms like CV́*x*.*y*V, where *x* and *y* are consonants and *x* has lower sonority than *y*, violating the common cross-linguistic tendency to avoid increasing sonority across a syllable boundary (Murray & Vennemann's "Syllable Contact Law"). Furthermore, in West Germanic this changed, not simply to resyllabified CV́.*xy*V, but to CV́*x*.*xy*V with gemination. To explain both the marked Proto-Germanic syllabification and also the development of gemination rather than simple resyllabification in West Germanic, Murray & Vennemann propose a "Stressed Syllable Law", which states, "The preferred stressed syllable (in Germanic) has exactly two morae."[6] Their Stressed Syllable Law corresponds to the positional augmentation constraint HEAVYσ/σ́.[7]

Thus, two familiar kinds of stress-related phenomena — stressed-syllable alteration, as in Mohawk and West Germanic, and stress attraction, as in Aguacatec — can be attributed to the same positional augmentation constraint, HEAVYσ/σ́. The difference between alteration and attraction languages comes from the relative ranking of the constraint or constraints that determine the location of stress (alignment constraints, faithfulness constraints, or both) with respect to the faithfulness constraints on syllable weight (such as a constraint against vowel lengthening, or a constraint against consonant gemination). As always, it is the lower-ranked constraint that is violated.

(10) Alteration versus stress attraction

(a) Alteration ranking: HEAVYσ/σ́, LOCATE(Stress) >> FAITH

(b) Attraction ranking: HEAVYσ/σ́, FAITH >> LOCATE(Stress)

The results obtained in this section can be extended to the analysis of other augmentation processes that affect stressed syllables. In general, given a high-ranking stressed-syllable augmentation constraint that demands prominent property *P*, languages in which the relevant faithfulness constraints are ranked low will alter stressed syllables so that they have *P*, whereas

[6]See also Lahiri & Dresher (1999) on Open Syllable Lengthening in descendants of West Germanic. They argue that Open Syllable Lengthening was specifically a lengthening of short vowels in stressed open syllables, analogous to the Mohawk case, and was not due to compensatory lengthening (contra, e.g., Minkova 1982).

[7]In this example, the faithfulness constraint that must be dominated by HEAVYσ/σ́ is not a constraint against vowel lengthening, but rather, a constraint against converting an underlying singleton consonant into a geminate. But the more general pattern is the same: a weight-related faithfulness constraint that would otherwise protect a phonological contrast between light and heavy syllables is ranked below both HEAVYσ/σ́ and a stress-location constraint, so it is syllable weight that is altered in response to HEAVYσ/σ́.

languages with low-ranking stress-location constraints will place stress on a syllable that already has *P*. Evidence that this is the right approach to take for stressed-syllable alteration and attraction phenomena in general comes from the fact that the same properties are involved in both patterns (11,12).

(11) Stressed-syllable alteration effects

(a) σ́ becomes heavy	▹ Mohawk, West Germanic
(b) σ́ acquires high tone	▹ Slave (§3.1.2)
(c) σ́ increases the sonority of its nucleus	▹ Slovene (§3.1.3)
(d) σ́ epenthesizes an onset	▹ Dutch (§3.2.1)
(e) σ́ rejects a high-sonority onset	▹ Niuafo'ou (§3.2.2)

(12) Stress attraction effects

(a) Attracted to heavy σ	▹ Aguacatec
(b) Attracted to σ with high tone	▹ Golin, Serbo-Croatian (§3.1.2)
(c) Attracted to σ with high-sonority nuclei	▹ Mokshan Mordwin (§3.1.3)
(d) Attracted to σ with onsets	▹ Arrernte (§3.2.1)
(e) Attracted to σ with low-sonority onsets	▹ Pirahã (§3.2.2)

Because stressed-syllable alteration and stress attraction are both responses to the same augmentation constraints, the fact that these two phenomena are sensitive to the same set of properties — syllable weight, high tone, sonority, and the presence of onsets — is given a principled account.

The additional stressed-syllable augmentation constraints whose effects are seen in the languages listed in (11) and (12) are given in (13) below; these constraints are addressed in the remainder of this section (§§3.2.1.2-3) and in §3.2.2. (The general counterparts of these **M/str** constraints have been introduced in §2.3.2.)

(13) Additional **M/**σ́ constraints

(a) HTONE/σ́ (§3.1.2) — For all syllables *x*, if *x* is a σ́, then a tone-bearing unit associated with *x* bears high tone

(b) [*PEAK/X]/σ́ (§3.1.3) — For every segment *a* that is the head of some syllable *x*, if *x* is a σ́, then |*a*| > X

where |*y*| is the sonority of segment *y*
X is a particular step on the segmental sonority scale

(c) ONSET/σ́ (§3.2.1) — For all syllables *x*, if *x* is a σ́, then $a \neq b$

where *a* is the leftmost segment dominated by *x*
b is the head of *x*

(d) [*ONSET/X]/σ́ (§3.2.2) — For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is a σ́, then $|a| < X$

where |*y*| is the sonority of segment *y*
X is a particular step on the segmental sonority scale

In summary, the commonly observed interactions between stress and syllable weight in which stressed syllables are required to become heavy or stress is attracted to heavy syllables can be accounted for with the constraint HEAVYσ/σ́. This constraint is one member of the set of **M**/σ́ constraints, markedness constraints that are relativized to the strong position stressed syllable. The fact that languages can satisfy HEAVYσ/σ́ in one of two ways, through stressed-syllable alteration or through stress attraction, is true of other **M**/σ́ constraints as well. In general, languages with stressed-syllable alteration change input material (violating some faithfulness constraint) to satisfy an **M**/σ́ constraint without affecting stress placement; languages with stress attraction force stress to fall on a syllable that already satisfies **M**/σ́, violating the stress-location constraints but maintaining faithfulness.

3.2.1.2 High tone in stressed syllables: HTONE/σ́

Another perceptually prominent property that is often seen to have a special relationship with stress is high (H) tone. For example, in the Hare dialect of Slave (Rice 1987), H tone is realized on stressed syllables, and in Golin (Bunn & Bunn 1970; Hayes 1995; Walker 1996; de Lacy 1999) and Serbo-Croatian (Zec 1999), stress is attracted to syllables with H tone. According to the treatment of strong-position-specific phonological requirements being developed here, these phenomena occur when the positional augmentation constraint HTONE/σ́ is ranked high, so that stressed syllables are required to be associated with H tone.

(14) HTONE/σ́ — For all syllables *x*, if *x* is a σ́, then a tone-bearing unit associated with *x* bears high tone

Again, just as for HEAVYσ/σ́, the difference between the stressed-syllable alteration pattern found in Slave and the stress attraction pattern found in Golin or Serbo-Croatian emerges from the different ranking of tonal faithfulness constraints and stress-location constraints in these languages.

The Hare dialect of Slave (Athapaskan; Rice 1987) has an underlying contrast between morphemes that have an associated H tone and those that do not. But, in verbs, the surface location of the H tone (if any) is entirely determined by the location of the stressed syllable in the morphologically complex form.

The following forms, composed of a person/number prefix with no lexical H tone and a verb root, show that there is a contrast between verb roots with and without H tone. Nevertheless, the H tone surfaces on the prefix rather than on the root itself. (Vowels associated with H tone are underlined.)

(15) Tonal contrasts in Hare verbs (Rice 1987:240)

(a)	wɛh-dzo	/dzo/	's/he trapped'
	wɛ̲h-k'e	/k'e̲/	's/he shot'
(b)	nɛ-dõ	/dõ/	'you (sg.) drink'
	nɛ̲-ʔa	/ʔa̲/	'you (sg.) eat'
(c)	hɛh-ɟi	/ɟi/	'I sing'
	hɛ̲h-lu	/lu̲/	'I net'

Verb roots are always monosyllabic; one or more prefixes may precede the root; at most one suffix syllable may follow the root; and the location where the H tone is realized is always the syllable immediately preceding the root.

According to Rice (1987), the syllable preceding the root is the location of stress. Rice justifies this claim on the basis of processes of vowel deletion and tenseness harmony that are sensitive to metrical structure (as well as on impressionistic evidence that the pre-root syllable has greater amplitude and/or duration than the root syllable even when no H tone is present). Therefore, the placement of H tone in Slave verbs is an example of a stressed-syllable alteration effect. As usual for an alteration pattern, both the stressed-syllable augmentation constraint HTONE/σ́ and the constraint(s) determining the location of stress, encapsulated here as LOCATE(Stress),[8] must outrank the faithfulness constraint(s) against tone shift, represented here as NOSHIFT (16). To account for the fact that no H tone is epenthesized to satisfy HTONE/σ́ when the input lacks a H tone, the ranking DEP-TONE >> HTONE/σ́ is also necessary (17).

(16) Stressed syllable is altered by attracting H tone

/wɛh + k'e̲/	DEP-TONE	HTONE/σ́	LOCATE(Stress)	NOSHIFT
a. wɛ́hk'e̲		*!		
☞ b. wɛ̲́hk'e				*
c. wɛhk'é̲			*!	

[8]Rice (1987) accounts for stress location with a trochaic foot that is right-aligned with the verb root (since the addition of a suffix vowel does not affect the placement of stress).

(17) No H-tone epenthesis
(HTONE/σ́ violations tolerated when the input has no H tone)

/wɛh + dzo/	DEP-TONE	HTONE/σ́	LOCATE(Stress)	NOSHIFT
☞ a. wɛ́hdzo		*		
b. wɛ́hdzo	*!			*

Thus, whenever there is a H tone present in the input, as in (16), violation of low-ranking NOSHIFT allows for the satisfaction of both the LOCATE(Stress) constraints and HTONE/σ́. That is, stressed syllables are altered so that they bear H tone.

Other languages in which stressed syllables are altered to bear H tone, providing further motivation for the positional augmentation constraint HTONE/σ́, include Safwa (Zoll 1997b) and Sukuma (Kang 1997).[9]

The other expected pattern — the attraction of stress to syllables intrinsically associated with H tone — is found, for example, in Golin (Chimbu; New Guinea). This language has been analyzed by Hayes (1995), Walker (1996), and de Lacy (1999), based on the description by Bunn & Bunn (1970). Stress in Golin appears on the rightmost syllable with H tone, and on the final syllable in words with only L tones. (Again, vowels with high tone are underlined.)

(18) Stress in Golin (Bunn & Bunn 1970:5)

(a) Rightmost H-tone syllable

owaré	'bat'
ogalá	'woven hat'
enderín	'fire'
onibá	'snake'
sibági	'type of sweet potato'

[9]As noted in §2.3.2.5, a complete account of the interaction between tone and strong positions would probably also include a constraint LTONE/σ́. Sukuma is, according to Kang's (1997) analysis but in terms of the constraints developed here, an example of a language where HTONE/σ́ outranks LTONE/σ́ (this is presumably a universally fixed ranking, given the greater intrinsic prominence of H over L tones; see de Lacy 1999), but LTONE/σ́ is also active, with the result that a metrical head is supplemented with a L tone when a H tone is not available. Arguments for the affinity of stressed syllables for all tones, not just H, are also presented in Yip (2000).

gomági 'type of sweet potato'
ákola 'wild fig tree'

(b) Final syllable (no H)

kawligí 'post'

These facts indicate that the positional augmentation constraint HTone/σ́ dominates the stress-placement constraint Align-R(σ́, PrWd). As a result of this ranking, stress appears as far to the right as possible (19), but it must appear on a H-tone syllable when there is one (20).

(19) Rightmost stress preferred when possible

/oware/	HTone/σ́	Align-R(σ́, PrWd)
☞ a. owaré		
b. owáre		*!
c. óware		*!*

(20) Attraction of stress to H tone takes priority over right-edge alignment

/sibagi/	HTone/σ́	Align-R(σ́, PrWd)
a. sibagí	*!	
☞ b. sibági		*
c. síbagi		**!

Another example of stress attraction to syllables with H tone is found in the Neo-Štokavian dialects of Serbo-Croatian (Zec 1999). Here, the placement of H tone in a form is largely determined by morphological factors (see Zec 1999 for discussion), but it is in turn the location of the H that determines the surface location of stress. To account for the attraction of stress to H tones, Zec (1999) proposes a constraint called SFootSalience, formulated as in (21).

(21) SFootSalience Head$_{PrWd}$ has to be associated with a High tone (Zec 1999:251)

This constraint is clearly analogous to HTone/σ́.

Thus, the interaction between stress and H tone in the languages discussed above can be accounted for with the positional augmentation constraint HTONE/σ́. Moreover, both of the two possible ways of satisfying this constraint are attested. In Hare, stressed-syllable alteration effects are observed. The location of stress is fixed by high-ranking metrical constraints and never varies; instead, if there is a H tone present in the representation, it becomes affiliated with the stressed syllable so that the stressed syllable will bear H tone. On the other hand, Golin and Serbo-Croatian show the typical stress-attraction pattern. In these languages, the location of a H tone is determined by factors other than stress (faithfulness to lexical specification in Golin and constraints on morphological structure in Serbo-Croatian), and the location of stress is determined by the location of H tone.

3.2.1.3 High-sonority nuclei in stressed syllables: [*PEAK/X]/σ́

The constraint subhierarchy that demands high-sonority syllable nuclei, [*PEAK/X], is also predicted to have a version specific to stressed syllables, since higher sonority nuclei are more perceptually prominent. And as predicted, the relativized constraint subhierarchy [*PEAK/X]/σ́ is attested. Once again, languages in which members of the [*PEAK/X]/σ́ subhierarchy are active come in the predicted two varieties: stressed-syllable alteration languages such as Zabiče Slovene, in which the nuclei of stressed syllables become higher in sonority, and stress-attraction languages like Mokshan Mordwin, in which stress placement is determined by the sonority of syllable nuclei.

Crosswhite (1999b), in a study of stress-related vowel-neutralization effects, reports a large number of languages that follow the familiar positional neutralization pattern: vowel qualities that are contrastive in stressed syllables undergo neutralization in unstressed syllables. However, there is one language reported in the study, the Zabiče dialect of Slovene, that has vowel qualities that are contrastive in unstressed syllables but are neutralized in *stressed* syllables. Crucially, as predicted by the theory of **M/str** constraints developed here, the vowels that are banned from stressed syllables are those of low sonority (low perceptual prominence); they are replaced in stressed syllables with vowels of higher sonority.

Crosswhite, citing Rigler (1963), lists the following inventories of possible monomoraic nuclei in stressed and unstressed syllables in Zabiče Slovene. As indicated, the high vowels [i ɨ u] are banned from stressed syllables.[10]

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[10]A few additional facts about the vowel system of Zabiče Slovene are as follows. First, *long* high vowels [iː ɨː uː] are permitted even when stressed. Also, there is a long vowel [ɛː] that does not have a short counterpart. These two facts can both be accounted for with high-ranking positional faithfulness constraints on vowel features relativized to the strong position long vowel. These positional faithfulness constraints must outrank the stressed-syllable augmentation constraint [*PEAK/HIGHV]/σ́ (see below) and the featural markedness constraint against the highly marked vowel quality [ɛ], so that short versions of [ɛ] and of high stressed vowels are prohibited, but long versions of these vowels are protected.

(22) Possible monomoraic nuclei in Zabiče Slovene (Crosswhite 1999b:43)

(a) Unstressed syllable

i	ɨ	u
e	ə	o
	a	

(b) Stressed syllable

e	ə	o
	a	

Crosswhite (1999b) accounts for the ban on stressed high vowels with a constraint subhierarchy called *STRESSED/X, which is defined as a version of the *PEAK/X subhierarchy making explicit reference to the peak of a stressed syllable. Crosswhite's proposed hierarchy is thus nearly equivalent to what would under the constraint naming conventions adopted here be called [*PEAK/X]/σ́.[11]

(23) [*PEAK/X]/σ́ For every segment *a* that is the head of some syllable *x*, if *x* is a σ́, then |*a*| > X

where |*y*| is the sonority of segment *y*
X is a particular step on the segmental sonority scale

[*PK/T]/σ́ >> ... >> [*PK/HIGHV]/σ́ >> [*PK/MIDV]/σ́ >> [*PK/LOWV]/σ́

Crosswhite (1999b) does not present any actual examples from Zabiče Slovene in her discussion, but she gives the following description of her source, Rigler (1963).

> Although Rigler does not provide dialectal forms illustrating the relevant neutralizations, he indicates that in this dialect etymological short accented high vowels are realized as mid vowels: /í,ɨ́,/ > [é], /ú/ > [ó]. (Crosswhite 1999b:44)

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[11]There are two differences between Crosswhite's (1999b) *STRESSED/X subhierarchy and the [*PEAK/X]/σ́ subhierarchy as adopted here (see §2.3.2.2 for detailed discussion of *PEAK/X). First, Crosswhite (1999b) follows Kenstowicz (1994) in postulating that *PEAK(*STRESSED)/[ə] is the highest-ranking member of the *PEAK(*STRESSED)/X subhierarchy. As discussed in §2.3.2.2, it is argued here that schwa patterns with other mid vowels in terms of its sonority, and the avoidance of stressed schwa that is observed in many languages stems from factors other than sonority. Second, in order to allow stressed high vowels to surface when long, Crosswhite (1999b) stipulates that the *STRESSED/X subhierarchy refers explicitly to monomoraic vowels. Here, it is proposed that the [*PEAK/X]/σ́ subhierarchy is not sensitive to mora count, but only to vowel quality; the appearance of long stressed high vowels in Zabiče Slovene can be independently accounted for by means of a positional faithfulness constraint that protects the feature [+high] in the strong position long vowel.

The analysis here follows Crosswhite in assuming, based on the diachronic pattern that Rigler reports, that synchronically too, underlying short high vowels are realized as mid vowels when they are stressed. This means that [*PEAK/HIGHV]/σ́, which forbids high vowels in stressed syllables, dominates the faithfulness constraint that would otherwise prevent high vowels from being realized as mid, IDENT[high]. Also undominated, given that this is an alteration language, are the constraints that determine stress placement, once again encapsulated as LOCATE(Stress).

(24) [*PEAK/HIGHV]/σ́ For every segment *a* that is the head of some syllable *x*, if *x* is a σ́, then |*a*| > HIGHV

where |*y*| is the sonority of segment *y*

IDENT[high] Output segments agree with their input correspondents in their specification for the feature [high] (McCarthy & Prince 1995)

The interaction among these constraints is shown in (25).

(25) Lowering of high vowels in stressed syllables (hypothetical input)

/túka/	LOCATE(Stress)	[*PEAK/HIV]/σ́	IDENT[high]
a. túka		*!	
b. tuká	*!		
☞ c. tóka			*

Because it is not the case that all vowels become as high in sonority as possible when they appear in stressed syllables, we know that the next lower member of the [*PEAK/X]/σ́ hierarchy, [*PEAK/MIDV]/σ́, is dominated by IDENT[low], the faithfulness constraint that forbids changes in the specification of the feature [low] (on the assumption that mid vowels are [-high, -low]). Otherwise, underlying high and mid vowels would be realized as low vowels, rather than mid vowels, in stressed syllables. ([*PEAK/HIGHV]/σ́ and IDENT[low] do not conflict, so their ranking relationship cannot be directly established; the same is true of IDENT[high] and IDENT[low].)

(26) [*PEAK/MIDV]/σ́ For every segment *a* that is the head of some syllable *x*, if x is a σ́, then |*a*| > MIDV

where |*y*| is the sonority of segment *y*

IDENT[low] Output segments agree with their input correspondents in their specification for the feature [low] (McCarthy & Prince 1995)

(27) Stressed vowels do not all become low (hypothetical input)

/túka/	[*PK/HIV]/σ́	IDENT[high]	IDENT[low]	[*PK/MIDV]/σ́
a. túka	*!			
☞ b. tóka		*		*
c. táka		*	*!	

Members of the [*PEAK/X]/σ́ subhierarchy are thus responsible for stressed-syllable alteration effects in languages like Slovene, where low sonority nuclei become higher in sonority under stress. As with the other **M**/σ́ constraints, members of the [*PEAK/X]/σ́ hierarchy can also be responsible for stress-attraction effects, as seen in languages where stress is attracted to vowels that are already high in sonority. Such languages have been discussed by, among others, Hayes (1995) and Kenstowicz (1994). One example is the Mokshan dialect of Mordwin (Finno-Ugric; Kenstowicz 1994, citing data from Tsygankin & Debaev 1975), in which stress is never assigned to high vowels if there are non-high vowels in a word.[12]

In Mokshan Mordwin, stress falls on the leftmost possible vowel but avoids high vowels. This pattern indicates that the left-alignment constraint for stress, ALIGN-L(σ́, PrWd), must be dominated by [*PEAK/HIGHV]/σ́ (28). However, the fact that mid and low vowels are treated equivalently shows that ALIGN-L(σ́, PrWd) dominates both [*PEAK/MIDV]/σ́ and [*PEAK/LOWV]/σ́; that is, placing stress as close to the left edge as possible is preferable even to choosing a low vowel over a mid vowel (29).

(28) High vowels are avoided for stress: /putat/ 'you set down'

/putat/	[*PK/HIV]/σ́	ALIGN-L	[*PK/MIDV]/σ́	[*PK/LOV]/σ́
a. pútat	*!			
b. putát		*		*

[12]Stress also avoids schwa in Mokshan Mordwin. As discussed in §2.3.2.2, this fact is best accounted for with a separate constraint, orthogonal to the *PEAK/X subhierarchy.

(29) Leftmost stress preferred, given a non-high vowel: /noldasak/ 'you release it'

/noldasak/	[*PK/HIV]/σ́	ALIGN-L	[*PK/MIDV]/σ́	[*PK/LOV]/σ́
☞ a. nóldasak			*	
b. noldásak		*!		*
c. noldasák		**!		*

In both Zabiče Slovene and Mokshan Mordwin, the line between good and bad stressed-syllable peaks is drawn between mid and high vowels; that is, high vowels and everything lower in sonority are avoided as peaks in stressed syllables, while mid vowels and everything higher in sonority are selected. This division is the result of some other constraint (IDENT[low] in Slovene and ALIGN-L in Mordwin) dominating [*PK/MIDV]/σ́ and rendering it inactive. However, there is nothing intrinsically important about the division between high and mid vowels, and in fact, there are stress systems in which other divisions of the sonority hierarchy are observed.

For example, English allows syllabic sonorants, [r̩ l̩ m̩ n̩ ŋ̩], as nuclei in unstressed syllables. However, the options for stressed syllables are more limited: syllabic nasals are banned, and some dialects ban [l̩] as well, allowing only [r̩].

(30) Syllabic sonorants in English

	(a) Unstressed syllables		(b) Stressed syllables		
[r̩]	*maker*	[méj.kr̩]	*cur*	[kŕ̩]	
[l̩]	*able*	[éj.bl̩]	*bull*	[bʊ́l]	*[bl̩]
[m̩]	*complain*	[km̩.pléjn]	*come*	[kʌ́m]	*[km̩]
[n̩]	*mason*	[méj.sn̩]	*sun*	[sʌ́n]	*[sn̩]
[ŋ̩]	*congratulate*	[kŋ̩.grǽʤəlèjt]	*hung*	[hʌ́ŋ]	*[hŋ̩]

That is, English makes a sonority division for stressed-syllable nuclei, not between high and mid vowels as in the previous examples, but between laterals and rhotics.[13] This time, the constraint that crucially intervenes at some point along the [*PEAK/X]/σ́ subhierarchy (perhaps DEP-SEG, which would prevent the insertion of an epenthetic vowel to serve as the syllable nucleus) is ranked higher than in Slovene and Mordwin — dominating [*PEAK/RHO]/σ́ and all the lower-ranked [*PEAK/X]/σ́ constraints, rather than dominating only the last two [*PEAK/X]/σ́ constraints, [*PEAK/MIDV]/σ́ and [*PEAK/LOWV]/σ́.

[13] This pattern is additional support for the sonority distinction between rhotics and laterals (see also §2.3.2.2 and §4.2.1.2).

(31) Sonority division between rhotics and laterals for stressed-syllable nuclei

(a) Stressed [r̩] is permitted

/kr/ *cur*	[*Pk/Nas]/σ́	[*Pk/Lat]/σ́	Dep-Seg	[*Pk/Rho]/σ́
☞ a. ˈkr̩				*
b. ˈk*V*r			*!	

(b) Stressed [l̩] not permitted (*hypothetical input*)

/bl/	[*Pk/Nas]/σ́	[*Pk/Lat]/σ́	Dep-Seg	[*Pk/Rho]/σ́
a. ˈbl̩		*!		
☞ b. ˈb*V*l			*	

It should be noted that example (31b) is not intended to assert that the stressed vowel in the English word *bull* is epenthetic. No words with stressed nuclear [l] are possible in English, so even though no actual lexical entries probably contain such a structure, the grammar of English must ensure that *if* such an input were encountered, some unfaithful candidate that has eliminated the stressed nuclear [l] would be selected; this outcome is what (31b) demonstrates. See the discussion of richness of the base in §1.3.2, especially footnote 12.

Thus, as predicted given the Prominence Condition and the relationship of nuclear sonority to perceptual prominence, there is a positional version of the [*Peak/X] constraint subhierarchy for stressed syllables: [*Peak/X]/σ́.

3.2.1.4 Summary

The Schema/Filter Model of Con holds that any formally possible constraint is an actually occurring constraint as long as there are no substantively based constraint filters to rule it out. **M/str** constraints formed by relativizing markedness constraints to the phonetically strong position stressed syllable are subject only to one filter, the Prominence Condition. This filter passes **M/str** constraints if they are formed from markedness constraints that require the presence of perceptually prominent properties. Therefore, this system predicts that **M/σ́** constraints requiring syllable weight, high tone, and high-sonority syllable nuclei should exist, since these are widely recognized examples of perceptually prominent properties.

In accordance with this prediction, the **M/σ́** constraints Heavyσ/σ́, HTone/σ́, and the [*Peak/X]/σ́ subhierarchy are in fact attested. This section has reviewed familiar examples of interaction between stress and the perceptually prominent properties syllable weight, high tone, and high-sonority syllable nuclei, showing that these interactions are accounted for with the positional augmentation constraints given above. Furthermore, depending on the ranking of other constraints in the system, satisfaction of these **M/σ́** constraints can result in either stressed-syllable alteration or stress attraction effects. The fact that exactly the same properties are involved in alteration and attraction supports an approach, like this one, in which the same constraints are responsible for both classes of phenomena.

3.2.2 Stress/onset interactions through M/σ́ constraints

As argued in §2.3.2.3, syllables with onsets are more perceptually prominent than syllables without onsets, and the lower in sonority the onset, the more perceptually prominent the syllable. Markedness constraints requiring onsets and those requiring low-sonority onsets thus qualify as augmentation constraints and are predicted to have **M/str** counterparts.

The languages discussed in this section show that ONSET and the members of the *ONSET/X constraint subhierarchy do, as predicted, have positional counterparts relativized to the strong position stressed syllable. As was the case for the **M/σ́** constraints considered in the preceding section, these onset-related **M/σ́** constraints give rise to both stressed-syllable alteration and stress attraction phenomena. The effects of ONSET/σ́, which requires stressed syllables to have onsets, are seen in Dutch (§3.2.2.1), where stressed syllables acquire epenthetic glottal-stop onsets, and in Western Arrernte (§3.2.2.2), where stress is attracted to syllables with onsets. Likewise, the effects of the [*ONSET/X]/σ́ subhierarchy, which enforces low sonority in onset consonants, are seen in Niuafo'ou (§3.2.2.3), where glide onsets are banned from appearing in stressed syllables, and in Pirahã (§3.2.2.4), where stress is attracted to syllables with voiceless obstruent onsets.

3.2.2.1 ONSET/σ́ in Dutch: Glottal-stop epenthesis in stressed syllables

In Dutch, as described by Booij (1995), onsetless syllables are avoided whenever possible. This fact can be attributed to a relatively high rank for the general markedness constraint ONSET. Nevertheless, unstressed syllables manage to surface without onsets if the only way for them to have an onset would be to epenthesize one, indicating that DEP-SEG dominates ONSET. Crucially, however, stressed syllables must always have an onset, even if this forces epenthesis. ONSET/σ́, a stressed-syllable augmentation constraint requiring onsets specifically in stressed syllables, must therefore dominate DEP-SEG.

Given an underlying /V_1-V_2/ sequence where V_1 is nonlow, hiatus in Dutch is always resolved by glide formation (32). The glide that appears agrees with V_1 in rounding and backness, indicating that the glide is created from V_1 (Rosenthall 1994). Glide formation occurs regardless of the surface stress pattern of the word.

(32) Glide formation after nonlow V_1 (Booij 1995, (23))

(a) [ɥ] after rounded front vowels

januari	[janyɥ̱ári]	'January'
ruine	[ryɥ̱ínə]	'ruin'
duo	[dýɥ̱o]	'duo'
uien	[œ́yɥ̱ən]	'onions'
reuen	[rǿ̸ɥ̱ən]	'male dogs'
Eduard	[édyɥ̱ɑrt]	'Edward'

(b) [j] after unrounded front vowels

dieet	[dij̱ét]	'diet'
bioscoop	[bij̱ɔskóp]	'cinema'
Indriaas	[ɪndríj̱as]	'Andrew'
Gea	[ɣéj̱a]	'id. (fem. name)'
zeeen	[zéj̱ən]	'seas'
vijand	[vɛ́ij̱ɑnt]	'enemy'

(c) [ʋ] after nonlow back (=round) vowels

Ruanda	[ruʋ̱ɑ́nda]	'Rwanda'
houen	[hɔ́uʋ̱ən]	'to hold'

The appearance of an onset glide homorganic to V_1 in the forms in (32) indicates that the input vowel has two output correspondents — the vowel and the glide. Such output forms violate INTEGRITY (McCarthy & Prince 1995), the faithfulness constraint against multiple output correspondents, but in doing so they satisfy ONSET while also avoiding the DEP-SEG violation that would be incurred by a truly epenthetic onset (a segment with no input correspondent).

(33) ONSET — For all syllables x, $a \neq b$
where a is the leftmost segment dominated by x
b is the head of x

DEP-SEG — Output segments have input correspondents (McCarthy & Prince 1995)

INTEGRITY — Input segments do not have multiple output correspondents (McCarthy & Prince 1995)

The interaction among these three constraints for a word like those in (32) is shown in (34). Numerical subscripts indicate correspondence relations between input and output segments; for readability, only the crucial correspondence relations are shown in the output forms. Epenthetic segments (with no input correspondents) are in boldface.

(34) Glide formation to provide onsets

/d$_1$i$_2$e$_3$t$_4$/	DEP-SEG	ONSET	INTEGRITY
a. di$_2$.et		*!	
b. di$_2$.ʔ$_5$et	*!		
☞ c. di$_2$.j$_2$et			*

The facts discussed so far are true of any instance of hiatus in which V$_1$ is a nonlow vowel, independent of stress. Stress becomes relevant when V$_1$ is the low vowel [a]. In an [a]-V$_2$ sequence, no glide is formed (low vowels are often dispreferred as glides; see, e.g., McCarthy & Prince 1993b, Rosenthall 1994). If the potentially onsetless syllable (the one containing V$_2$) is not stressed, then it simply surfaces without any onset (35).

(35) [a]-V$_2$ hiatus, where V$_2$ is not stressed (Booij 1995, (22))

chaos	[xá.ɔ̲s]	'chaos'
farao	[fá.ra.o̲]	'pharaoh'

The above examples show that the constraint that disfavors low glides, here informally called *LOWGLIDE, must dominate ONSET. That is, pressure to satisfy ONSET generally causes glide formation but cannot cause the formation of a glide corresponding to [a] (represented as [a̯]). Another way to avoid an onsetless syllable would be to epenthesize an onset consonant, but the data in (35) above show that this does not occur. Since no consonant is epenthesized to allow satisfaction of ONSET, then DEP-SEG must also dominate ONSET. The combined ranking for the Dutch examples seen so far is therefore { *LOWGLIDE, DEP-SEG } >> ONSET >> INTEGRITY, exemplified in (36).

(36) No glide formation after [a]

/f$_1$á$_2$r$_3$a$_4$o$_5$/	*LOWGLIDE	DEP-SEG	ONSET	INTEGRITY
☞ a. fá.ra$_4$.o			*	
b. fá.ra$_4$.ʔ$_6$o		*!		
c. fá.ra$_4$.a̯$_4$o	*!			*

To summarize the important constraint interactions in (36), onsetless syllables are tolerated following [a] despite the fact that INTEGRITY is ranked lower than ONSET because an INTEGRITY violation in this case would also entail a violation of the higher-ranked *LOWGLIDE (36c).[14]

The outcome of [a]-V_2 hiatus is different, however, when the would-be onsetless syllable is stressed. In this case only, epenthesis of an onset consonant, [ʔ], does occur (37).

(37) [a]-V_2 hiatus, where V_2 is stressed (Booij 1995, (22))

paella	[paʔέlja]	'paella'
aorta	[aʔɔ́rta]	'aorta'
Kaunda	[kaʔúnda]	'Kaunda'

These examples show that some constraint compelling stressed syllables to have onsets outranks DEP-SEG, even though DEP-SEG outranks ordinary ONSET.

The high-ranking constraint in question is ONSET/σ́ (38), a positional version of the augmentation constraint ONSET that is specific to stressed syllables.

(38) ONSET/σ́ For all syllables *x*, if *x* is a σ́, then $a \neq b$
where *a* is the leftmost segment dominated by *x*
b is the head of *x*

As noted above, this constraint must dominate DEP-SEG. (The constraint *LOWGLIDE must also dominate DEP-SEG, because epenthesis is chosen instead of [a]-glide formation to provide onsets in (37).)

(39) Onset epenthesis in stressed syllables, after [a]

/$p_1a_2έ_3l_4j_5a_6$/	*ONSET/σ́	*LOWGLIDE	DEP-SEG	ONSET	INTEGRITY
a. $pa_2.έlja$	*!			*	
☞ b. $pa_2.ʔ_7έlja$			*		
c. $pa_2.ă_2έlja$		*!			*

[14]Two other constraints must also be ranked above ONSET. One is IDENT[low], which rules out a candidate such as *[fa.r$á_2$.j_2o] in which the input /a_2/ corresponds to some nonlow glide. The other is a constraint against the formation of an onset glide from V_2 instead of V_1; see Rosenthall (1994) on the disfavored nature of such a structure.

The final ranking for Dutch is therefore as shown in (40).

(40) { ONSET/σ́, *LOWGLIDE } >> DEP-SEG >> ONSET >> INTEGRITY

This ranking makes the following predictions, which match the phenomena that Booij (1995) describes: The splitting of input vowels to create glides will occur when needed to provide onsets (ONSET >> INTEGRITY), except when the vowel is [a] (*LOWGLIDE >> ONSET). An underlyingly onsetless vowel following [a] will remain onsetless (DEP-SEG >> ONSET) unless that vowel is in the stressed syllable, in which case an onset consonant is epenthesized (ONSET/σ́ >> DEP-SEG).

It might seem possible to consider an alternative analysis for Dutch [ʔ]-epenthesis in stressed syllables, under which it is a general constraint (such as ONSET) that drives [ʔ]-epenthesis, not a position-specific constraint like ONSET/σ́, and it is the blocking effect of some higher-ranked constraint ***C*** that prevents glottal stop onsets from appearing in unstressed syllables.[15] Under this approach, the blocking constraint ***C*** is highest ranked; also, ONSET must dominate DEP-SEG, since epenthesis is now a "general" repair blocked in unstressed syllables, rather than a "special" repair triggered by an **M**/σ́ constraint. Because glide formation is preferred over [ʔ]-epenthesis after vowels other than [a], the ranking DEP-SEG >> INTEGRITY is still necessary.

(41) An alternative: General [ʔ]-epenthesis, blocked in unstressed syllables

(a) Epenthesis in stressed syllables

/paɛ́lja/	***C***	ONSET	DEP-SEG	INTEGRITY
a. pa.ɛ́lja		*!		
☞ b. pa.ʔɛ́lja			*	

(b) Blocking of epenthesis in unstressed syllables

/fárao/	***C***	ONSET	DEP-SEG	INTEGRITY
☞ a. fá.ra.o		*		
b. fá.ra.ʔo	*!		*	

[15] An analysis along these lines is presented in McCarthy (2002).

For this alternative to work, it is necessary to find a plausible constraint to stand in for ***C***. It must be a constraint that penalizes glottal stop specifically in unstressed syllables (because a form with a glottal stop onset in the stressed syllable, such as [paʔɛ́lja], can surface and so evidently satisfies ***C***). However, such a constraint could only take the form of a markedness constraint specific to the position *unstressed syllable*, which is a weak position.[16] As discussed in §1.3.2, it is preferable to allow constraints to make specific reference to phonological positions only if they are members of the set of strong positions. This alternative account for Dutch, under which the positional augmentation constraint ONSET/σ́ is unnecessary, is viable only if constraints are permitted to make reference, not only to strong positions, but to weak positions as well. Since positional augmentation constraints — including positional ONSET constraints like ONSET/σ_1 (§4.2.1.1) — are needed for the analysis of other languages, it is better to reject the ***C*** analysis and account for the distribution of [ʔ]-epenthesis in Dutch by means of ONSET/σ́.

3.2.2.2 ONSET/σ́ in Western Arrernte: Stress attraction to syllables with onsets

The Arandic language Western Arrernte [Aranda], as described by Strehlow (1942; see Downing 1998, Breen & Pensalfini 1999, and Pensalfini 1998 for recent analyses), assigns main stress to the initial syllable of the word unless that syllable has no onset. If the initial syllable is onsetless, stress is assigned to the following (peninitial) syllable.

(42) Stress placement in Western Arrernte
(Downing 1998:35; data from Strehlow 1942)

(a) Initial stress in C-initial words

párpa	'quickly'
kála	'already'
rá:tama	'to emerge'
kútungula	'ceremonial assistant'
wóratara	(place name)

(b) Second-syllable stress in V-initial words (> 2σ)

ergúma	'to seize'
ulúrba	'cold; cold wind'
urká:buma	'to work'

[16]As usual, where phonological requirements are concerned, a (positional) faithfulness-based analysis is not a viable option. The ranking FAITH(ʔ)/σ́ >> *ʔ >> FAITH(ʔ) can account for the restriction of glottal stop to stressed syllables only, but does not explain why glottal-stop epenthesis is *obligatory* for an otherwise vowel-initial stressed syllable.

The Arrernte pattern is the stress attraction counterpart to the stressed-syllable alteration pattern seen in Dutch. In both languages, stress must fall on a syllable that has an onset, because the positional augmentation constraint ONSET/σ́ is high ranking. In Dutch, this is accomplished through the epenthesis of an onset for the stressed syllable, violating the faithfulness constraint DEP-SEG. In Western Arrernte, there is no epenthesis or other faithfulness violation. Instead, the constraint that requires initial stress, ALIGN-L(σ́, PrWd), is (minimally) violated, so that stress can fall on a syllable that already has an onset.

(43) ALIGN-L(σ́, PrWd) ∀ σ́ ∃ PrWd such that the Left edges of σ́ and PrWd are aligned (McCarthy & Prince 1993a) ('Stress is leftmost in the prosodic word')

The fact that Western Arrernte chooses to satisfy ONSET/σ́ by disrupting the location of the stress, rather than epenthesizing an onset or deleting the initial vowel, shows that DEP-SEG and MAX-SEG dominate ALIGN-L(σ́, PrWd). ONSET/σ́ must also dominate ALIGN-L(σ́, PrWd), or the stressed-syllable onset requirement would not be enforced at the expense of alignment.

(44) ONSET/σ́ satisfaction through misalignment

/ulurba/	ONSET/σ́	MAX-SEG	DEP-SEG	ALIGN-L(σ́, PrWd)
a. úlurba	*!			
b. lúrba		*!		
c. **t**úlurba			*!	
☞ d. ulúrba				*
e. ulurbá				**!

Thus, in Western Arrernte, the segmental composition of a vowel-initial word is unchanged, but the left-alignment of stress is compromised. As usual, however, the alignment constraint is only minimally violated; realizing the stress any further to the right than the peninitial syllable merely increases violation of ALIGN-L(σ́, PrWd) without improving performance on any higher-ranked constraint.

To give a complete analysis of Western Arrernte stress, it is necessary to consider also the placement of stress in disyllabic vowel-initial words (Arrernte has a disyllabic minimal-word requirement). In these words, stress falls on the initial, onsetless syllable.

(45) Stress in disyllabic V-initial words
(Downing 1998:35; data from Strehlow 1942)

á:twa	'man'
ílba	'ear'

Thus, the constraint NONFINALITY must dominate ONSET/σ́.[17] As a result, it is better to stress an onsetless syllable than to have stress on the final syllable.

(46) NONFINALITY The stressed syllable is not final in the PrWd
(Prince & Smolensky 1993:40)

(47) Initial stress in disyllabic words

/a:twa/	NONFINALITY	ONSET/σ́	ALIGN-L(σ́, PrWd)
☞ a. á:twa		*	
b. a:twá	*!		*

Thus, the constraint ranking responsible for stress placement in Arrernte is as follows.

(48) Stress-related constraints in Arrernte

NONFINALITY
|
DEP-SEG ONSET/σ́ MAX-SEG
ALIGN-L(σ́, PrWd)

The positional augmentation constraint ONSET/σ́ dominates the stress-location constraint ALIGN-L(σ́, PrWd), which is also dominated by the faithfulness constraints MAX-SEG and DEP-SEG. Therefore, initial stress is generally sacrificed when that would mean stress on an onsetless syllable. However, since NONFINALITY dominates ONSET/σ́, stress is realized on an initial onsetless syllable when the only other available syllable is the word-final syllable.

In this account of Arrernte stress, the constraint ONSET/σ́ is crucial in driving stress away from onsetless syllables. Other analyses of Arrernte have also been developed. Downing (1998)

[17] The reverse ranking, ONSET/σ́ >> NONFINALITY, is seen in closely related Alyawarra (Yallop 1977), in which even disyllabic words avoid initial stress on an onsetless syllable.

proposes that stress avoids initial onsetless syllables because they fall outside the prosodic word. In her account, a high-ranking alignment constraint demands that the PrWd be left-aligned with a syllable that has an onset. The initial syllable is thus excluded from the PrWd in a vowel-initial (morphological) word, and stress must be realized on some syllable that is actually in the PrWd. However, the crucial PrWd-to-onsetful-syllable constraint in Downing's (1998) system is created by the Boolean conjunction (in the sense of Crowhurst & Hewitt 1997) of two rather different constraints, ONSET and ALIGN-L(PrWd, σ). Downing argues that the conjunction of these two constraints is legitimate because the (left edge of the) syllable is an argument of both constraints. However, while the constituent σ is arguably the focus — the element associated with universal quantification — of ONSET, it is not the focus of the alignment constraint (the second argument of an alignment constraint is associated with existential quantification; McCarthy & Prince 1993a). Thus, pending further development of the theory of constraint conjunction, it remains to be seen whether ONSET∩ALIGN-L(PrWd, σ) is in fact a well-formed constraint.[18]

Breen & Pensalfini (1999) have yet another take on Arrernte stress. They propose that Arrernte words are all vowel-initial at the time when stress is assigned, stress is always assigned to the second syllable of the word, and apparent consonant-initial words with initial stress are created by a later rule that deletes all word-initial schwas. However, this analysis (which reflects historical developments in Arrernte) is advanced as part of Breen and Pensalfini's proposal that all syllables in Arrernte have the structure [.VC.], and such a proposal runs counter to the widely accepted typological universal that languages with VC syllables also have CV and CVC syllables (Jakobson 1962). Furthermore, even if Breen and Pensalfini's diachronically based analysis of Arrernte stress proves to be the most insightful approach, there exist languages outside Arandic with the same onset-sensitive stress-placement pattern; for example, Downing (1998) mentions Banawá (citing Buller, Buller & Everett 1993 and Everett 1995) and Iowa-Oto (citing Robinson 1975).[19]

In summary, Dutch and Western Arrernte both show the effects of high-ranking ONSET/σ́, a constraint that is predicted to exist because the Prominence Condition allows any **M/**σ́ constraint that enforces the presence of some perceptually prominent property. The difference

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[18]A related possibility, that avoids the questions raised by the use of constraint conjunction in Downing's (1998) analysis, is to propose a constraint of the form ALIGN-L(PrWd, C), in the spirit of Goedemans (1996; see also Buckley 1998 for a related proposal). There appears to be no empirical distinction between ONSET/σ́ and a potential ALIGN-L(PrWd, C) constraint in the context of Arrernte stress. Nevertheless, the movement of stress to syllables with onsets, as seen in Arrernte, is precisely the kind of stress-attraction effect that is predicted by the existence of the constraint ONSET/σ́, which is independently motivated in the analysis of Dutch given above.

[19]In a paper written after Breen & Pensalfini (1999), Pensalfini (1998) presents an OT analysis of Arrernte word-edge phenomena in which the assumption that all syllables are .VC. is no longer necessary.

between the two languages, as for all cases of alteration versus stress-attraction phenomena, stems from whether it is a stress-location constraint or a faithfulness constraint that is violated to satisfy the high-ranking positional augmentation constraint.

The next two subsections exemplify a different onset-related **M/σ́** constraint, or rather, constraint subhierarchy: [*ONSET/X]/σ́. The *ONSET/X subhierarchy enforces low sonority in segments that are parsed as syllable onsets. Since low-sonority onsets contribute to the perceptual prominence of syllables, the constraints in this subhierarchy are legitimate augmentation constraints, and the positional version of the subhierarchy [*ONSET/X]/σ́ is predicted to exist. Indeed, there are languages in which members of this subhierarchy are ranked high enough to have an effect on the composition of stressed syllables. In Niuafo'ou (§3.2.2.3), the constraint [*ONSET/GLI]/σ́ keeps glide onsets out of stressed syllables. In Pirahã (§3.2.2.4), [*ONSET/D]/σ́, the constraint against voiced obstruent onsets in stressed syllables, forces stress to be attracted to syllables with voiceless obstruent onsets.

3.2.2.3 [*ONSET/X]/σ́ in Niuafo'ou: Avoidance of glide onsets in stressed syllables

In Niuafo'ou (Polynesian; Tsukamoto 1988, de Lacy 2000, 2001), although glide onsets are not found in native forms, they do occur in loanwords (49).

(49) Glide onsets in Niuafo'ou (de Lacy 2000, to appear; data from Tsukamoto 1988)

j̲u.ní.ti̥	'unit'
w̲a.é.a	'wire'
w̲e.lì.ŋa.tó.ni̥	'Wellington'
w̲a.í.ne	'wine'

But there is an absolute ban on glide onsets in main-stress syllables — they are always avoided, even in loanwords (50). Loanwords that have glide onsets to stressed syllables in the source language are realized in Niuafo'ou with a fully syllabic high vowel preceding the stressed syllable.

(50) No glide onsets in stressed syllables (de Lacy 2000, 2001; data from Tsukamoto 1988)

i.á.te	*já.te	'yard'
u.á.fu̥	*wá.fu̥	'wharf'
u.í.pi̥	*wí.pi̥	'whip'

In order to account for the special prohibition against glides in the onsets of stressed syllables, de Lacy (2000) argues for the existence of the constraint subhierarchy [*MARGIN/X]/σ́, with [*MARGIN/GLI]/σ́ ranked high in Niuafo'ou. As discussed in §2.3.2.3.3, the "margin" constraint subhierarchy that is responsible for onset-sonority effects is implemented here as

*Onset/X, formulated as in (51) for the anti-glide step of the subhierarchy and relativized to the position stressed syllable.

(51) [*Onset/Gli]/σ́ For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is a σ́, then |*a*| < Gli

where |*y*| is the sonority of segment *y*

This positional augmentation constraint is undominated in Niuafo'ou, since nothing can ever force glide onsets to surface in stressed syllables. In particular, [*Onset/Gli]/σ́ must dominate Onset and Onset/σ́, because stressed syllables avoid glide onsets by appearing with no onset at all. [*Onset/Gli]/σ́ must also dominate the faithfulness constraint that regulates moraic status (informally, "Faith(μ)"), because even if a form had an underlying glide, as in the potential input /jate/, it would surface as a high vowel rather than as an onset to the stressed syllable.[20]

(52) Avoidance of glide onsets in stressed syllables

/jate/	[*Onset/Gli]/σ́	Onset/σ́	Onset	Faith(μ)
a. já.te	*!			
☞ b. i.á.te		*	*	*

The ranking Onset >> Faith(μ) is motivated, as de Lacy (2000, to appear) argues, because high vocoids that appear before non-main stress vowels always surface as glide onsets, never as vowels (53).

(53) Glide onsets in other syllables

/iuniti/	[*Onset/Gli]/σ́	Onset/σ́	Onset	Faith(μ)
a. i.u.ní.ti̥			*!	
☞ b. ju.ní.ti̥				*

[20]de Lacy (2000) assumes that a potential input like /jate/ will surface as [i.a.te] rather than as, e.g., [a.te] or [ta.te] — that is, that vocalization of the glide is the chosen repair. There are apparently no overt alternations to show that this is in fact so, but since the (English) source words for the forms in question do have glide onsets in the stressed syllables, and these correspond to high vowels in Niuafo'ou, it seems plausible that glide vocalization is in fact the chosen repair for an impossible form like /jate/.

Of course, as seen in (52), the positional augmentation constraint [*ONSET/GLI]/σ́ outranks ONSET, but since the glide onset in (53) above is not part of the stressed syllable, [*ONSET/GLI]/σ́ is irrelevant for this form.

Thus, the fact that glide onsets are prohibited from stressed syllables, but are in fact preferred to vowels in hiatus in other syllables, is evidence for a stressed syllable-specific version of the augmentation constraint *ONSET/GLI, namely, [*ONSET/GLI]/σ́.

§2.3.2.3.3 argues that ONSET is not simply "[*ONSET/Ø]", an endpoint of the *ONSET/X subhierarchy, but must be viewed as a formally separate constraint. The crucial ranking [*ONSET/GLI]/σ́ >> ONSET/σ́ in Niuafo'ou is evidence for this claim. Since ONSET/σ́ must be ranked *below* [*ONSET/GLI]/σ́, ONSET/σ́ cannot possibly be the same thing as "[*ONSET/Ø]/σ́," which would be universally ranked at the top of the [*ONSET/X]/σ́ hierarchy. (See also §4.2.1.2.5 on differences between ONSET and *ONSET/X.)

3.2.2.4 [*ONSET/X]/σ́ in Pirahã: Stress attraction and low-sonority onsets

Once again, there is a close link between stressed-syllable alteration and the attraction of stress to syllables that have particular properties. In Niuafo'ou, considered above, the ranking of the [*ONSET/X]/σ́ hierarchy causes a syllable that would otherwise surface with a glide onset to be altered so that the glide onset is not present in the output form when the syllable is stressed. Stress-attraction phenomena driven by [*ONSET/X]/σ́ constraints are also observed, as for example in Pirahã (an Amazon language of the Mura family; Everett & Everett 1984ab; Everett 1988), where stress is attracted to the syllable with the lowest-sonority onset available. (Other positional augmentation constraints are also active in Pirahã: ONSET/σ́ and HEAVYσ/σ́.)

While Pirahã is a tone language, contrasting high and low tones, it also has phonologically relevant stress that is independent of tone. (In all Pirahã data shown here, stress is indicated with an acute accent, and high tone is marked by underlining. Vowels that are not underlined have low tones.)

(54) Tone does not affect stress placement (Everett & Everett 1984a)

ʔáo.o̲i	'foreigner'
ʔá̲o.o̲i	'ear'
ʔá̲o.oi̲	'type of fruit'
ʔáo.o̲i̲	'skin'
ʔáo̲.o̲i	'Brazil nut shell'

Everett (1988) argues that stress in Pirahã has phonological relevance. For example, native speakers correct mistakes in stress placement made by non-native speakers, and there are optional processes of devoicing and deletion that are sensitive to stress placement.

In Pirahã (as in other languages such as Spanish; Harris 1983), there is a "window" for stress: it must fall within the last three syllables. However, the determination of stress placement within that window is dependent on the characteristics of the last three syllables. Long vowels and diphthongs take precedence over short vowels (there are no CVC syllables), and if two syllables have the same rime weight, then syllables with voiceless onsets are preferred to those with voiced onsets, which in turn are preferred to onsetless syllables. (In the examples below, the three classes of onsets are labeled T, D, and Ø respectively.)

The data in (55) show that, regardless of onset class, stress is placed on a heavy syllable (CVV) rather than on a light one (CV).

(55) Stress is attracted to heavy syllables (Everett & Everett 1984a)

ØVV ≻ TV	ho.ái̲.pi	'type of fish'
ØVV ≻ TV, DV	ʔa.ho.áo̲.gi	(proper name)
DVV ≻ TV	bíi̲.si	'red'
DVV ≻ TV, DV	gíi.so̲.gi	'turtle'

The attraction of stress to heavy syllables can be accounted for by HEAVYσ/σ́, the positional augmentation constraint that requires stressed syllables to be heavy (§3.2.1.1). Since onset-sonority effects appear only when rime weight is held constant, HEAVYσ/σ́ must outrank the constraints that are sensitive to onset sonority. However, the matter of syllable weight will be set aside for now, and only syllables with equivalent rime weight will be compared, because the focus of the current discussion is onset sonority.

The scale of onset preference, T ≻ D ≻ Ø, is demonstrated in (56).

(56) Onset-sensitive stress placement (Everett & Everett 1984a)
(Italics indicate the relevant syllables to be compared.)

(a) Heavy syllables

TVV ≻ DVV	*káa.gai*	'word'
	pa.*hái.bii̲*	(proper name)
	bii̲.sái	'red'
	ʔi.*bao̲.sái̲*	'her cloth'
TVV ≻ ØVV	po̲o̲.*hói*.hi̲.*ai*	'fish'
	ʔi̲.*síí*.ho.*a̲i*	'liquid fuel'
	soi.*oa̲*.ga.*hái*	'thread'
	ko.so.*ii*.gai.*tái*	'eyebrow'

DVV ≻ ØVV	*gáo.ii*	(proper name)
	poo.*gái*.hi.*ai*	'banana'
	gi.*ai.bái*	'dog'

(b) Light syllables[21]

TV ≻ DV	*ʔá.ba.gi*	'toucan'
	ti.*pó.gi*	'species of bird'
	ka.*gi.hí*	'wasp'
	ʔa.*ba.pá*	(proper name)

Thus, syllables with voiceless obstruent onsets are preferred to those with voiced onsets, which in turn are preferred to syllables with no onset at all. The difference between voiced and voiceless obstruents can be viewed as a difference in sonority (see §2.3.2.2 for discussion). Since the *ONSET/X subhierarchy is derived from the segmental sonority scale, this means that there are *ONSET/X constraints that distinguish between voiced (*D*) and voiceless (*T*) obstruents. For Pirahã, it is the positional versions of these constraints, relativized to stressed syllables, that are relevant.

(57) [*ONSET/D]/σ́ For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is a σ́, then |*a*| < D

[*ONSET/T]/σ́ For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is a σ́, then |*a*| < T

These two constraints, being members of the [*ONSET/X]/σ́ subhierarchy, are universally ranked: [*ONSET/D]/σ́ >> [*ONSET/T]/σ́. With [*ONSET/D]/σ́ ranked above the constraint that would otherwise determine default stress placement, and with faithfulness to voicing undominated, then syllables with voiceless onsets will be preferred to those with voiced onsets for stress.

The constraint that is responsible for default stress placement can be determined by the stress pattern of words with syllables that agree in rime weight and onset sonority. In such cases, there is a preference for stress on the rightmost syllable.

(58) All else being equal, stress is rightmost (Everett & Everett 1984a, Everett 1988)

TVV TVV 'TVV	pao.hoa.hái	'anaconda'
(DVV) TVV 'TVV	bai.toi.sái	'wildcat'
TV TV 'TV	ko.ʔo.pá	'stomach'
DV DV 'DV	gi.go.gí	'what about you?'

[21]Everett (1988) argues that there are no ØV syllables.

The preference for right-edge stress can be seen as the result of the constraint ALIGN-R(σ́, PrWd). This constraint is dominated by the stressed-syllable onset-sonority constraint [*ONSET/D]/σ́ (and by HEAVYσ/σ́), since rightmost stress emerges only when onset sonority (and rime weight) are equal across syllables.

(59) Avoiding voiced onsets has priority over right-edge stress

(a) Default stress is rightmost

/pao̲hoahai/	[*ONSET/D]/σ́	[*ONSET/T]/σ́	ALIGN-R(σ́, PrWd)
a. páo̲.hoa.hai		*	*!*
b. pao̲.hóa.hai		*	*!
☞ c. pao̲.hoa.hái		*	

(b) Voiceless onsets preferred to voiced

/ʔabagi/	[*ONSET/D]/σ́	[*ONSET/T]/σ́	ALIGN-R(σ́, PrWd)
☞ a. ʔá.ba.gi		*	**
b. ʔa.bá.gi	*!		*
c. ʔa.ba.gí	*!		

As noted above, however, syllables with voiced onsets are preferred to syllables with no onsets at all. This means that ONSET/σ́ dominates [*ONSET/D]/σ́. However, ONSET/σ́ is itself dominated by the constraint or constraints responsible for keeping the stress within the final three syllables, encapsulated here as "STRESSWINDOW"; thus, every word has stress within that three-syllable window. (See Green (1995) for one proposal concerning the nature of the constraints enforcing a three-syllable stress window in Pirahã.)

(60) Even voiced onsets are preferred to onsetless syllables[22]

/poo.gai.hi.ai/	Stress Window	Ons/σ́	[*Ons/D]/σ́	[*Ons/T]/σ́	Align-R (σ́, PrWd)
☞ a. poo.gái.hi.ai			*		**
b. poo.gai.hi.ái		*!			
c. póo.gai.hi.ai	*!			*	***

Thus, the constraint ranking motivated here for Pirahã is as in (61).

(61) Constraint ranking for Pirahã stress

StressWindow >> Heavyσ/σ́>> Onset/σ́ >> [*Onset/D]/σ́ >>
{ [*Ons/T]/σ́, Align-R(σ́, PrWd) }

The ranking relationship of greatest interest here is [*Onset/D]/σ́ >> Align-R(σ́, PrWd), which accounts for the ability of the onset-sonority preference (voiceless over voiced) to override default right-edge stress (as long as higher-ranked constraints like StressWindow and Heavyσ/σ́ are satisfied). The constraints of the *Onset/X subhierarchy, and therefore of its positional versions like [*Onset/X]/σ́, are in a universally fixed ranking derived from the segmental sonority scale. Consequently, the fact that [*Onset/D]/σ́ is active in Pirahã entails that the higher-ranking members of the subhierarchy, [*Onset/LowV]/σ́ >> [*Onset/MidV]/σ́ >> [*Onset/Gli]/σ́ >> [*Onset/Rho]/σ́ >> [*Onset/Lat]/σ́ >> [*Onset/Nas]/σ́, are also ranked high enough to be active. However, the effect of these constraints cannot be seen, as they are vacuously satisfied — Pirahã has no such segments in its phonemic inventory.

(62) Segmental phoneme inventory of Pirahã (Everett & Everett 1984a)[23]

/p t (k) ʔ s h b g i a o/

Interestingly, it may be the general version of the *Onset/X subhierarchy that is responsible for such a segmental inventory. Pirahã has no closed syllables, so all consonants are onsets. If the constraints *Onset/Gli >> *Onset/Rho >> *Onset/Lat >> *Onset/Nas are

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[22]An output candidate with penultimate stress, [poo.gai.hí.ai], is not considered here because, as noted above, rime weight takes precedence over onset sonority.

[23]Everett & Everett (1984b) state that [k] appears to be a variant of [h], as well as a portmanteau of the sequence [hi], and is probably not an independent phoneme.

ranked above MAX-SEG or IDENT[*f*], this would explain the absence of any consonant higher in sonority than the voiced obstruents.[24]

3.2.2.5 Concluding remarks on stress/onset interactions

The last four languages discussed — Dutch, Western Arrernte, Niuafo'ou, and Pirahã — show that there are interactions between stressed syllables and onset-related properties that pattern just like the familiar stress/prominence interactions reviewed in §3.2.1. Namely, there are languages in which stressed syllables are altered to have onsets or to have low-sonority onsets, and there are languages in which stress is attracted to syllables that have onsets or to syllables that have low-sonority onsets.

The existence and the nature of these stress/onset interactions follow directly from the theory of **M/str** constraints developed in this dissertation. First, stressed-syllable versions of ONSET and the *ONSET/X subhierarchy exist because these constraints are prominence-enhancing, satisfying the Prominence Condition. Second, these **M/**σ́ constraints, like the **M/**σ́ constraints in §3.2.1, are able to give rise to either alteration or attraction effects because the difference between the two patterns depends on the relative ranking among other constraints in the system (faithfulness constraints related to the prominent property in question versus stress-location constraints).

This approach to onset-related stress-attraction effects also makes a contribution to the long-standing debate about the role of syllable onsets in stress assignment. Syllable *weight* is determined without reference to onsets; this is one of the insights that has led to the development of moraic theory (Hyman 1985; Hayes 1989), in which onsets are not weight-bearing elements. Nevertheless, several cases of onset-sensitive *stress placement* have been reported (see, e.g., Davis 1988). As should be obvious from the nature of the stressed-syllable augmentation constraints introduced throughout this section, the approach taken here is consistent with an insight from Hayes (1995:Ch 7): not every property that is involved in stress placement need be related directly to syllable weight in the narrow sense of mora count, since other dimensions of prominence (including tone and vowel quality as well as properties of syllable onsets) may also be independently invoked. Thus, it seems reasonable to separate onset-related stress effects from syllable weight per se. (Recall that in Pirahã, syllable weight in the conventional sense has absolute priority over onset preferences in stress placement; this fact further supports the claim that these two factors affecting stress placement are distinct rather than cumulative.)

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[24]It is apparently not the case that Pirahã completely lacks sonorant consonants in surface forms. Everett (1988:106) states that /b/ and /g/ have optional realizations as nasals (following pause or word-initially) and as "vibrants" (in certain intervocalic environments). The analysis outlined here predicts that these phonemes are most likely to be realized as stops when they are in the main-stress syllable, although since it is not clear which constraints drive their (optional) realization as sonorants, it is impossible to predict exactly what the pattern would be.

It follows from the theory developed here that stress placement can be sensitive to some property of syllable onsets only if that property involves perceptual prominence. This is because stress attraction effects are a response to demands imposed by high-ranking stressed-syllable augmentation constraints, and the only possible positional augmentation constraints are those involving properties that serve to enhance perceptual prominence.

The prediction that onset-sensitive stress placement is necessarily related to perceptually prominent properties appears to be borne out. The languages surveyed by Davis (1988), in which stress is sensitive to certain characteristics of syllable onsets, include Pirahã and Western Arrernte, which, as shown above, do involve independently attested stressed-syllable augmentation constraints.

Another case that Davis (1988) also discusses is the Australian language Mathimathi [Madimadi], based on work by Hercus (1969). Hercus and Davis propose that stress placement in this language is sensitive to whether or not an onset consonant is coronal: according to Davis's analysis, stress is attracted away from an initial light syllable onto the second syllable if the onset of the second syllable is coronal. If stress placement in Mathimathi truly were sensitive to the place of articulation of onset consonants, then this would be a counterexample to the claim that onset-sensitive stress must involve prominence-enhancing constraints — except in the case of laryngeal versus supralaryngeal places of articulation (see §3.4 below), there does not seem to be a phonologically relevant distinction in prominence among the different places of articulation.

However, the stress pattern of Mathimathi has been reanalyzed by Gahl (1996), who shows that stress is assigned on the basis of morphological, rather than phonological, factors. That is, stress falls on the final syllable of the morphological stem. The reason for the apparent relationship of coronal consonants to stress is that possible root shapes in Mathimathi are quite restricted. Out of 104 roots of the form CV<u>C</u>VC and 22 of the form CV<u>C</u>V in Hercus (1969), every single one has a coronal consonant in the intervocalic position. Therefore, disyllabic roots always have second-syllable stress, and they always have coronal onsets in the second syllable, but stress placement is truly determined with reference to the right edge of the stem rather than to place of articulation in onset consonants. Gahl supports this alternative analysis by analyzing a number of forms that would be exceptions to a coronal-onset account of stress placement but are consistent with the morphological account.

Davis (1988) discusses two further examples of onset-sensitive stress assignment. The first involves *-ere* verbs in Italian (based on work by Davis, Manganaro, & Napoli 1987), which according to his analysis attract stress onto the antepenultimate syllable (away from the penult), as in *lú.ce.re* 'to be light', if the root final vowel has a sonorant onset (among other factors). The second is stress assignment in *-ative* adjectives in English, in which the first syllable of the suffix is destressed when it has a sonorant onset (as in *nómi<u>na</u>tive*, **nómi<u>nà</u>tive*; cf. *quáli<u>tà</u>tive*). The crucial onset property in both these cases is sonority, which is a property that is relevant to perceptual prominence, although the Italian pattern seems to go the wrong way (with stress being attracted to a syllable that has a relatively poor sonority contrast between onset and nucleus). In any case, as noted by Gahl (1996:343), these two examples both involve morphologically restricted sets of words; it is not necessarily clear that a phonological account of stress placement in these cases is the correct approach.

Thus, it seems to be the case that phonological, productive instances of onset-sensitive stress placement do involve perceptually prominent properties, as predicted by the positional augmentation approach to stress-attraction effects.

3.2.3 Summary: stressed-syllable augmentation

This section has considered a number of languages in which stressed-syllable augmentation constraints are phonologically active. As predicted by the theory of **M/str** constraints developed in Chapter 2, the kinds of phonological requirements that can hold specifically of stressed syllables are varied in nature, but they all involve perceptually prominent properties. The Prominence Condition ensures that all **M/str** constraints are prominence-enhancing, and since there is no additional constraint filter on **M/Φstr** constraints, the full set of augmentation constraints can be freely relativized to phonetically strong positions like the stressed syllable. Moreover, there are many augmentation constraints whose constraint focus is compatible with relativization to a syllable-sized position like the stressed syllable.

It has also been shown in this section that **M/σ́** constraints can account for both alteration and attraction effects in stress systems, explaining why these two types of patterns are sensitive to the same set of prominent properties.

The remaining two sections of this chapter discuss augmentation effects for two more phonetically strong positions, long vowels (§3.3) and onsets (§3.4).

3.3 Positional augmentation in long vowels: [*PEAK/X]/Vː in Yawelmani

Another member of the set of phonetically strong positions is the long vowel. Thus, any markedness constraint that enforces the presence of perceptually prominent properties in vowels is predicted to have a counterpart that is relativized to long vowels.

The *PEAK/X subhierarchy, which calls for high sonority in vowels, qualifies as an augmentation constraint (§2.3.2.2). As predicted, this constraint subhierarchy has a [*PEAK/X]/Vː counterpart.

(63) [*PEAK/X]/Vː For every segment *a* that is the head of some syllable *x*, if *a* is a Vː, then |*a*| > X

where |*y*| is the sonority of segment *y*
X is a particular step on the segmental sonority scale

The effects of the positional augmentation constraint [*PEAK/HIGHV]/Vː are seen in the Yawelmani dialect of Yokuts (California; Newman 1944). Yawelmani has a process of vowel lowering that affects long high vowels, causing them to surface as mid vowels (Kuroda 1967, Kisseberth 1969, Archangeli 1984).

Yawelmani long-vowel lowering interacts in complex ways with other processes in the language, including vowel epenthesis and a height-sensitive process of rounding harmony; in fact, Yawelmani is a classic example that has been used to argue for abstract intermediate levels in phonological derivations (Kisseberth 1969). Therefore, Yawelmani vowel phonology poses a challenge for non-derivational theories like OT that do not recognize such intermediate levels. Several non-derivational analyses of the vowel alternations in Yawelmani have been put forward (Cole & Kisseberth 1996; Sprouse 1997; McCarthy 1999; cf. Goldsmith 1993; Archangeli & Suzuki 1997), but to present and evaluate these proposals in detail here is beyond the scope of the present discussion. Here, the question of how all the different vowel-related processes interact will be set aside to focus on just this one aspect of the phonology of Yawelmani vowels.

The lowering of long high vowels is exemplified by the forms in (64ab). Evidence that the root vowels in these forms, which appear as [o(ː)][25] on the surface, are underlyingly /uː/ comes from the behavior of these roots with respect to vowel harmony. Yawelmani [round] harmony occurs only between vowels of the same height (where [i u] are high and [a o] are low). Therefore, the unexpected occurrence of harmony in (64a) and the blocking of harmony in (64b) both indicate that the root vowel is underlyingly high, not low (compare the forms in (64cd), formed from roots with underlying /oː/, where harmony applies as expected given the surface root vowel).

(64) Lowering of /uː/ (Kenstowicz & Kisseberth 1979:90; data from Newman 1944)

Roots with /uː/			*Roots with /oː/*		
(a)	woːʔuy-hun	'falls asleep'	(c)	soːnil-hin	'packs on the back'
	doːlul-hun	'climbs'		hoːtin-hin	'takes the scent'
	c'om-hun	'destroys'		dos-hin	'reports'
	ṣog-hun	'pulls out a cork'		won-hin	'hides'
(b)	woyʔ-al	'might fall asleep'	(d)	sonl-ol	'might pack on the back'
	doll-al	'might climb'		hotn-ol	'might take the scent'
	c'oːm-al	'might destroy'		doːs-ol	'might report'
	ṣoːg-al	'might pull out the cork'		woːn-ol	'might hide'

[25] Long vowels in Yawelmani are regularly shortened when they appear in closed syllables.

There is no direct evidence from harmony patterns that surface [eː] corresponds to underlying [iː], since the unrounded version of the suffix vowels (and of the epenthetic vowel that appears in CVC_C roots) is the default form. But other phonological alternations in the language do provide evidence for an underlying /iː/ that surfaces as /eː/ (Kisseberth 1969). In any case, in an OT analysis that assumes richness of the base, it is necessary to account for why there is no surface contrast between [iː] and [eː], or between [uː] and [oː];[26] this point would still hold even without the evidence from harmony for /uː/. Clearly, something is forcing the neutralization of (potential) /iː/ and /eː/ to [eː], and that of /uː/ and /oː/ to [oː].

The non-derivational accounts of Yawelmani vowel phonology in Cole & Kisseberth (1996), Sprouse (1997), and McCarthy (1999) differ considerably, but all of these proposals include a constraint that bans long high vowels from surface forms.

(65) Constraints against long high vowels in Yawelmani

(a) Cole & Kisseberth (1996)

LOWER Vμμ → [low]

(b) Sprouse (1997)

*VV[high] No [high] on a V linked to two **μ** [...]

(c) McCarthy (1999)

LONG/-HIGH If long, then non-high

Cole & Kisseberth (1996) give a substantive justification for their constraint LOWER that is entirely compatible with the notion of positional augmentation under development here.

> Lowering can be viewed as an optimizing constraint that increases the sonority of bimoraic vowels. This is a case of *the strong* (in terms of weight) *becoming stronger* (in terms of peak sonority). (Cole & Kisseberth 1996:13; emphasis added)

That is, [*PEAK/HIGHV]/Vː (or LOWER) is a legitimate augmentation constraint, because it acts to enhance the prominence of the strong position Vː.

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[26]Actually, [iː] and [uː] do sometimes occur, as contractions of [iw] and [uw] respectively in certain highly restricted morphological environments (Kenstowicz & Kisseberth 1979:99); however, the analyses of Yawelmani that I have consulted tend to regard this as a limited and exceptional phenomenon.

3.4 Positional augmentation in syllable onsets: HAVECPLACE/Onset

Yet another phonetically strong position is the syllable onset (as noted in §2.3.3, *onset* here is used as an abbreviation for "the phonetically strong position onset/released consonant"). Again, because the only filter relevant for phonetically strong positions is the Prominence Condition, any prominence-enhancing markedness constraint that can be relativized to the syllable onset is predicted to have an onset-specific counterpart. One such constraint is HAVECPLACE (§2.3.2.4). Evidence for HAVECPLACE/Onset, an onset-specific version of HAVECPLACE, is found in Chamicuro (Parker 1994, 2000).

In Chamicuro, the glottal consonants [h, ʔ] are contrastive members of the phoneme inventory, but they occur only in coda position and are banned from appearing as syllable onsets. Parker (1994) presents data showing that the glottals [h, ʔ] in coda position contrast with each other, with vowel length, with zero, and with other consonants (although most codas in the language are in fact glottals; S. Parker, p.c.).

(66) Coda [h, ʔ] contrastive in Chamicuro (data from Parker 1994)

(a) meʔsa 'sea lion'
meːsa 'party'
meØsa 'table'

(b) ičehki 'it burns'
ičeːki 'it is abundant'

(c) meʔna 'woodpecker'
netna 'how much?'
yelna 'man; husband'
meØnu 'tongue'

(d) aʔtikana 'we'
ahtini 'path, trail'
uanasti 'I look'

(e) saʔpu 'lake'
kahpu 'bone'
syekpuč̢le 'pot-bellied'[27]

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[27]Following Parker (1994), I use the symbol [č̢] to stand for a retroflex alveopalatal affricate.

Parker (1994, 2000) specifically argues that [h, ʔ] should be considered coda consonants and not part of syllabic nuclei, because they have the same distribution as other coda consonants in the language. For example, syllables can be maximally CVC or CVV, and [h, ʔ] cannot cooccur with a long vowel or another coda consonant. Also, final syllables must be light in Chamicuro, and syllables with [h, ʔ] do not occur in word-final position.

Since the glottals [h, ʔ] are allowable segments in Chamicuro, then their inability to serve as onset consonants can obviously not be explained as part of a general prohibition against glottals in the language. Also, the familiar argument against a faithfulness-based account holds here as well; special faithfulness constraints for onsets cannot account for a language in which some permissible input structure *fails* to appear in onset position (see Parker 2000 for further discussion of problems that a faithfulness-based analysis would encounter). To account for the distribution of glottal consonants in Chamicuro, Parker (2000) argues that it is necessary to recognize a markedness constraint that specifically bans glottal consonants in onset position: the positional augmentation constraint HAVECPLACE/Ons (the formulation given here has been slightly modified from Parker's original constraint to make it consistent with the **C**/*str* schema).

(67) HAVECPLACE/Ons For all consonants *x*, if *x* is $C_{[+release]}$, then *x* has a supralaryngeal Place specification

Parker (2000) proposes the following ranking for Chamicuro (some constraint names have been altered here in the interest of consistent nomenclature).

(68) Glottal-related constraint ranking for Chamicuro (Parker 2000)

HAVECPLACE/Ons
|
IDENT[Place]   MAX-SEG
\ /
*PHARYNGEAL

The ranking IDENT[Place], MAX-SEG >> *PHARYNGEAL is necessary because outside of onset position, input glottals surface faithfully, without being either changed to a non-glottal or deleted (69a). On the other hand, HAVECPLACE/Ons must dominate at least one of the two faithfulness constraints shown in (68) above, so that an input glottal, if it is syllabified as an onset, will not surface as a glottal. According to the ranking given in Parker (2000), the crucial interaction for onset glottals is HAVECPLACE/Ons >> IDENT[Place], so that an input glottal will surface as a non-glottal consonant in onset position rather than being deleted (69b).

(69) Glottal consonants surface in the coda, but not in the onset

(a) HAVECPLACE/Ons is irrelevant for coda glottals (Parker 2000);
[apehta] 'sardine'

/apehta/	MAX-SEG	HAVECPL/Ons	IDENT[Place]	*PHAR
☞ a. a.peh.ta				*
b. a.pe.ta	*!			
c. a.pek.ta			*!	

(b) Onset glottals surface with a supralaryngeal Place specification
(hypothetical input; Parker 2000)

/hapeta/	MAX-SEG	HAVECPL/Ons	IDENT[Place]	*PHAR
a. ha.pe.ta		*!		*
b. a.pe.ta	*!			
☞ c. ka.pe.ta			*	

Thus, Parker's (2000) analysis shows that an account of the distribution of glottal consonants in Chamicuro crucially depends on the existence of a constraint HAVECPLACE/Ons. Parker notes that languages of the Cariban family, such as Tiriyó, restrict glottal consonants to coda position just as Chamicuro does, indicating that HAVECPLACE/Ons is high ranking in these languages as well. Under the model of **M/str** constraints developed here, HAVECPLACE/Ons is a well-formed positional augmentation constraint, because it requires the strong position onset to have an additional perceptually prominent property, supralaryngeal place.

3.5 Conclusion: Predicted and attested M/Φstr constraints

This chapter has focused on the phonetically strong positions stressed syllable, long vowel, and onset/released consonant, presenting a number of languages in which markedness constraints relativized to these positions play a crucial role.

Under the Schema/Filter model of CON, all formally possible constraints exist unless there is a constraint filter that excludes them. The Prominence Condition is one filter that applies to **M/str** constraints, ensuring that markedness constraints are relativized to strong positions only when they are augmentation (prominence-enhancing) constraints. If there are no other relevant filters, then there should be no further restrictions on possible **M/str** constraints. This prediction is borne out for the phonetically strong positions, as shown in (70). Setting aside cases of domain mismatch, in which the size of the strong position is not compatible with the focus of the augmentation constraint (§2.2.2), nearly all expected combinations of augmentation constraints and strong positions do occur. The only exceptions are constraints that are vacuously satisfied by any output candidate ([*ONSET/X]/Vː, HAVESTRESS/σ́) or essentially indistinguishable from other constraints ([*PEAK/X]/Ons, [*ONSET/X]/Ons); see §2.3.3 for further discussion of these cases.

(70) Predicted positional augmentation constraints for phonetically strong positions

	σ́	Vː	onset
HEAVYσ	Mohawk West Germanic Aguacatec	***domain mismatch***	***domain mismatch***
HTONE	Slave Golin Serbo-Croatian	***domain mismatch***	***domain mismatch***
[*PEAK/X]	Slovene Mordwin English	Yawelmani	*(hard to distinguish from other constraints)*
ONSET	Dutch W. Arrernte	***domain mismatch***	***domain mismatch***
[*ONSET/X]	Niuafo'ou Pirahã	*(vacuously satisfied)*	*(hard to distinguish from other constraints)*
HAVECPLACE	***domain mismatch***	***domain mismatch***	Chamicuro
HAVESTRESS	*(vacuously satisfied)*	***domain mismatch***	***domain mismatch***

In the matter of domain mismatches versus well-formed **M/str** constraints, the *PEAK/X subhierarchy is an interesting case. The focus of *PEAK/X (shown in bold in (71)) includes reference to both a segment and a syllable, because a syllable peak is crucially identified as a segment that has a particular relationship to a syllable.

(71) *PEAK/X **For every segment *a* that is the head of some syllable *x*,** |*a*| > X

where |*y*| is the sonority of segment *y*
X is a particular step on the segmental sonority scale

Thus, relativization to both a syllable-sized strong position (72a) and a segment-sized strong position (72b) is possible.

(72) Positional versions of *PEAK/X

(a) [*PEAK/X]/σ́ — For every segment *a* that is the head of some syllable *x*, <u>if *x* is a σ́</u>, then |*a*| > X

where |*y*| is the sonority of segment *y*
X is a particular step on the segmental sonority scale

(b) [*PEAK/X]/Vː — For every segment *a* that is the head of some syllable *x*, <u>if *a* is a Vː</u>, then |*a*| > X

where |*y*| is the sonority of segment *y*
X is a particular step on the segmental sonority scale

As seen from the discussion of Zabiče Slovene, Mokshan Mordwin, and rhotic dialects of English, in which [*PEAK/X]/σ́ is active (§3.2.1.3), and Yawelmani, in which [*PEAK/X]/Vː is active (§3.3), these two relativized versions of the *PEAK/X subhierarchy are both attested.

In conclusion, the languages discussed in this chapter support the model of positional augmentation constraints developed in Chapter 2, according to which the Prominence Condition is the only constraint filter that is relevant for **M/str** constraints on the phonetically strong positions stressed syllable, long vowel, and onset/released consonant. That is, any markedness constraint can be relativized to a phonetically strong position, as long as the basic criterion for possible **M/str** constraints — the Prominence Condition — is met. A wide variety of augmentation effects are therefore observed in these positions. Of course, the kinds of augmentation phenomena that affect long vowels and onsets are necessarily limited to phenomena that can affect vowels and consonants respectively; other positional augmentation constraints for these positions lead to a domain mismatch. However, the comparatively unrestricted nature of **M/str** constraints for phonetically strong positions (assuming only satisfaction of the Prominence Condition) is seen in the great variety of augmentation phenomena affecting stressed syllables. The syllabic size of this position makes it compatible with augmentation effects involving consonantal, vocalic, and prosodic features.

The varied combination of phonetically strong positions with augmentation constraints stands in contrast to the restricted augmentation possibilities for psycholinguistically strong positions, examined in the following chapter. The set of legitimate **M/str** constraints for psycholinguistically strong positions is restricted not only by the Prominence Condition, but also by the Segmental Contrast Condition (§2.4.1), which basically prohibits augmentation constraints from being relativized to psycholinguistically strong positions if such constraints would result in the neutralization of lexical contrasts in those positions. As a result, even though the psycholinguistically strong positions — initial syllable and root — are domains large enough for all the augmentation constraints enumerated in (70) to apply, the actual number of attested **M/str** constraints for these two positions is somewhat smaller.