The Stress-Encapsulation Universal and Phonological Modularity*

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Abstract

I propose a new formal universal in phonology that concerns an asymmetry in the relationship between stress and segmental features. The distribution of segmental features is often conditioned by the position of stress, but I claim that the distribution of stress is never directly conditioned by segmental features. To establish the claim, the paper re-evaluates the evidence for patterns of sonority-driven stress reported in the literature and shows that such patterns do not require direct reference to sonority. I use the universal as an argument for a modular architecture of phonology where the computation of stress is carried out in a separate informationally encapsulated module with a limited interaction with the rest of phonology.

1 Overview

1.1 The Stress-Encapsulation Universal

The distribution of segmental features is often conditioned by the position of stress. In American English, for example (and simplifying), /t/ is flapped between a preceding stressed vowel and a following unstressed vowel (políɾical, politícian), voiceless stops are aspirated at the onset of a stressed syllable, (opp^{h}óse, opposítion), stressless vowels undergo reduction (átəm, ətómic), and /h/ is deleted before an unstressed, non-initial vowel (vé~~h~~icle, vehícular) (see Chomsky and Halle 1968; Kahn 1976; Borowsky 1986; Davis and Cho 2003, among many others). Such stress-sensitive segmental processes are commonly attested across the world's languages, and they are many and diverse, as shown by the list in (1).

(1) Types of stress-sensitive segmental processes (Gonzalez, 2003; Giavazzi, 2010, and references therein)

a. Processes affecting consonantal features: affrication, aspiration, deletion, devoicing, flapping, fricativization, glottalization, glottalization-attraction, metathesis, occlusivization, voicing

*Acknowledgements: to be added.

b. Processes affecting vocalic features: lowering, reduction, vowel harmony (including metaphony, umlaut)
c. Other processes: nasal harmony

As noted by de Lacy (2002) and Blumenfeld (2006), stress-segmental interactions in the opposite direction are almost non-existent. While stress is sensitive to suprasegmental features such as length, syllable structure, and tone, it is arguably never sensitive to segmental features such as aspiration, continuancy, stridency, anteriority, place of articulation, laterality, rhoticity, nasality, rounding, and so on. For example, no language is known to have stress patterns like the following:

(2) a. Stress the leftmost round vowel
b. Stress the penultimate syllable, but if it has an unaspirated onset, stress the antepenultimate syllable

The segmental property that stands apart from the rest is vowel sonority. A literature on so-called 'sonority-driven stress' that goes at least back to Kenstowicz (1997) has documented multiple stress patterns in which the position of stress is determined by the hierarchy in (3). According to this hierarchy, lower vowels are more sonorous than higher vowels and peripheral vowels are more sonorous than central vowels. Kobon (Kenstowicz, 1997; Davies, 1981) provides an example of a stress pattern that reportedly makes full use of the sonority hierarchy and displays a five-way distinction between vowels in determining stress placement (4).

(3) Vowel sonority hierarchy (Kenstowicz, 1997)
a > o, e > u, i > ə > ɨ

(4) Kobon stress in Kenstowicz (1997)
Stress falls on the more sonorous vowel among the final two vowels, according to the sonority hierarchy in (3)

Encoding the sonority hierarchy in (3) using suprasegmental features would be an undesirable move: more sonorous vowels are greater in duration, but phonological length is arguably binary (Odden, 2011) and cannot represent the hierarchy in its full granularity; any other representation of vowel sonority as a suprasegmental property would require at least three features to capture the five-way distinction in (3) and would simply restate segmental features as suprasegmental. Assuming the existence of sonority-driven stress, Blumenfeld (2006) treated the universal asymmetry between stress and segmental features as a list of specific universals, one for every segmental feature but sonority:[1]

(5) Blumenfeld's list of universals:
a. The distribution of stress is never conditioned by aspiration
b. The distribution of stress is never conditioned by continuancy
c. The distribution of stress is never conditioned by stridency

[1] A few potential counterexamples to Blumenfeld's universals are discussed in section 5.7.

d. ...

Continuing a line of work by Hargus (2001), Blumenfeld (2006), Canalis (2007), de Lacy (2013), Shih (2016), and Bowers (2016), I re-evaluate the evidence for sonority-driven stress. My main claim in this paper is that reported patterns of sonority-driven stress do not in fact require direct reference to sonority, either because they have been mis-analyzed or because they can be reanalyzed without reference to sonority. If this claim is correct, the result is that Blumenfeld's list of universal asymmetries between stress and segmental features becomes a generalization over all segmental features. This generalization is given in (6) as the *Stress-Encapsulation Universal*.

(6) *The Stress-Encapsulation Universal*
The distribution of stress is never conditioned by segmental features

1.2 The Modularity Hypothesis

Apart from establishing the Stress-Encapsulation Universal, my second goal in this paper is to propose a phonological architecture from which the universal can be derived.

Note, first, that the universal is surprising under existing theories of phonology. Rule-based theories of stress (e.g., Halle and Vergnaud, 1987; Idsardi, 1992; Hayes, 1995) have assumed a representational separation between stress and segmental features following Liberman and Prince (1977), who argued that the principles that govern the distribution of stress are fundamentally different from those that govern the distribution of segmental features. This view is illustrated in Figure 1 in which stress is represented on a separate plane and the planes intersect. The planar architecture does not predict an asymmetry between stress and segmental features: regardless of what the content of the planes is and regardless of how one interprets intersection, this architecture is completely symmetric. Intersection is a symmetric relation – if *A* intersects with *B* then *B* intersects with *A* – so there is no reason to expect any sort of asymmetric encapsulation given this architecture. Indeed, rule-based theories of stress have used rules that make direct reference to segment quality, and even if reference to segment quality can be avoided, the fact that stress rules would consistently ignore the same information in their input would be left as an accident.

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              *                   (*
  *          (*         *)        (*        *)        *
  |           |         |          |         |        |
-----------------------------------------------------------
  o     r     i    g    i    n     a    l    i    t   y
-----------------------------------------------------------
  |     \ /        \ /       \ /        \ /       \ /
  σ      σ          σ         σ          σ         σ
```

Figure 1: Planar architecture of phonology (modeled after a diagram in Halle, 1998). The stress plane (top) intersects with the syllable plane (bottom) at the level of segmental representation (middle).

In Optimality Theory (OT; Prince and Smolensky, 1993), stress and segmental processes are computed in parallel, and markedness constraints that trigger stress-sensitive segmental processes are symmetric and may be used to trigger quality-sensitive stress. An example is the markedness constraint in (7), which is a simplified version of the constraint that would trigger aspiration in English. This constraint can be satisfied by aspirating a prevocalic voiceless stop, but it can alternatively be satisfied by shifting away stress to a vowel that is not preceded by an unaspirated voiceless stop. Given such constraints, OT has no general way of banning quality-sensitive stress processes, as I discuss later in more detail.

(7) *tV́ = *unaspirated voiceless stop before a stressed vowel

The Stress-Encapsulation Universal can be derived in an architecture where the computation of stress has no access to segmental features. Information encapsulation of this kind is a hallmark of modular cognitive architectures, and it motivates a simple decomposition of phonology into modules that can capture the universal (cf. Scheer, 2016). The hypothesis, which I refer to as *The Modularity Hypothesis*, is given in (8). The stipulation in (8a) is meant to ensure that computations carried out in the stress module do not refer to segmental features. But (8a) is not enough. Segmental processes that rely on the position of stress require access to stress representations, implying that stress representations must be available wherever segmental processes are computed. The stipulation in (8b) will ensure that access to stress is not exploited outside of the stress module to manipulate stress representations with reference to segmental features.[2] As we will see shortly, the main component of the modular architecture that restricts the interaction between stress and segmental features is the interface. A concrete theory of the interface to the stress module that specifies what information stress can access will determine the range of possible stress-segmental interactions.

(8) *The Modularity Hypothesis*
Stress is computed in an informationally encapsulated module with the following properties:
  a. The input to the stress module excludes representations of segmental features
  b. Outside of the stress module, stress representations cannot be changed

The move from Blumenfeld's list of universals in (5) to the Modularity Hypothesis in (8) would be a desirable theoretical result. First, it eliminates a list of specific stipulations from the theory and replaces them with a simple statement about information encapsulation. It thus achieves greater restrictiveness through a significant simplification of the theory. Modularity can also help us understand differences between stress and segmental computation that go beyond information encapsulation. In addition to encapsulation, phonological computation shows another hallmark of modularity recently discovered by Heinz (2014). Heinz observed that the computational complexity of attested stress patterns goes beyond that of segmental patterns (including long-distance

[2] How access to stress can be exploited to change the location of stress depends on the formalism. Suppose that the component responsible for stress-sensitive segmental processes is rule-based, using rules of the form $A \rightarrow B/X \_ Y$. Then at least XAY should be able to refer to stress information, and nothing in principle prevents B from doing so as well. If the component in question is implemented using OT and its input contains stress information, nothing in principle prevents GEN from generating candidates with unfaithful stress.

patterns like harmony). In particular, stress patterns can require exactly one primary stress per word, but segmental patterns that require exactly one e.g. sibilant per word are unattested. This distinction places stress and segmental phonology in two different domains of the Subregular Hierarchy, a hierarchy of formal languages contained in the regular class of the Chomsky Hierarchy. A modular architecture allows for a simple account of this distinction in terms of separate limitations on the computational power of each module.

Given the theoretical advantages of the Modularity Hypothesis, my approach to evaluating counterexamples to the Stress-Encapsulation Universal is to require conclusive evidence against it: I will take a tie between a sonority-driven analysis and an alternative that respects encapsulation to be sufficient to reject the evidence for sonority-driven stress in a given language.

1.3 Outline of the paper

The claim that the computation of stress is blind to segmental features can only be evaluated given a concrete phonological architecture. My first step is therefore to develop the basic properties of a modular architecture – the theory of the interface to the stress module and the interaction between the stress module and the rest of the grammar (section 2). After developing the modular architecture, I present some of its predictions regarding possible stress patterns (section 3). Then, using the perspective provided by that architecture, I take a closer look at patterns of sonority-driven stress reported in the literature. I first provide a general overview of those patterns (section 4) and then re-evaluate individual cases in more detail (section 5). Finally, I discuss non-modular accounts of encapsulation and show that they face non-trivial challenges in accounting for the Stress-Encapsulation Universal (section 6).

2 A modular architecture

2.1 The role of the interface

According to the Modularity Hypothesis in (8), the stress module has no access to segmental features. Stress can only see other suprasegmental information, which serves as the interface between the stress module and the rest of phonology. In this architecture, segmental features can only affect stress indirectly through the interface. To illustrate the role of the interface, consider the representation of the made-up word in Figure 2. At the top, a stress representation is given in a grid-based theory of stress where asterisks indicate prominence, as in Prince (1983) and Halle and Vergnaud (1987). Below stress, a skeletal representation is given which encodes the distinction between consonants and vowels (the CV tier of McCarthy, 1979b and Clements and Keyser, 1983). The segmental representation at the bottom is connected to the skeletal representation using association lines.

		*								line 2
Stress representation		*				*	*			line 1
		*				*	*		*	line 0
Skeletal representation	C	V	C	C	C	V	V	C	V	
	|	|	|	|	|	\	/	|	|	
Segmental representation	l	i	n	ɡ	k	a		r	ɔ	

Figure 2: Representation of the made-up word lı́ngkaːrɔ

Suppose now that the stress module has access to the skeletal CV tier (and to association lines) but not to segmental representations (this assumption is only used for illustration and will be replaced below with a concrete proposal). This assumption about the interface separates possible statements that could be made in the stress module from impossible statements. Stated informally in grid-theory terms, examples of possible statements are that 'every vowel projects an asterisk to line 0' and that 'the leftmost vowel projects an asterisk to line 2', as neither statement makes reference to segmental features. Examples of impossible statements are that 'every *low* vowel projects an asterisk to line 0' and that 'every vowel followed by a *flap* projects an asterisk to line 1', as both reference segmental features (*low* and *flap* respectively). In contrast, since a property like *length* is represented at a suprasegmental level – a long vowel is associated with two V slots in Figure 2 – stress may be sensitive to length. More generally, if stress is conditioned by some phonological distinction, that distinction must be represented at some suprasegmental level. With this background in hand, I proceed to propose a concrete theory of the interface.

2.2 A theory of the interface

My strategy in constructing the theory of the interface is to start with the bare minimum assumptions regarding the information that stress can access and complicate the theory incrementally only when necessary. Simple patterns of quantity-sensitive stress suggest that vowel length and the distinction between consonants and vowels are important for determining stress placement. For example, in Classical Arabic and some of its colloquial dialects, a word-final CVVC sequence (where VV stands for a long vowel) always receives primary stress, but a final CVC sequence does not; similarly, a final CVCC sequence is always stressed but a final CVCV is not (McCarthy, 1979a; Watson, 2002). Since the CV tier encodes those two properties as suprasegmental, it makes sense to take it as an initial hypothesis regarding interface representation. My first version of the theory of the interface, given in (9), is that interface representations are a subset of the set of strings that can be written using the symbols C and V. The asterisk in (9) stands for the Kleene Star Operator.

(9) *Theory of the interface* (to be updated below in (12))
Interface representations are a subset of Σ^* where $\Sigma = \{C, V\}$

2.2.1 Syllable structure

A CV tier is not enough to capture all attested stress patterns. In some languages, segmental features determine syllable structure which in turn affects the position of stress. A simple example comes from Latin (10) (see Allen, 1973 and Mester, 1994 for general analyses of Latin stress and Lahiri, 2001 for a discussion of the significance of syllable structure to Latin stress). In (10a), the penultimate syllable is a heavy CVC syllable which attracts stress, and stress is penultimate. In (10b), the penultimate syllable is a light CV syllable, and stress is antepenultimate. The only relevant difference between the two words is the underlined consonant. In (10b), that consonant is the liquid [r], which allows the preceding consonant to join it into the complex onset of the final syllable, which in turn makes the preceding syllable light. In (10a), that consonant is the non-liquid [t], which cannot function as the second member of a complex onset and thus forces the preceding consonant to be parsed as a coda consonant.

(10) Indirect effect of liquidity on stress in Latin
  a. [vo.lúp.tas] (non-liquid)
  b. [vó.lu.kris] (liquid)

To accommodate such patterns, the input to the stress module should include information about syllable structure. Assuming a CV tier, information about syllable boundaries (without internal syllable structure) will be enough. (11) shows that the difference between the two words can be captured through a distinction in the position of the dot, which indicates a syllable boundary.

(11) a. [voluptas] ↔ [CV.CVC.CVC]
  b. [volukris] ↔ [CV.CV.CCVC]

The second version of the theory of the interface, given in (12), includes the new symbol '.' (dot) in the set of interface symbols.

(12) *Theory of the interface* (to be updated below in (16))
  Interface representations are a subset of Σ^* where $\Sigma = \{C, V, .\}$

2.2.2 Empty vowels

In section 4, we will see stress patterns in which stress avoids reduced vowels like schwa ([ə]). A simple example comes from French:

(13) *French stress* (violates encapsulation given (12))
  Stress is final unless the final vowel is *schwa*, in which case stress is penultimate

This statement makes reference to vowel quality – it mentions schwa – so it is a direct counterexample to the Stress-Encapsulation Universal given my current assumptions about the interface. Since word-final schwas are not epenthetic in French (Anderson, 1982), a simple solution that assigns final stress before epenthesis is untenable. The present section introduces a representational mechanism proposed elsewhere in the literature that would allow me to encode the distinction between reduced and full vowels at the interface and avoid reference to vowel quality in the analysis of stress patterns like that of French.

Vowels like schwa exhibit special distributional properties that have motivated various representations of them as structurally deficient segments. In Dutch, for example, Kager (1990) notes that schwa is unstressable and that it is invisible to some syllable-sensitive processes and phonotactic restrictions: some segmental combinations (/h/, /ŋχ/, and /diphthong+r/) occur before full vowels but are banned syllable-finally and before schwa; consonant clusters are broken up by epenthesis syllable-finally and before schwa but not before full vowels; and so on. Kager argues that a structural representation of schwa as a defective vowel that cannot be the nucleus of a syllable provides the best account of its behavior: if stress is a property of syllables, then schwa's inability to be the head of a syllable accounts for its unstressability; and if consonants immediately preceding schwa have no choice but to close the preceding syllable, it follows that schwa is preceded by a syllable boundary.[3] While Kager's original generalizations have been challenged in later literature, his insight that the distributional properties of schwa follow from its structural deficiency has remained (van Oostendorp, 1997). In a similar vein, Anderson (1982) argues that the distribution of schwa in French involves an alternation between [œ], [ɛ], and ∅ (it is not pronounced in some environments). He shows that /œ/ and /ɛ/ are not possible underlying representations for schwa and is left to conclude that its underlying representation is ∅. Since the position in which schwas occur is unpredictable, schwa cannot be epenthetic. Consequently, Anderson develops an autosegmental analysis of schwa as a skeletal V slot that lacks any association to segmental features. That V slot is assigned segmental features in some environments in the course of the derivation; otherwise, it is not pronounced. I will refer to V slots that are not associated to any segmental features as *empty vowels*. The representation of empty vowels is given in (14) and a sample spell-out rule for empty vowels is given in (15). Empty vowels or other implementations of structural deficiency have been defended by Levin (1985), Rubach (1986), Szpyra (1992), Zoll (1996), van Oostendorp (1997), and Kiparsky (2003), among others, and have played a central role in the literature on Government Phonology (see especially Lowenstamm, 1996 and Scheer, 2004).

(14) Representation of empty vowels

	Empty vowel	Low central vowel
Skeletal representation	V	V
	$\vert$	$\vert$
Segmental representation	[ ]	[a] = [+low,+back,. . .]

(15) Sample spell-out rule for empty vowels

$$\begin{array}{ccc} \mathrm{V} & & \mathrm{V} \\ | & \Rightarrow & | \\ [\ ] & & [\text{ə}] \end{array}$$

[3] Kager's original argument is stated within a moraic framework, where the structural deficiency of schwa is implemented as weightlessness. I have restated the argument here in mora-free terms without affecting its force, as far as I can tell.

If reduced vowels like [ə] are structurally distinct from full vowels, it is a natural move to assume that the stress module can be sensitive to that distinction. I will adopt empty-vowel representations along with the assumption that the stress module can see the binary distinction between an empty vowel and a non-empty vowel at the interface. Formally, empty vowels receive the special skeletal symbol $V_{\emptyset}$ which I add to the set of interface symbols:

(16) *Theory of the interface* (final)
Interface representations are a subset of Σ^* where $\Sigma = \{C, V, V_{\emptyset}, .\}$

The updated theory of the interface enables a restatement of French stress that ignores schwa and does not violate encapsulation:

(17) *French stress* (respects encapsulation given (16))
Stress the final V

At present, I do not impose any restrictions on empty-vowel representations other than what is already implied by their definition – namely, that there is a one-to-one mapping between the symbol $V_{\emptyset}$ and its segmental content (18). I also do not posit any restrictions on empty-vowel spell-out rules.[4]

(18) $V_{\emptyset} \leftrightarrow []$

Below I will show that the theory of the interface in (16) can take us quite far in reanalyzing sonority-driven stress patterns, and I will discuss some typological consequences of representing reduced vowels as empty vowels at the interface.

2.3 Interaction between stress and the rest of the grammar

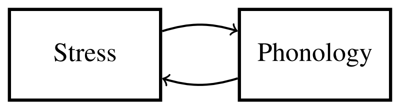
The Modularity Hypothesis in (8) only concerns the relationship between stress and segmental features. It has nothing to say about other aspects of phonology or where they are computed. If, for example, the distribution of tone can be conditioned by segmental features (see Tang 2008 and references therein), then at least some aspects of the computation of tone would have to take place outside of the module in which stress is computed. As it currently stands, the Modularity Hypothesis does not preclude non-stress computation from taking place in the stress module as long as it makes no reference to segmental features. It is conceivable, then, that a process like final-vowel lengthening would be computed in the same module as stress. In what follows, I will tentatively name the modules *Stress* and *Phonology* where *Phonology* minimally includes segmental computation.

In discussing the interaction between stress and phonology, it would be helpful to make use of the terms *Interactionist* and *Non-Interactionist* sometimes used in the literature to describe models of modular interaction. An interactionist architecture for stress and phonology would be one where stress and segmental processes are interspersed and the grammar goes back and forth between stress and non-stress computation given

[4]This means, for example, that any vowel could be empty, including sonorous vowels like [a]. In my analyses below, empty vowels will always be associated with low-sonority vowels such as [ə] and [i]. The theory is compatible with restrictions on the realization of empty vowels and they can be added if needed.

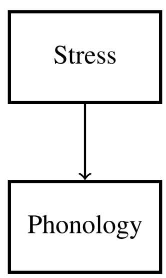
some ordering, as schematized in (19). Examples of interactionist architectures for the interaction between morphology and phonology include Lexical Phonology and Morphology (Pesetsky, 1979; Kiparsky, 1982) and Stratal OT (Kiparsky, 2000).

(19) Interactionist architecture



In a non-interactionist architecture, stress computation would precede segmental computation in every cycle, as schematized in (20) (the reverse order is untenable because stress assignment can feed segmental processes within the same cycle – see, e.g., Noyer, 2013). For the interaction between morphology and phonology, a non-interactionist architecture was adopted in SPE (Chomsky and Halle, 1968) and later work in Distributed Morphology following Halle (1990).

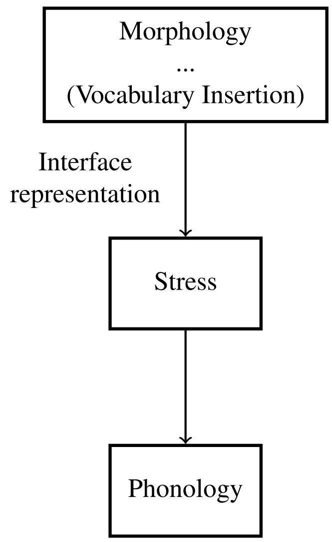
(20) Non-Interactionist architecture



The non-interactionist architecture for stress and phonology is both simpler and more restrictive than the interactionist architecture. It is simpler since the grammar includes just one instruction to move once from stress to phonology as opposed to multiple instructions to move back and forth between the modules; and it is more restrictive since the requirement that all stress processes precede all segmental processes in every cycle reduces the range of possible orderings. It makes sense, then, to take the non-interactionist architecture as the null hypothesis and abandon it only in the face of sufficient evidence to the contrary.

The final architecture is schematized in (21) and the computation proceeds according to the order of operations in (22). First, underlying phonological representations are inserted using an operation like Vocabulary Insertion (Halle and Marantz, 1993). The interface representation is computed based on the phonological representation (which includes segmental information) and is sent off to the stress module. The output of the stress module is sent back and the derivation proceeds to the phonology. Since segmental features are not sent off to the stress module but are accessible again in the phonology, this is not a classical feed-forward architecture. The operations in (22) can be read as a sequence of instructions to a central processor. The stress module serves as a function that receives a representational chunk as an input from the central processor and returns an output.

(21) Hypothesis about the architecture of grammar



(22) Order of operations

1. Insert underlying phonological representation
2. Construct interface representation
3. Send interface representation to the stress module
4. Receive interface representation from the stress module
5. Send phonological representation to the phonology

3 Predictions regarding possible patterns

With a concrete modular architecture in hand, my next goal is to explore its predictions regarding possible stress patterns. Before doing so, I would like to mention an open issue for this approach that I do not resolve in this paper.

A modular architecture with encapsulation can sometimes derive patterns that are extensionally equivalent to quality-sensitive stress patterns (derived in architectures with no encapsulation). In such cases, translating encapsulation to predictions regarding possible patterns is not straightforward. To see why, recall that a modular architecture is necessarily serial, because stress and segmental processes are not computed together and, for example, stress can feed segmental processes. In a serial architecture, quality-sensitive stress can be mimicked in indirect ways, such as using a suprasegmental property as a diacritic for the sole purpose of determining stress placement. The grammar in (23) follows a general rule schema that lengthens vowels in some segmental environment only to shorten them back after stress assignment. The result is equivalent to quality-driven stress.

(23) Grammar:

1. $V_{[+F]} \rightarrow$ long / A _ B
2. Assign stress to {every long vowel / the rightmost long vowel / ...}
3. $V_{[+F]} \rightarrow$ short / A _ B

This grammar combines two properties whose existence has been long debated in the literature. First, it involves so-called 'Feeding Duke-of-York' derivations (see McCarthy, 2003), where a process that changes A into B feeds some process P, before another rule changes B back into A and removes the environment of P. The second property is a version of 'Absolute Neutralization' where a feature (*long* in the example above) is eliminated from surface representations completely (see Kiparsky, 1968; Hyman, 1970; McCarthy, 2005). To my knowledge, grammars like (23) that combine both properties are unattested independently of stress-segmental interactions, but I am not aware of a satisfying account of their absence within serial architectures. If such grammars are unavailable, though, encapsulation could derive interesting predictions regarding possible patterns which I would like to explore in this section. The predictions I discuss next are therefore conditional on grammars like (23) being unavailable: I will assume that using suprasegmental features as diacritics as in (23) is not an option, but at present I leave as a black box a formal explanation for why this is so.

3.1 Prediction regarding vowel invisibility to stress

The theory of the interface in (16) predicts that distributional differences between distinct vowels with respect to stress should be limited to the binary distinction between non-empty vowels and the empty vowel. In some languages, a distinction has been reported between multiple full vowels and multiple reduced vowels, such that the latter are invisible to stress. Since the empty vowel as defined in section 2.2.2 is unique (the symbol $V_{\emptyset}$ corresponds to no segmental features), the theory makes the following prediction regarding invisibility to stress in such languages:

(24) *Prediction regarding invisibility to stress*
All vowels that are invisible to stress must be either epenthetic or (underlyingly) empty[5]

To illustrate this prediction, consider a hypothetical language where stress falls on the final vowel but shifts left when the final vowel is a schwa or an [a], but only when [a] is followed by a glottal stop ([ʔ]). Some examples are given in (25). If epenthesis is not involved, the only way to account for the data systematically is by deriving [a] from schwa precisely where [a] is skipped. In other words, the modular architecture forces the existence of a vowel lowering process that turns schwa into [a] before [ʔ], a process familiar from Semitic languages. In such cases we would expect lowering to leave some distributional signature. For example, the sequence [əʔ] could be unattested in the language and rejected by speakers (26a), or, if lowering only applies before coda glottal stops, adding a suffix with a vowel could reveal a schwa before the glottal stop (26b).

[5] Leaving aside other options, like underlying glides undergoing vocalization or extrametrical suffixes.

(25) Hypothetical pattern: final stress skips [ə] and [aʔ]

a. kogá
b. kógə
c. kogɨ́ʔ
d. kógaʔ

(26) Possible distributional signatures of lowering

a. *əʔ
b. kógaʔ ~ kógəʔ-i

The theory rules out stress patterns where stress skips two distinct vowels whose distribution is unpredictable. In section 5.1 I will discuss the stress pattern of Mari, where stress skips multiple surface-distinct vowels and the prediction in (24) is borne out: all skipped vowels can be traced back to an underlying schwa. I would like to note that even if this prediction turns out to be false, the revision required from the theory would not necessarily be dramatic. The prediction results from a particular implementation of empty-vowel representations that enforces a one-to-one mapping between the interface symbol $V_\emptyset$ and the vocalic features that it is associated to (namely, no features). We could imagine a less restrictive variant of the theory that allows a many-to-one mapping between vowels and the symbol $V_\emptyset$ which would not make the prediction in (24). Instead, stress would be able to skip a set of derivationally unrelated vowels (corresponding to $V_\emptyset$) as long as it treats them in the same way. As a matter of methodology, it makes sense to retreat to the less restrictive variant only given sufficient evidence against (24).

3.2 Prediction regarding segmental restrictions on stress alignment

If the computation of stress has no access to segmental features, the assignment of stress to the rightmost or leftmost vowel in some segmental environment is impossible. A general statement of the class of patterns that is ruled out is given in (27).

(27) *Segmental restrictions on stress alignment*
'stress the rightmost/leftmost vowel V such that $f(\mathrm{V})$',
where $f(\mathrm{V})$ is a description of the identity or environment of V that makes reference to segmental features

Examples of unattested stress patterns in this class are the following:

(28) Stress the leftmost round vowel

(29) Stress the penultimate syllable, but if it has an unaspirated onset, stress the antepenultimate syllable

(30) Stress the rightmost vowel not preceded by an unaspirated obstruent

The patterns in (28) and (29) are simple and do not require further elaboration. According to (30), stress seeks the rightmost vowel but shifts left whenever a vowel is preceded by an unaspirated obstruent (like [t]). This pattern is illustrated in (31). In (31a), stress is final since the final vowel is preceded by an aspirated stop. In (31b), the final consonant is unaspirated, so stress shifts once to the left. It remains on the penultimate vowel since the preceding consonant is an aspirated stop. In (31c), the penultimate consonant is an unaspirated stop as well. Stress is antepenultimate since the antepenultimate vowel is preceded by another vowel (and not by an unaspirated stop).

(31) a. [titatut^{h}ó]
b. [titat^{h}ú$\underline{\text{t}}$o]
c. [tiá$\underline{\text{t}}$u$\underline{\text{t}}$o]

Patterns with a stress shift along the lines of (29) and (30) can be easily generated in OT using the markedness constraint *tV́ to trigger stress shift.[6]

3.3 Prediction regarding destressing

If the stress module has no access to segmental features, feature-specific destressing processes cannot be stated. A general statement of the class of patterns that is ruled out is given in (32), followed by some examples of patterns in this class.

(32) *Feature-specific destressing*
'Delete stress from a vowel V such that f(V)',
where f(V) is a description of the identity or environment of V that makes reference to segmental features

(33) a. Pre-stress destressing of low or front vowels
b. Pre-stress destressing of vowels preceded by an unaspirated obstruent
c. Destressing of high vowels

To illustrate (33a), imagine a language that assigns stress to the final vowel of the stem regardless of the identity of the vowel (34). Then, a lexically-stressed suffix is added and creates a sequence of two stressed vowels (35). Finally, only non-low back vowels maintain stress (36).

(34) Stem-final stress
a. [CVCáC]
b. [CVCíC]
c. [CVCúC]

(35) Lexically-stressed suffix creates a clash
a. /CVCáC-ó/
b. /CVCíC-ó/

[6]The precise nature of the shift in (30) will vary depending on the constraints used to generate rightmost and leftmost stress effects. For example, OT with gradient alignment constraints will be able to generate precisely the pattern in (30).

c. /CVCúC-ó/

(36) Only non-low back vowels maintain stress

a. [CVCaC-ó]

b. [CVCiC-ó]

c. [CVCúC-ó]

Similarly, an example of (33b) is a language that assigns stress to the final vowel of the stem regardless of its segmental environment (37). Then, as before, a lexically-stressed suffix is added and creates a sequence of two stressed vowels (38). Finally, only vowels preceded by a unaspirated obstruent lose stress (39).

(37) Stem-final stress

a. [CVt^háC]

b. [CVCnáC]

c. [CVCtáC]

d. [CVCuáC]

(38) Lexically-stressed suffix creates a clash

a. /CVt^háC-ó/

b. /CVCnáC-ó/

c. /CVCtáC-ó/

d. /CVCuáC-ó/

(39) Only vowels preceded by an unaspirated obstruent lose stress

a. [CVt^háC-ó]

b. [CVCnáC-ó]

c. [CVCtaC-ó]

d. [CVCuáC-ó]

The destressing process in (33c) can create unattested vowel-specific gaps in alternating stress. Suppose that a language assigns alternating stress as in (40a) and deletes stress from every high vowel (40b).

(40) a. Stress every second vowel from the left

b. Destress a high vowel

The result is a pattern where words with only non-high vowels have stress on every second vowel from the left (41) but words with high vowels have gaps in alternating stress such that a stressed vowel may be preceded or followed by three unstressed vowels (42).

(41) Words with only non-high vowels: alternating stress

a. [CaCóCoCáCa]

b. [CaCóCoCáCaCó]

(42) Words with high vowels: gaps in alternating stress

a. [CaCi̱CoCáCa]

b. [CaCóCoCu̱CaCó]

3.4 Prediction regarding indirect effects of segmental features on stress

If the interface only allows segmental features to affect stress indirectly through syllable structure, we make the prediction in (43) regarding indirect effects of segmental features on stress placement:

(43) *Prediction regarding indirect effects of segmental features on stress*
Indirect effects of segmental features on stress should have a distributional signature expressed in terms of syllable structure

Consider again the Latin stress pattern, where the presence of a liquid affects stress (44). This effect is mediated by syllable structure: [pt] is broken up by a syllable boundary but [kr] is not. There is an independent restriction on complex onsets in Latin such that a consonant-liquid complex onset like [kr] is allowed but other consonant-stop complex onsets like [pt] are not. What is ruled out is a language that has the same stress pattern as Latin but without the distributional restriction on complex onsets.

(44) a. [volúp.ṯas] (non-liquid)

b. [vólu.kṟis] (liquid)

4 Sonority-driven stress in the literature

Previous studies on the phonology of stress include analyses of stress patterns that make direct reference to vowel sonority, thus violating the Stress-Encapsulation Universal. The present section provides a brief history of sonority-driven stress in the literature and its role in the development of theories of stress.

My starting point is Halle and Vergnaud (1987), whose grid-based theory of stress explicitly allows vowel quality to influence the distribution of stress through prominence. Halle and Vergnaud (1987) is by no means the first work to discuss patterns of sonority-driven stress – see references to earlier work in Gordon (1999/2006) – but it will be a convenient point of departure for discussing the role of vowel quality in stress theory. On Halle and Vergnaud's theory (following Liberman and Prince, 1977; Prince, 1983), asterisks indicate prominence and higher lines on the grid correspond to greater prominence (see Figure 2). Metrical constituents are constructed based on the lines of asterisks. Importantly, an element's degree of prominence can be determined by its quality. Stress rules explicitly refer to quality in Halle and Vergnaud's analysis of the default-to-opposite pattern in (45a) that distinguishes full from reduced vowels, reportedly found in 6 languages. Halle and Vergnaud's rule in (45b) is the one that refers to quality, and their system imposes no restrictions on how quality can be used in the description of stress rules.

(45) Sonority-driven stress pattern in Halle and Vergnaud (1987: 51)

a. Stress falls on the last syllable that has a full vowel, but in words where all syllables have only reduced vowels, stress falls on the first syllable

b. Rule: Assign line 1 asterisks to **full** vowels

A more fine-grained sensitivity to vowel quality was considered by Hayes (1995), who developed a theory of stress based on the stress patterns of more than 150 languages. Asheninca, as described by Payne (1990), is the only language in Hayes (1995) whose stress pattern is sensitive to vowel quality. Drawing on Payne's description, Hayes' analysis of Asheninca associates syllables with different degrees of prominence based on vowel length and quality:

(46) Asheninca hierarchy of prominence in Hayes (1995)

***	CVV
**	Ca, Co, Ce, CiN (N = nasal consonant)
*	Ci

The rhythmic aspect of Asheninca stress is not sensitive to vowel quality: on both Payne's and Hayes' analyses, metrical constituents are built based on quantity alone. The basic rhythmic pattern can be perturbed by processes such as destressing that are sensitive to the prominence hierarchy in (46). Hayes divided stress rules into two subsets, foot construction rules and rules like destressing, end rules (which refer to edges), and extrametricality. He suggested that foot construction is encapsulated from vowel quality but that other rules are not (without developing the architecture responsible for semi-encapsulation in much detail).[7]

In the early OT literature, Kenstowicz (1997) claimed that stress is sensitive to vowel sonority based on the distribution of stress in several languages (Kobon, Chukchi, Aljutor, Mari, and Mordwin). He proposed a hierarchy of markedness constraints that makes more sonorous vowels better stress-bearers. Notably, Kenstowicz offered the fine-grained sonority hierarchy in (47) for Kobon stress. On his analysis, Kobon stress is sensitive to a five-way distinction in terms of vowel quality. Following Kenstowicz's analysis, Kobon has become a showcase pattern of sonority-driven stress. The markedness theory of sonority-driven stress was further developed in a series of works by de Lacy (2002, 2004, 2007) with support from several more languages.

(47) Kobon stress in Kenstowicz (1997)

a. Stress falls on the more sonorous vowel among the final two vowels, according to the sonority hierarchy in (47b)

b. a/au/ai > o/e > u/i > ə > ɨ

Gordon's (1999/2006) survey of 388 languages provided cross-linguistic support for Kenstowicz's small survey, reporting 28 languages with sonority-sensitive stress patterns. A rough classification of those patterns according to their type of sonority-sensitivity is given in (48). Type I is of languages that show a distinction between full

[7] Hayes also allowed segmental features to project directly into the prominence grid in the analysis of Pirahã (Everett and Everett, 1984; Everett, 1988), where stress assignment has been claimed to be sensitive to the [voice] feature of the onset. See discussion of consonantal features in section 5.7.

and reduced vowels and where stress often skips reduced vowels. Out of 28 languages with sonority-driven stress in the survey, 20 are of Type I. Type II is of languages where the low vowel attracts stress as opposed to every other vowel (5/28). Finally, Type III is of languages where stress is sensitive to a fine-grained sonority hierarchy based on vowel height or peripherality (3/28).

(48) Sonority-driven stress in Gordon (1999/2006) (my classification)

- **Type I**: Full vs. reduced vowels (20/28)
  - Aljutor, Au, Chuvash, Javanese, Karo Batak, Lamang, Lillooet, Lushootseed, Malay, Mari, Mordvin, Moro, Nankina, Ngada, Patep, Sarangani Manobo, Sentani, Siraiki, Vach Ostyak, Yil
- **Type II**: Low vowel vs. other vowels (5/28)
  - Gujarati, Kara, Komi, Mayo, Yimas
- **Type III**: Fine-grained sonority hierarchy based on vowel height or peripherality (3/28)
  - Asheninca, Chukchi, Kobon

Following the works of Hayes, Kenstowicz, de Lacy, and Gordon, the existence of sonority-driven stress has been taken for granted in the literature and the theoretical apparatus introduced in those works has influenced later studies on stress. Later works that introduce sonority-driven stress patterns include Crowhurst and Michael (2005), Vaysman (2008), Trommer (2013), and Moore-Cantwell (2016).

Some of the reported cases have already been reanalyzed in the literature. Hargus (2001) suggested that sonority-driven stress can be reduced to quantity-driven stress based on the durational properties of reduced vowels in two languages, Sahaptin and Witsuwit'en. Shih (2016) conducted a phonetic experiment on Gujarati, a Type II language, and showed that low vowels claimed to attract stress do not in fact correlate with stress-related phonetics, suggesting that properties like length may have been misinterpreted as stress (see also Bowers, 2016). Canalis (2007) showed that the correlation between stress and vowel quality in Albanian (Type III, see Trommer, 2013) is due to morphological factors. Chukchi, another Type III language, was discussed by de Lacy (2013), who argued that descriptions of Chukchi stress as sonority-sensitive had been based on insufficient evidence from conflicting sources. More generally, de Lacy (2013) rejected the evidence for sonority-driven stress in his own work altogether.

In the next section I will re-evaluate the evidence for all of the remaining sonority-driven stress patterns in Halle and Vergnaud (1987), Hayes (1995), Kenstowicz (1997), Gordon (1999/2006), and patterns I have been able to find in later work (Nanti, Crowhurst and Michael, 2005; English, Moore-Cantwell, 2016). I will offer a general recipe for re-analyzing Type I patterns using empty-vowel representations at the interface, and I will claim that there is no convincing evidence for any Type II or Type III patterns. The tables in (49)-(53) summarize the list of sonority-driven stress languages in Halle and Vergnaud (1987), Hayes (1995), Kenstowicz (1997), Gordon (1999/2006), and later work and state where each language is re-evaluated. In the columns labeled 'Status', I use the word 'Reanalysis' for cases where an alternative analysis that does not make direct reference to sonority is presented. ‘Discussion’ is used for cases where a convincing alternative is not presented but a critical discussion of the evidence is provided that I believe weakens the case for sonority-sensitivity.

(49) Sonority-driven stress in Halle and Vergnaud (1987)

Language	Type	Status
6 languages	I	Recipe for reanalysis in section 5.1

(50) Sonority-driven stress in Hayes (1995)

Language	Type	Status
Asheninca	III	Discussion in section 5.3

(51) Sonority-driven stress in Kenstowicz (1997)

Language	Type	Status
Kobon	III	Reanalysis in section 5.2
Chukchi	III	Data re-evaluated in de Lacy (2013)
Aljutor	I	Recipe for reanalysis in section 5.1
Mari	I	Reanalysis in section 5.1
Mordwin	I	Recipe for reanalysis in section 5.1

(52) Sonority-driven stress in Gordon (1999/2006)[8]

Language	Type	Status
20 languages	I	Recipe for reanalysis in section 5.1
Gujarati	II	Data re-evaluated in Shih (2016) and Bowers (2016)
Kara	II	Reanalysis in Blumenfeld (2006)
Komi	II	Re-evaluation in footnote 8
Mayo	II	Reanalysis in section 5.5
Yimas	II	Discussion in section 5.3
Asheninca	III	Discussion in section 5.3
Chukchi	III	Data re-evaluated in de Lacy (2013)
Kobon	III	Reanalysis in section 5.2

(53) Sonority-driven stress in later literature

Language	Source	Status
Nanti	Crowhurst and Michael (2005)	Discussion in section 5.4
Albanian	Trommer (2013)	Reanalysis in Canalis (2007)
English	Moore-Cantwell (2016)	Reanalysis in section 5.6

5 Re-evaluation of sonority-driven stress patterns

5.1 Reanalysis of Mari stress

This section provides a general recipe for reanalyzing Type I patterns of sonority-driven stress, where stress is sensitive to the distinction between full and reduced vowels. The

[8]The generalization regarding stress in Komi is described in the sources as a diachronic pattern, so I do not discuss it further (see Hausenberg, 1998).

key ingredient in the analysis is the representation of reduced vowels as empty vowels at the interface. The language that I reanalyze is Eastern Mari (henceforth Mari) as described in Vaysman (2008). Mari was chosen over other Type I languages for two reasons. First, it appears to be a challenging case to the binary distinction between empty and non-empty vowels at the interface. Mari stress often skips schwas, but there is no one-to-one correspondence between schwas and vowels skipped by stress, in both directions (some full vowels are skipped and some schwas are stressed). Mari thus makes a good test case for the prediction in (24). The second reason is that the claims in Vaysman (2008) are supported by rich data controlled for lexical category, morphosyntactic environment, and other factors, so the generalizations regarding stress placement are quite clear. I will begin by discussing stress in mono-morphemic words, all of which are underived nouns, and then proceed to discuss stress in morphologically complex words.

5.1.1 Mono-morphemic words

In mono-morphemic words, stress normally falls on the rightmost full vowel – the rightmost vowel that is not a schwa ([ə]):

(54) a. koŋgá 'oven'
b. sérəʃ 'letter'
c. jóŋələs 'mistake'
d. paréŋə 'potato'

Stress also skips vowels that alternate with schwa and are the result of vowel harmony:[9]

(55) a. pö́rʃö ~ pö́rʃə-m 'frost'∼'frost ACC'
b. ʃóʃo ~ ʃóʃə-m 'spring'∼'spring.ACC'

Finally, when every vowel in a word is a schwa, stress is initial:

(56) βə́nər 'canvas'

The pairs in (57) suggest that schwa is not epenthetic in Mari, as it is not possible to state a general schwa epenthesis rule that would insert the schwa in the second member of each pair without also inserting a schwa in the first member.

(57) a. kučém 'stress'
ürémə 'handle'
b. meráŋ 'hare'
paréŋə 'potato'

The basis of a modular analysis is that schwa and vowels derived from it through vowel harmony are underlyingly empty. The analysis is given informally using a serial rule-based formalism with rule ordering and cyclicity as in Halle and Vergnaud (1987) and

[9]Vaysman presents evidence for vowel harmony over a process that goes in the other direction (vowel reduction). The environment of application of vowel harmony is somewhat complicated; the precise details are not important for the analysis so I will not discuss them here.

assuming the architecture in (21), where stress rules precede segmental rules in every cycle. As far as I can tell, the choice of rules over constraints will not affect the analysis in any meaningful way, but serialism will be needed for a proper treatment of the opacity of Mari stress. A grammar for stress in mono-morphemic words is given in (58). The horizontal line marks the end of the stress rule block.

(58) A fragment of Mari grammar (to be revised below)

1. If no vowel is stressed, stress the rightmost V
2. If no vowel is stressed, stress the leftmost $V_\emptyset$

---

3. Vowel harmony
4. Empty-vowel spell-out ([] → [ə])

Here are some sample derivations. (59) shows a derivation of a word with a final schwa and penultimate stress. Rightmost stress applies and targets the penultimate vowel. Then leftmost stress and vowel harmony do not apply and the empty vowel is spelled out as schwa. (60) is an example with vowel harmony. As before, rightmost stress targets the penultimate vowel and leftmost stress does not apply. Then, vowel harmony applies and rewrites the final vowel as the full vowel [ö]. Since the final vowel is no longer empty, empty-vowel spell-out does not apply. Finally, (61) is a word that only contains schwas. Here all vowels are initially empty, so rightmost stress applies vacuously. Then leftmost stress applies and assigns initial stress.

(59) Derivation of [paréŋə]

$$\begin{array}{cccccccccccccccccccc}
C & V & C & V & C & V_\emptyset & & C & V & C & \acute{V} & C & V_\emptyset & & C & V & C & \acute{V} & C & V \\
| & | & | & | & | & | & \xrightarrow{\text{rightmost stress}} & | & | & | & | & | & | & \xrightarrow[\text{VH }(\emptyset),\ [\,] \to [\text{ə}]]{\text{leftmost stress }(\emptyset)} & | & | & | & | & | & | \\
p & a & r & e & \text{ŋ} & [\,] & & p & a & r & e & \text{ŋ} & [\,] & & p & a & r & e & \text{ŋ} & \text{ə}
\end{array}$$

(60) Derivation of [pö́rʃö]

$$\begin{array}{ccccccccccccccccc}
C & V & C & C & V_\emptyset & & C & \acute{V} & C & C & V_\emptyset & & C & \acute{V} & C & C & V \\
| & | & | & | & | & \xrightarrow{\text{rightmost stress}} & | & | & | & | & | & \xrightarrow[\text{VH, } [\,] \to [\text{ə}]\ (\emptyset)]{\text{leftmost stress }(\emptyset)} & | & | & | & | & | \\
p & \ddot{o} & r & \int & [\,] & & p & \ddot{o} & r & \int & [\,] & & p & \ddot{o} & r & \int & \ddot{o}
\end{array}$$

(61) Derivation of [βə́nər]

$$\begin{array}{ccccccccccccccccc}
C & V_\emptyset & C & V_\emptyset & C & & C & \acute{V}_\emptyset & C & V_\emptyset & C & & C & \acute{V} & C & V & C \\
| & | & | & | & | & \xrightarrow[\text{leftmost stress}]{\text{rightmost stress }(\emptyset)} & | & | & | & | & | & \xrightarrow[[\,] \to [\text{ə}]]{\text{VH }(\emptyset)} & | & | & | & | & | \\
\beta & [\,] & n & [\,] & r & & \beta & [\,] & n & [\,] & r & & \beta & \text{ə} & n & \text{ə} & r
\end{array}$$

5.1.2 Multi-morphemic words

The distribution of stress in suffixed words will be demonstrated using two suffixes, -lan (DATIVE case) and -ge (COMITATIVE case). First, when the root only contains full vowels, stress in the suffixed form is root-final:

(62) a. paʃá ~ paʃá-lan 'work'~'work.DAT'
b. paʃá ~ paʃá-ge 'work'~'work.COM'

When the root only contains schwas, stress falls on the suffix:

(63) a. rə́wəz ~ rəwəz-lán 'fox'~'fox.DAT'
b. rə́wəz ~ rəwəz-gé 'fox'~'fox.COM'

Finally, when the root has non-final stress, the two suffixes behave differently. -lan attracts stress from the root, but -ge does not:

(64) a. sérəʃ ~ serəʃ-lán 'letter'~'letter.DAT'
b. sérəʃ ~ sérəʃ-ge 'letter'~'letter.COM'

Vaysman takes stress attraction to be a general property of suffixes with the vowel [a] (as opposed to suffixes with the vowel [e]). However, the number of suffixes is very small: Vaysman reports 4 suffixes with [a] and 3 suffixes with [e], and it is possible that some idiosyncratic property of the morphemes is what causes their different behavior rather than the quality of the vowel. This property could be lexical stress or, in the cyclic framework of Halle and Vergnaud (1987) that I have been assuming here, the feature [±cyclic].[10] In the absence of evidence for choosing one option over the other, I will go with lexical stress. I will show that the assumption that suffixes like -lan are lexically stressed (whereas suffixes like -ge are not) is enough to derive the distribution of stress in suffixed words. Respecting encapsulation here comes with a price – a memorization of 4 instances of stress in the lexicon – but I believe that it is a small price to pay.[11] The correlation between lexical stress and vowel height is an accident on this analysis as far as the phonology is concerned, but it is not surprising once their acoustic correlates are considered. Lower vowels are characterized by greater duration, an acoustic properties that they share with stress, so they are expected to be more confusable with stress than higher vowels are (Lehiste 1970, Gordon 1999/2006). Channel bias (in the sense of Moreton, 2008) is an extra-phonological factor that could be responsible for such correlations on the surface. A way to argue against the lexical-stress analysis and in favor of the sonority-driven analysis is to show that speakers of Mari generalize the stress pattern to nonce suffixes with [a] (contrary to the prediction of lexical stress).

[10][+cyclic] suffixes trigger a pass through the cyclic rule block and can trigger stress rules that would not apply with [-cyclic] suffixes.

[11]Vaysman states that verbal suffixes behave like nominal suffixes in that [a] attracts stress but [e] does not. The data are not provided in Vaysman (2008), but the existence of additional [a]-suffixes would weaken the present analysis. Other sources on Mari morphology (e.g., Kangasmaa-Minn, 1998) distinguish two verbal declensions – *-am* and *-em* – but without stress data or a morphosyntactic analysis of those verbs it is difficult to determine whether more than one additional suffix (corresponding to *-am*) would have to be marked as lexically stressed on the present analysis.

The final version of the grammar in (65) includes the assumption regarding stress marking in the lexicon. The rules are divided into a cyclic component, which applies once whenever a morpheme is added in the derivation, and a post-cyclic component which applies once at the end of the derivation. Rightmost stress is a now a cyclic rule and the post-cyclic component includes two new destressing rules.

(65) A fragment of Mari grammar (final)

- Assumptions about the lexicon:
  - The suffix -lan bears stress
  - The suffix -ge does not bear stress
- Cyclic rules:
  1. If no vowel is stressed, stress the rightmost V
- Post-cyclic rules:
  2. If there are two consecutive stressed Vs, destress the rightmost V
  3. If there are two stressed Vs, destress the leftmost V
  4. If no vowel is stressed, stress the leftmost $V_{\emptyset}$

  ---

  5. Vowel harmony
  6. Empty-vowel spell-out ([] → [ə])

I will now show how this grammar accounts for the distribution of stress in (62)-(64), starting with the derivation of the two suffixed words in (62), given in (66). I will go through the derivation one rule at a time, considering the effect of each rule on both the lán-derivation and the ge-derivation. In the first cycle, the stem /paʃa/ is evaluated by itself and receives final stress. In the second cycle, the suffixes are added, -lán with lexical stress and -ge without any stress marking. Rightmost stress does not apply again since both representations are already marked for stress, and the representation is sent off to the post-cyclic component. In the post-cyclic component, post-stress destressing resolves the stress clash created by the addition of -lán by removing stress from the suffix. post-stress destressing does not apply with -ge since only one vowel is marked for stress. None of the remaining rules applies: the environment of pre-stress destressing includes two stressed vowels, vowel harmony is irrelevant here, initial stress does not apply since both representations are marked for stress at the time of its application, and empty-vowel spell-out is irrelevant. The result is stem-final stress in both words.

(66) Derivation of the suffixed words in (62)

Word	[paʃá-lan]	[paʃá-ge]
Cycle I	paʃa	paʃa
Rightmost stress	paʃá	paʃá
Cycle II	paʃá-lán	paʃá-ge
Rightmost stress	-	-
Post-cycle	paʃá-lán	paʃá-ge
Post-stress destressing	paʃá-lan	-
Pre-stress destressing	-	-
Vowel harmony	-	-
Leftmost stress	-	-
$V_\emptyset$ spell-out	-	-
Output	[paʃá-lan]	[paʃá-ge]

Next, (67) shows the derivation of the two suffixed words in (63) along with their unsuffixed variant. Here, square brackets indicate an empty vowel. In the first cycle, rightmost stress does not apply: it only targets full V's, but all vowels are empty ($V_\emptyset$). In the second cycle, the suffixes are added. Rightmot stress again does not apply to the unsuffixed stem. It does not apply in the lán-derivation because stress is already present, but it does apply in the ge-derivation and assigns final stress. This is how the difference between the two suffixes is neutralized when the stem only contains schwas. Next, destressing rules and vowel harmony do not apply, but initial stress targets the first vowel of the unsuffixed word. Then, the empty vowels are spelled out as schwas.

(67) Derivation of the words in (63)

Word	[rə́wəz]	[rəwəz-lán]	[rəwəz-gé]
Cycle I	r[]w[]z	r[]w[]z	r[]w[]z
Rightmost stress	-	-	-
Cycle II	-	r[]w[]z-lán	r[]w[]z-ge
Rightmost stress	-	-	r[]w[]z-gé
Post-cycle	r[]w[]z	r[]w[]z-lán	r[]w[]z-gé
Post-stress destressing	-	-	-
Pre-stress destressing	-	-	-
Vowel harmony	-	-	-
Leftmost stress	r[́]wəz	-	-
$V_\emptyset$ spell-out	rə́wəz	rəwəz-lán	rəwəz-gé
Output	[rə́wəz]	[rəwəz-lán]	[rəwəz-gé]

Finally, (68) shows the derivation of the two suffixed words in (64). In the first cycle, rightmost stress targets the penultimate vowel, which is the rightmost V. In the second cycle, rightmost stress does not apply. In the post-cyclic component, post-stress destressing cannot apply in the lán-derivation since the two stressed vowels are not adjacent. Pre-stress destressing does apply (since it does not require adjacency) and removes stress from the stem. Otherwise, only empty-vowel spell-out applies.

(68) Derivation of the suffixed words in (64)

Word	[serəʃ-lán]	[sérəʃ-ge]
Cycle I	ser[]ʃ	ser[]ʃ
Rightmost stress	sér[]ʃ	sér[]ʃ
Cycle II	sér[]ʃ-lán	sér[]ʃ-ge
Rightmost stress	-	-
Post-cycle	sér[]ʃ-lán	sér[]ʃ-ge
Post-stress destressing	-	-
Pre-stress destressing	ser[]ʃ-lán	-
Leftmost stress	-	-
Vowel harmony	-	-
$V_\emptyset$ spell-out	serəʃ-lán	sérəʃ-ge
Output	[serəʃ-lán]	[sérəʃ-ge]

As far as I can tell, the proposed analysis correctly derives the distribution of stress in all of the data in Vaysman (2008) without reference to vowel quality. Beyond Mari, the analysis demonstrates how the distinction between empty and non-empty vowels at the interface can be used to reanalyze Type I languages without reference to segmental features, even when stress skips multiple surface-distinct vowels.

5.2 Reanalysis of Kobon stress

The stress pattern of Kobon has been a showcase of sonority-driven stress and is famous for its fine-grained sonority hierarchy. The source of the claim regarding sonority-driven stress in Kobon is Davies (1981), which states:

> "The rules for positioning stress in two-syllable words have yet to be determined. Relative vowel strength is almost certainly a conditioning factor since *stress is almost always placed on the syllable which is strongest according to the following hierarchy*:
>
> (69) a/au/ai > o/e/u/i > ə/ɨ
>
> Almost all three-syllable words manifest [a] as the vowel of the penultimate syllable and all of these words carry stress on that penultimate syllable. The few words which do not manifest [a] as the vowel of the penultimate syllable also carry stress on the penultimate syllable unless the final syllable manifests a stronger vowel than the penultimate syllable, in which case stress falls on the final syllable. Such cases are very few."

The low vowel [a] and diphthongs containing the low vowel ([au] and [ai]) are at the top of Davies' sonority hierarchy. Lower in the hierarchy are the non-low non-central vowels [o], [e], and [u]. The central vowels [ə] and [ɨ] are the least sonorous.

Based on Davies' (1981) description, Kenstowicz (1997) proposed the following hypothesis for Kobon stress (which assumes a more fine-grained sonority hierarchy than Davies'):

(70) Kobon stress in Kenstowicz (1997)

a. Stress falls on the more sonorous vowel among the final two vowels, according to the sonority hierarchy in (70b)

b. a/au/ai > o/e > u/i > ə > ɨ

The data in (71)-(72) from Kenstowicz (1997) (citing Davies, 1981) are given to illustrate the sensitivity of stress to sonority. In (71), the final two vowels in each word differ in their sonority level. (71a) shows that [a] is a better stress-bearer than [o]: when [a] is the penultimate vowel and [o] is the final vowel, the penultimate vowel receives stress, but when the order of the two vowels is reversed it is the final vowel that receives stress. The remaining examples in (71) show that stress tracks sonority when other vowels are involved. When the final two vowels are of equal sonority, stress is penultimate (72).

(71) Vowels that differ in their sonority level
  a. [a > o]: alágo vs. kɨdolmáN
  b. [a > i]: ki.á vs. háu.i
  c. [o > u]: mó.u
  d. [o > i]: si.óg
  e. [i > ə]: wí.ər
  f. ...

(72) Vowels of equal sonority
  a. [u ~ u]: dúbu-dúbu
  b. [u ~ i]: jínup-jínup
  c. ...

Another source on Kobon is Davies (1980), a book on Kobon phonology (written by the same author) where the description of stress does not mention sonority. According to Davies (1980), Kobon stress is normally penultimate:

> "Although the rules for the placement of stress cannot be stated comprehensively at this stage, it appears that stress is not phonemic. In phonological words of more than one syllable *stress normally falls on the penultimate syllable*."

Davies (1980) is a book dedicated to Kobon phonology that includes around 500 examples marked for stress, compared to around 50 examples marked for stress in Davies (1981), which is a general Kobon grammar. Since the description of stress in Davies (1980) as normally penultimate was based on a larger corpus, it raises the question of whether the correlation between sonority and stress placement observed in Davies (1981) generalizes to the entire body of data in both sources. To answer that question, I have reorganized the data from both sources according to lexical category, morphosyntactic environment, and syllable structure, with the goal of comparing the sonority hypothesis in (70) with the penultimate-stress hypothesis. The first observation is that the data include examples that pose a challenge to both hypotheses. Each pair of nouns in (73)-(74) is a near-minimal pair that differs in the location of stress. Aside from stress, the only difference between words in each pair is the place of articulation of some nasal consonants.

(73) a. ɸə́nʌm 'wind' [33]
b. ɸəŋʌ́n 'sweet potato sp.' [33]

(74) a. ambáɲ 'platform' [34]
b. ámbaŋ 'a river name' [34]

There were also examples in the data that posed a challenge to the penultimate-stress hypothesis – words with a final stressed syllable that has a diphthong or a complex coda and words with final stress whose penultimate vowel is schwa. Based on these examples, and based on an examination of the entire data, I have revised Davies' (1980) penultimate-stress hypothesis as follows:

(75) Revised penultimate-stress hypothesis
a. Stress falls on the final syllable if it is heavy (has a diphthong or a complex coda)
b. If the penultimate vowel is $V_\emptyset$ and the final vowel is V, stress falls on the final vowel. ($V_\emptyset \rightarrow$ [ə])
c. Otherwise, stress is penultimate

There are at least two types of examples that could distinguish the revised penultimate-stress hypothesis in (75) from the sonority hypothesis in (70). Consider first words that have a final light syllable with a vowel that is more sonorous than the penultimate (non-schwa) vowel, such as [kɨdolmán] and [gían]. Here the sonority hypothesis predicts final stress but the revised penultimate-stress hypothesis predicts penultimate stress. Consider now words that have a final heavy syllable with a vowel that is not more sonorous than the penultimate vowel, such as [rálempʰ]. Here the sonority hypothesis predicts penultimate stress but the revised penultimate-stress hypothesis predicts final stress.

The result is that the two hypotheses are nearly equally successful, with 6 examples that support the sonority hypothesis and 7 examples that support the revised penultimate-stress hypothesis (76).[12] As far as I can tell, each theory would have to mark the counterexamples to it as exceptions.

(76) a. Examples supporting the sonority hypothesis:[13]
kɨdolmán, uréf, kʰuám, báwunt, rálempʰ, wáimant (6)
b. Examples supporting the revised penultimate-stress hypothesis:
gíaŋ, múmon, kíe, wúse, mímor, gúlo, gúɭo (7)

[12] Despite the very different predictions that the two hypotheses make, there were not many distinguishing examples (13/550). One reason is that surprisingly many words in the data have [a] as their penultimate vowel (and such examples are usually unhelpful in distinguishing between the two hypotheses). Another reason is that verbs behave differently (stress is determined based on the identity of the suffixes) and so were not considered by Kenstowicz or in the present examination.

[13] I have omitted the following examples that appear in Kenstowicz's paper as support for the sonority hypothesis: [kiá], because the same word is given with penultimate stress in Davies (1980); and [siόg], because its surface form is reported to be [sióŋkʰ], which is a heavy syllable.

Since there is a successful alternative to the sonority hypothesis – the hypothesis in (75) with 6 exception marks – I conclude that there is no decisive evidence for sonority-driven stress in Kobon.

5.3 Discussion of Asheninca and Yimas

The present section discusses the reported patterns of sonority-driven stress in Asheninca (Type III; Payne, 1990) and Yimas (Type II; Foley, 1991). Both are cited in Gordon (1999/2006) as stress patterns that are sensitive to vowel height. As mentioned in section 4, Asheninca played a special role in Hayes (1995) as the only stress pattern analyzed using reference to vowel quality. Both cases involve an optional process that either shifts or deletes stress. While I do not provide sufficient support for alternative analyses of the data, I would like to mention some methodological questions that arise when optional processes are involved that I believe weaken the evidence for sonority-driven stress in those two languages.

Consider first Asheninca. According to Payne (1990), the basic stress pattern of Asheninca is Left-to-Right Iambic where CVV(C) syllables are heavy and CV(C) are light and where the final syllable is extrametrical. The examples in (77) illustrate Payne's analysis (the distinction between primary and secondary stress is ignored): in (77a), all syllables are light and binary feet are constructed from left to right. The final syllable is extrametrical and does not receive stress. The penultimate syllable is assigned a degenerate foot (not marked in the example) that loses its stress due to clash with the preceding stressed syllable. Example (77b) demonstrates that heavy syllables always carry stress and can form their own foot.

(77) Basic quantity-sensitive rhythmic pattern

a. (pa.mé).(na.kó).(weŋ.tá).ke.ro 'take care of her'

b. (no.má).(ko.ryáa).(wái).(ta.páa).ke 'I rested a while'

Payne presents four processes that perturb that basic rhythmic pattern based on vowel quality. Three of them are sensitive to the sonority scale in (78a) and the fourth to the more fine-grained scale in (78b).

(78) Payne (1990)'s sonority scales for Asheninca stress[14]

a. a, e, o > i

b. a > e, o > i

An example of a process that relies on (78a) is prestress destressing, which removes stress from a CV syllable before a heavy syllable. Destressing applies obligatorily to Ci syllables but only optionally to Ce, Co, and Ca syllables. In (79), expected secondary stress on the second syllable is absent from a Ci syllable before a heavy CVV syllable. In contrast, (80) shows two variants of a word with a Ca syllable before a heavy CVV syllable, one with stress and one without it.

[14]Payne's hierarchy includes a further distinction between Ci with a strident onset (realized allophonically as Cɨ) and Ci with a non-strident onset. Feet with a second Cɨ syllable are unexpectedly trochaic. Hayes (1995:289-290) shows that most examples of this sort can be analyzed using an /i/-deletion rule that triggers stress shift, though as noted by Hayes, several problematic examples remain where deletion is of no help.

(79) Ci syllable *obligatorily* loses stress before a heavy syllable
kan.<u>ti</u>.mái.ta.cya ‘however’ (no expected secondary stress)

(80) Ca syllable *optionally* loses stress before a heavy syllable

a. a.tı̀.ri.<u>pà</u>.yée.ni ‘people’

b. a.tı̀.ri.<u>pa</u>.yée.ni ‘people’ (no expected secondary stress)

A binary distinction as in (78a) can be captured using empty-vowel representations. Following a proposal in Gordon (1999/2006), the vowel [i] can be analyzed as the empty vowel of Asheninca. Prestress destressing would apply obligatorily to $CV_{\emptyset}$ but optionally to CV. We can analyze in a similar manner the two other aspects of stress that show the binary distinction in (78a), main-stress assignment and destressing in rapid-speech, so I do not discuss them here.

More problematic is another process of prestress destressing which is sensitive to the scale in (78b). Here, Ci obligatorily loses stress before Ca (81) but optionally before Ce, Co, and Ci, illustrated in (82) using Ce. In (82a), where destressing does not apply, the penultimate syllable (which forms a degenerate foot) loses its stress due to clash. This process is problematic because the low vowel [a] behaves differently from the mid vowels [e] and [o], and the empty-vowel has been reserved for the representation of [i]. Payne provides 3 examples like (81) and 4 examples like (82) (there is no indication in the paper that Asheninca provides additional examples).

(81) Ci syllable *obligatorily* loses stress before a Ca syllable
o.<u>pi</u>.ná.ta ‘it costs’ (no expected secondary stress)

(82) Ci syllable *optionally* loses stress before a Ce syllable

a. i.<u>kí</u>.te.ti ‘people’

b. i.<u>ki</u>.té.ti ‘people’

There are two questions to ask about the nature of the data in (81)-(82) and their interpretation. The first question is whether the examples come from a single speaker or from multiple speakers. If the latter, it is possible that some speakers omit stress obligatorily before every CV syllable ([o.<u>pi</u>.ná.ta], [i.<u>ki</u>.té.ti]) and some never omit stress ([i.<u>kí</u>.te.ti]), in which case no individual grammar would require reference to vowel quality for deleting stress. Subject information is not provided in Payne (1990); as noted by de Lacy (2013), this is a recurrent characteristic of studies on sonority-driven stress that leaves open the possibility that the pattern does not reflect any single speaker’s output. The question regarding the number of speakers arises even when stress assignment is obligatory, but answering it is particularly pressing when the process is optional and a handful of examples are involved, since a simple alternative story is easy to imagine. For explicitness, that story is given in (83). An argument against encapsulation from Asheninca would need to provide evidence against (83) – for example, by replicating Payne’s data with a single speaker.

(83) Alternative story about Asheninca stress

- The data in Payne (1990) come from two groups of speakers:

  - Group A: [o.pi.ná.ta], [i.ki.té.ti], etc.
  - Group B: [i.kí.te.ti], etc.
- Each individual grammar respects encapsulation:
  - Group A: Destress a $CV_\emptyset$ syllable before a CV syllable
  - Group B: - (no destressing)

The second question concerns the amount of data required to rule out an alternative formulation of the optional process which omits reference to vowel quality. A grammar that optionally omits stress from a $CV_\emptyset$ syllable before *any* CV syllable using the rule in (84) will never be contradicted by the data – it could be an accident that we have not yet encountered an example where stress is found on a Ci syllable that precedes a Ca syllable. Of course, more data along the lines of (81)-(82) would make an accident less plausible, but how many examples are needed for a sufficient level of confidence that quality matters? In particular, are 3 examples like (81) and 4 examples like (82) sufficient? I believe that speculation on this matter is futile. Ultimately, the question is about the amount of data required for the child rather than the linguist to choose a quality-driven generalization and as such should be determined empirically. In the meantime, I propose the stress rule in (84) as an account of the data in (81)-(82). One way to argue in favor of quality-driven stress and against (84) is to show that speakers of Asheninca reject forms like [o.pí.na.ta] (where destressing does not apply before a Ca syllable), which is unexpected given (84).

(84) Optional rule: destress a $CV_\emptyset$ syllable before a CV syllable

Similar questions arise regarding the distribution of stress in Yimas (Foley, 1991). In Yimas, more examples seem to support a quality-sensitive analysis, but the author chose an analysis that uses a general quality-insensitive rule. Foley (1991: 78) reports that stress in Yimas can optionally shift from the first to the second syllable in the word, and that this shift "*is found with many disyllabic or trisyllabic words with underlying vowels in the first two syllables, especially when these vowels are /a/*". Two examples out of 11 provided by Foley are given below. In all 11 cases the second vowel is [a].

(85) a. yúan ~ yuán 'good'
b. yánara ~ yanára 'bark of clove tree'

Foley's actual analysis of Yimas stress does not make reference to segmental features. Default stress assignment is optional (and quality-insensitive); when it does not apply, a second, obligatory stress rule assigns stress to the second syllable regardless of its quality.

Since the proposed quality-insensitive analyses for Asheninca and Yimas can be easily refuted, I will treat both languages as potential counterexamples to the universal, noting that the two methodological questions I raised in this section at least provide a loophole for analyses that respect encapsulation.

5.4 Discussion of Nanti

The Nanti stress pattern as described in Crowhurst and Michael (2005) is the strongest counterexample to the universal. While I am unable to provide an alternative analysis of the data at this point, I will show that various properties of Nanti discussed in Michael (2008) offer a different view of almost all of the core examples that motivated a sonority-driven analysis.

According to Crowhurst and Michael (2005), the distribution of stress in Nanti verbs is determined by a combination of several factors, including vowel length, syllable closure, and vowel height. The basic stress pattern is rhythmic: in words with only CV syllables, stress falls on every second syllable starting from the second syllable of the word. The final syllable is never stressed. The examples in (86) show Crowhurst and Michael's foot-based analysis, where ']' marks the right edge of the prosodic word.

(86) Basic rhythmic pattern

	a.	o.gó.te.ro	(o.gó).te].ro	'she will know it'
	b.	i.rì.pi.rí.ni.te	(i.rì).(pi.rí).ni.te]	'he will sit'

The basic iambic pattern is reportedly overriden by several factors, including syllable weight, stress clash, and vowel height. The effect of vowel height according to the scale in (87) is demonstrated by the core examples in (88): in the first foot of each word (underlined), the first vowel is lower than the second vowel and stress is unexpectedly trochaic.

(87) Vowel height scale for Nanti
a > e, o > i

(88) Stress tracks vowel height

a.	a > e	(nà.pe).(ʃi.gò).(pi.rè).(já.kse)]	'I rested'
b.	a > i	(nà.bi).(gʒi.tà).kse].ro	'I pick it (seed-like object) out of bag'
c.	o > i	(nò.ʃi).(po.kà).kse].ro	'I doused it (a fire)'
d.	o > i	(nò.dʒi).(wo.tà).kse].ro	'I placed it (vessel) mouth down'
e.	a > e	(à.b^{j}e).(tsi.kái)]	'we.INCL made it again'
f.	a > i	(à.wo).(te.hái).dʒi].ri	'we approached him/them'
d.	a > i	(à.tsi).(to.ká).kse].ro	'it crushed it'

Crowhurst and Michael's (2005) analysis was constructed based on the surface phonological representations of verbs. It is reasonable to ask whether other factors, such as morphsyntactic or phonological structure, could affect stress placement. Note that the words in (88) are not minimal pairs. Except for vowel quality, they vary at least with respect to the identity of the verb root, argument structure, tense, number, person, and gender. A morphosyntactic and phonological analysis of Nanti was developed in Michael (2008). According to Michael, the morphosyntactic structure of the Nanti verb is quite complex and has the basic structure in (89). The sequence of suffixes labeled 'inflection' in (89) is broken down in (90), and there are about 15 different derivational suffixes. Nanti's syllable structure forbids consonant clusters and vowel sequences; when these result from morpheme concatenation, various processes of epenthesis and deletion apply.

(89) SUBJECT=IRREALIS-CAUSATIVE-ROOT-DERIVATION-INFLECTION=OBJECT

(90) VERB QUANTIFIER- ARGUMENT NUMBER - DIRECTIONAL - ASPECT - REALITY STATUS

Let me show how morphosyntactic and phonological factors can conspire to derive a surface correlation between stress and vowel height. Consider (88a) and (88b). Michael (2008) reports that the [1st.sg] affix of Nanti is /no-/ and that a vowel hiatus is normally resolved by deleting the first vowel (at least when the sequence of vowels precedes the verb root; otherwise, it is resolved by [t] epenthesis). This suggests underlying /no-a.../ and the possibility of assigning iambic stress which seems trochaic on the surface following vowel deletion. In (88c) and (88d), the affix seems to keep its vowel. However, one of Nanti's causative prefixes is /o-/, and the structure in (89) suggests that the causative prefix indeed appears close to the subject marker (the irrealis marker is a circumfix whose prefixal part is often not pronounced). The meaning of (88c) and (88d) is consistent with Michael's description of the meaning of the causative /o-/, and none of the other causative prefixes of Nanti (/ogi-/, /otiN-/, and /omiN-/) seems to be present. This suggests underlying /no-o.../ with iambic stress and deletion of the first vowel, as in (88a) and (88b). Consider now (88e). The [1st.pl.INCL] prefix is /a-/ which seems not to have been deleted. Michael notes, however, that the behavior of this prefix with respect to hiatus resolution is exceptional: the vowel of this prefix survives and the second vowel gets deleted instead. This suggests that the first vowel of the root (whatever it might have been) could have received stress and deleted, followed by stress shift to the first syllable of the foot (Halle and Vergnaud, 1987 document various other cases where deletion of stressed vowels is resolved in this way). In (88e), the [1st.pl] marker is not glossed as inclusive, so the same story is not independently supported. Finally, consider (88g) and the hypothesis that it is not the height of the first vowel that attracts stress from a light syllable but rather the identity of the prefix, in this case the subject marker 'it'. This hypothesis is consistent with all 3 occurrences of the subject marker 'it' in Crowhurst and Michael (2005).[15]

The discussion so far has shown that 6 out of the 7 core examples given to demonstrate the effect of vowel height on stress may be the result of a conspiracy of other factors, but it should not be taken as a satisfactory alternative to Crowhurst and Michael's analysis. For example, even if iambic stress is assigned to the UR of (88a), an explanation would be needed for why two consecutive syllables surface unstressed; and the analysis of other examples discussed by Crowhurst and Michael relies on the sonority-driven analysis of the examples in (88a)-(88g) – if sonority does not play a role in (88a)-(88g), a principled account of the other examples might be lost. At present, constructing an alternative is difficult since the examples in Crowhurst and Michael (2005) are unanalyzed while the analyzed examples in Michael (2008) are not marked for stress. I will therefore treat Nanti as a potential counterexample to the universal, but I hope to have shown that controlling for morphosyntactic and phonological structure can change the picture regarding the factors that determine the stress placement in the language.

[15] There is one example (ma.gàn.táem.pa.ro.me.ra, 'it (sleeping hut) would be slept in again') where the subject is given as 'it' and the vowel is stressless. In this case, the prefix appears as [ma-]; regardless of whether it is the same morpheme, iambic stress in this example could be explained as stress attraction form 'it' to the second heavy syllable.

5.5 Reanalysis of Mayo stress

Mayo (Foreman and Marten, 1973) is cited in Gordon (1999/2006) as a Type II language, where the low vowel attracts stress as opposed to other vowels. The stress generalization provided in the source is the following:

(91) Sonority generalization in Foreman and Marten (1973)

1. The first syllable (of a word) which contains /a/ is stressed
2. When there is no syllable containing /a/ in a word, the first syllable of the word is stressed

The source includes around 400 examples marked for stress, most of which have initial stress. There are two types of examples that could distinguish a naive initial-stress generalization from Foreman and Marten's sonority generalization. Examples that would support initial stress are words with initial stress on a vowel other than [a] that have an [a] in a non-initial syllable; examples with non-initial stress on the first [a] in the word would support the sonority generalization. My count of distinguishing examples resulted in a near-tie between the two generalizations: 13 examples in the source support the sonority generalization but 11 examples support initial stress:

(92) a. Examples supporting the sonority generalization (13)
t^{h}owknátɨ, k^{h}ʌnákʌm, ngɨláng^{w}ow, t^{h}ɔpátɨ, t^{h}eyá, tɔrámsɨ, t^{h}ɨtánʌ, rɨmá, rɨmbá, kɔrándʌ, wiyákʌ, sɨpá, t^{h}ʌk^{h}námbʌ

b. Examples supporting initial stress (11)
ə́rank^h, ə́rowk^{w}atɨ, ə́rangiy, sɨ́ngampk^h, ə́rastɨ, lówanɨm, ə́rangʌrmbʌ, ə́ras, ə́raw, wúswar, lɛ́t^{h}lanʌ

Moreover, some of the counterexamples to initial stress may be due to morphosyntactic factors. For example, two of the examples that support the sonority generalization are infinitival forms with penultimate stress (t^{h}ɔpátɨ 'to buy', t^{h}ɨtánʌ 'to be'). All but one of the 9 infinitival forms in Foreman and Marten (1973) have penultimate stress. If infinitival forms are exceptions to initial stress and receive penultimate stress, the two hypotheses would be tied with 11 counterexamples each which would have to be marked as exceptions.[16]

Since initial stress is at least as successful as the sonority generalization, I conclude that the data do not support sonority-driven stress in Mayo.

5.6 Reanalysis of English i-extrametricality

As noted by Chomsky and Halle (1968), English stress normally ignores the final syllable of the word if its nucleus is the vowel [i]. Thus, for example, in words like résidency and éfficacy, main stress falls on the pre-antepenultimate syllable. These facts are surprising given the rules that govern the distribution of stress elsewhere in English (the expected forms are *residéncy, and *effícacy), but they are immediately explained if

[16] The single infinitival form with final stress is rɨmá 'to strengthen', which is already included in the count of counterexamples to initial stress in (92a).

the final vowel in those words is invisible to stress assignment (e.g., the stress contour of résidency is identical to that of résidence). Moore-Cantwell (2016) tested English speakers' preference regarding stress placement in trisyllabic nonce words that end in [i] or [ə]. Speakers showed a strong preference for antepenultimate over penultimate stress with [i] but just a slight preference with [ə], reflecting a similar asymmetry in the English lexicon. Moore-Cantwell proposed a constraint that makes word-final [i] extrametrical and thus violates encapsulation. Here is a version of the problematic constraint, stated as a rule of extrametricality that refers to vowel quality:

(93) Mark word-final [i] as extrametrical

Halle (1998) proposed a different treatment of the distributional facts. On his analysis, it is the suffix *-y* rather than the final vowel that is extrametrical. He notes that other English suffixes, such as the suffix *-ure*, show a similar behavior (e.g., main stress is surprisingly initial in words like músculature, cándidature, and líterature). On Halle's interpretation, we can restate (93) as a rule that refers to the morphological identity of the suffix rather than the quality of its vowel:

(94) Mark word-final $[-Y]$ as extrametrical

If Halle is right, a plausible interpretation of Moore-Cantwell's results is that participants had a strong preference for parsing nonce words with a final [i] as morphologically complex (there is no comparable parse for words with a final [ə]), and that the grammatical statement in (94) was responsible for antepenultimate stress in those words. A way to argue against (94) and in favor of (93) is to show that speakers show a preference for earlier stress in [i]-final nonce words that cannot be parsed using $[-Y]$. For example, since $[-Y]$ is not a verbal suffix, nonce words that are unambiguously verbal might do.

5.7 A remaining challenge: consonantal features

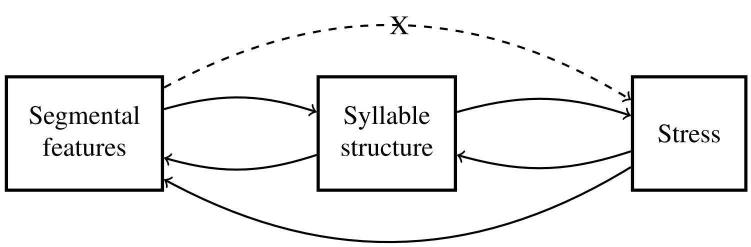
The Stress-Encapsulation Universal states that stress is never conditioned by any segmental features, including consonantal features. While the empirical focus of the present paper is on the relationship between vowel sonority and stress, effects of consonantal features on stress are potential counterexamples to the universal. The literature reports four rare types of such effects (see Davis, 2011 for a summary): 1) *Variable coda weight*. $CVC_{[+son]}$ syllables are reportedly heavier than $CVC_{[-son]}$ syllables for stress in three languages: Kwak'wala, the closely related Nuuchahnulth, and Inga Quechua (see Zec 1995 and references in Gordon, 1999/2006). 2) *Vowel - glottal stop is heavy*. Gordon (1999/2006) lists three languages in which a vowel followed by a coda glottal stop ([Vʔ]) is reportedly heavier than other vowel-coda sequences (Kamchadal, Mundari, Mam). 3) *Onset voice*. Syllables with a voiceless onset have been claimed to be heavier than ones with a voiced onset in Pirahã (Everett and Everett, 1984; Everett, 1988), Karo (Blumenfeld, 2006, citing Gabas, 1999), and Arabela (Topintzi, 2005, citing Payne and Rich, 1988). 4) *Coda place*. In Ngalakgan, CVC is heavy unless the postvocalic consonant is a glottal stop, the first part of a geminate consonant, or the first part of a homorganic nasal-stop sequence (Baker, 2008).

Those cases have already been analyzed in the literature as indirect effects of consonantal features on stress through syllable structure, as in Latin, making them consistent with the universal. I will provide references to the relevant analyses, though I leave a closer examination of the assumptions needed for those analyses and their consequences for the universal for a separate occasion. Analyses of variable coda weight in terms of syllable structure can be found in Levin (1985) and Hulst and Ritter (1999) (see also Zec, 1995). Gordon (1999/2006) proposes an analysis of heavy vowel - glottal stop sequences in which stress makes reference to vowel length rather than to the quality of the coda. See Everett (1988) for an analysis of onset voice cases in terms of syllable structure and see Baker (2008) and Davis (2011) for two different interpretations of the Ngalakgan data as an indirect effect of [place] on stress.

6 Alternatives to modularity

My next goal is to discuss alternative explanations to the Stress-Encapsulation Universal that do not involve modularity. The reason is that information encapsulation by itself is not a sufficient argument for modularity: encapsulation can be emulated in non-modular architectures, whether serial or parallel. My claim, however, is that the Stress-Encapsulation Universal poses a special problem for non-modular accounts of encapsulation. Consider the diagram in (95), which shows the picture regarding attested phonological interactions that I have argued for. The bottom arrow indicates that stress is visible to segmental features and the dotted top arrow indicates that segmental features are not visible to stress. There are bidirectional interactions between stress and syllable structure and between syllable structure and segmental processes.

(95) *Attested phonological interactions* (a full arrow from A to B indicates that A is visible to B)



The modular architecture captures the asymmetry in (95) by removing segmental features from the input to the stress module and allowing segmental features to only affect stress through the interface. We will see that a main prediction made by non-modular accounts of encapsulation is that visibility is transitive: if A is visible to B and visible to C, then A should be visible to C. The challenge to that prediction comes from indirect effects of segmental features on stress (as in Latin, discussed above). Since segmental features are visible to syllable structure and syllable structure is visible to stress, non-modular accounts of encapsulation incorrectly predict that segmental features should be visible to stress as well and thus over-generate quality-driven stress.

Blocking quality-driven stress comes at the cost of under-generating attested indirect effects of segmental features on stress.

6.1 An ordering account

The first non-modular account of encapsulation to consider is an ordering account within a serial phonological architecture. The main idea behind an ordering account is that stress is universally assigned *before* the insertion of segmental features: stress can never see segmental features because they are universally inserted later. The first issue with implementing such an account is that all working theories of phonology assume that stored phonological information (including segmental features) is present in URs. For example, the place of articulation of the first consonant in the English word [k^{h}æt] 'cat' has to be memorized and present when stress applies. But perhaps the Stress-Encapsulation Universal suggests that phonology should be reconceptualized such that segmental features, including memorized ones, are inserted late. Here is how this reconceptualization would work. We can impose a universal ordering on phonological processes as in (96). According to (96), stress processes apply before the insertion of segmental information in the derivation. A word like [k^{h}æt] would be derived by inserting the information as two separate tiers, shown in (97).

(96) Universal ordering
  a. Insert CV tier and syllable structure
  b. Apply stress processes
  c. Apply non-stress processes and insert segmental tier (in any order)

(97) Representation of [k^{h}æt]:
  a. CV tier and syllable structure: /.CVC./
  b. Segmental tier: /kæt/

There are two immediate problems with (96). The first is that it does not prevent stress representations from being modified by processes that follow stress assignment. Recall from section 1.2 that stress-sensitive segmental processes require access to stress and nothing in principle prevents them from changing its location. This was the motivation for adding the second clause (8b) to the Modularity Hypothesis. The second problem is that the input to stress computation should be determined based on segmental features. This is particularly easy to see with the Latin example in (10), repeated below: segmental features must be available for the computation of syllable structure before the application of stress.

(98) Segmental feature → syllable structure → stress
  Latin: [vo.lúp.t̠as] (non-liquid) vs. [vó.lu.kr̠is] (liquid)

This is a general problem posed by indirect effects of segmental features on stress through syllable structure. For segmental features to determine syllable structure, they must be present in the derivation whenever syllable structure is computed. And for syllable structure to affect stress assignment, it must be present before stress is computed. By transitivity, segmental features are present in the derivation before stress applies.

I conclude that an ordering account does not provide a viable alternative to modularity.

6.2 Universal constraint rankings within a parallel architecture

Another alternative to modularity is to fix constraint rankings within a parallel architecture such as OT. Here the strategy would be to impose a universal ranking relation between disjoint sets of OT constraints (e.g., Prince and Smolensky, 1993; de Lacy, 2002). As an illustration of this strategy, one can define two sets of constraints $\mathbb{C}_1$ and $\mathbb{C}_2$ as in (99) and impose the universal ranking relation in (100), which means that every constraint in $\mathbb{C}_1$ outranks every constraint in $\mathbb{C}_1$ in every language. This strategy emulates encapsulation because, intuitively, $\mathbb{C}_2$ constraints will never be strong enough to affect $\mathbb{C}_1$-computation.

(99) a. $\mathbb{C}_1 = \{m : m$ is a prosodic markedness constraint$\}$
b. $\mathbb{C}_2 = \{f : f$ is a faithfulness constraint of the form IDENT[F]$\}$

(100) $\mathbb{C}_1 \gg \mathbb{C}_2$

To see how this strategy can be implemented as an account of the Stress-Encapsulation Universal, consider again English aspiration and the following constraint:

(101) *tV́ = *unaspirated voiceless stop before a stressed vowel

The constraint can be satisfied by shifting stress away from a syllable with an unaspirated voiceless onset – an unattested quality-driven stress pattern – as shown by the tableau in (102). Candidate (b) violates a faithfulness constraint that penalizes deviations in aspiration between URs and surface forms (ASP is used here as an abbreviation of [spread glottis]); candidate (a) violates *tV́, so candidate (c) with shifted stress wins.

(102) Satisfying *tV́ by shifting stress

	/datá/	IDENT[ASP]	*tV́	FINAL STRESS
a.	datá		*!	
b.	datʰá	*!		
c. ☞	dáta			*

There are two ways to block such patterns of quality-driven stress using the universal-ranking strategy. The first is to impose a universal ranking of stress constraints over segmental faithfulness constraints (which would translate into the ranking FINAL STRESS ≫ IDENT[ASP] in the example above). The second is to impose a ranking of stress over segmental markedness (which would translate into the ranking FINAL STRESS ≫ *tV́). In both cases, if FINAL STRESS is ranked higher, the problematic candidate (c) will be blocked. I will only discuss the 'stress over segmental faithfulness' approach since the logic of the heart of the argument against the 'stress over segmental markedness' approach is similar.

As shown in (103), forcing the ranking FINAL STRESS ≫ IDENT[ASP] blocks quality-driven stress shift:

(103) FINAL STRESS ≫ IDENT[ASP]

	/datá/	*tV́	FINAL STRESS	IDENT[ASP]
a.	datá	*!		
b. ☞	$\text{dat}^{\text{h}}\text{á}$			*
c.	dáta		*!	

Implementing this restriction as a universal can be done by enforcing the ranking $\mathbb{C}_1 \gg \mathbb{C}_2$ where the constraint sets $\mathbb{C}_1$ and $\mathbb{C}_2$ are defined as follows:

(104) a. $\mathbb{C}_1 = \{m : m$ is a markedness constraint that mentions stress$\}$[17]

b. $\mathbb{C}_2 = \{f : f$ is a faithfulness constraint that mentions segmental features$\}$

I discuss two problems for this account, an under-generation problem and an over-generation problem.

6.2.1 Problem #1: under-generation

Indirect effects of segmental features on stress as in Latin pose an under-generation problem for the universal-ranking approach. To see why, we will need to look at such patterns in more detail. I will discuss an oversimplified version of the Latin stress pattern. As far as I can tell, the simplification does not affect the argument.

In Latin, the penultimate syllable is stressed if it is heavy; otherwise, the antepenultimate syllable is stressed. For the analysis of Latin, I will use the default-stress constraint in (105a), a cover constraint that penalizes words with non-antepenultimate stress, and the weight-to-stress constraint in (105b).

(105) Constraints for an OT analysis of Latin stress

a. DEFAULT STRESS: assign * if the antepenultimate syllable is not stressed

b. WEIGHT-TO-STRESS PRINCIPLE (WSP): assign * for every unstressed heavy syllable

Assuming the ranking WSP ≫ DEFAULT STRESS, the tableau in (106) shows that a heavy syllable attracts stress. Candidate (a) with antepenultimate stress violates WSP; candidate (b) wins even though it violates the lower ranked DEFAULT STRESS constraint.

(106)

	/voluptas/	WSP	DEFAULT STRESS
a.	vó.lup.tas	*!	
b. ☞	vo.lúp.tas		*

The challenge for this approach is to block candidate (c) in (107), where the underlying consonant /t/ is changed into a liquid on the surface to avoid a violation of DEFAULT STRESS. Candidate (c) violates neither constraint and is thus more optimal than the desired winner candidate (b).

[17] This definition is overly simplified. To explain why languages that have contrastive aspiration do not show aspiration in response to *tV́, the definition has to be changed so as to allow IDENT[ASP] to outrank *tV́. The definition should be complicated as follows: $\mathbb{C}_1 = \{m :$ m is a markedness constraint that mentions stress but not segmental features$\}$.

(107)

	/voluptas/	WSP	Default Stress
a.	vó.lup.tas	*!	
b. ➽	vo.lúp.tas		*!
c. ☞	vó.lu.pras		

Candidate (b) should be selected as a winner because in Latin, violating default stress is better than changing the liquidity of a consonant. The following tableau includes the new segmental faithfulness constraint IDENT[LIQUID], which rules out candidate (c).

(108)

	/voluptas/	WSP IDENT[LIQUID]	Default Stress
a.	vó.lup.tas	*!	
b. ☞	vo.lúp.tas		*
c.	vó.lu.pras	*!	

For candidate (b) to win, IDENT[LIQUID] must outrank Default Stress. But since IDENT[LIQUID] is in $\mathbb{C}_2$ and Default Stress is in $\mathbb{C}_1$, this ranking violates the universal ranking $\mathbb{C}_1 \gg \mathbb{C}_2$. Note that replacing IDENT[LIQUID] with a markedness constraint like *Complex to penalize candidate (c) would incorrectly allow changing a liquid to an obstruent in /volukris/, favoring *[vo.lúk.tis] over the correct output [vó.lu.kris]. To block *[vo.lúk.tis], IDENT[LIQUID] would have to outrank *Complex and, by transitivity, Default Stress.

The argument does not depend on the choice of markedness constraints for the analysis of Latin stress. This is easy to see using the pair of words [vó.lu.kris] and (hypothetical) [vo.lúk.tis] which, stress aside, differ in the quality of a single consonant. No choice of stress markedness constraints could prefer [vó.lu.kris] to [vo.lúk.tis] as the output of /volukris/ while simultaneously preferring [vo.lúk.tis] to [vó.lu.kris] as the output of /voluktis/. To block the undesirable candidates that surface with an unfaithful consonant, a faithfulness constraint must outrank at least one markedness constraint. Since stress or syllable faithfulness would be of no help (stress and syllable structure are predictable), that faithfulness constraint must be a segmental faithfulness constraint. The problem, then, is quite general. As long as segmental features and stress are computed in parallel and segmental features indirectly affect stress, there will be a candidate that changes the feature instead of moving stress. To block that candidate, segmental faithfulness will have to outrank stress markedness. If this ranking is made impossible, as in the universal-ranking approach, stress patterns as in Latin cannot be generated.

6.2.2 Problem #2: over-generation

While a universal ranking of stress constraints over segmental faithfulness constraints blocks stress shift as in (103), it does not block all effects of segmental features on stress. Consider the following ranking:

(109) *Clash ≫ *í, *ú ≫ *é, *ó

This ranking is not blocked by the universal ranking, but it can create the following quality-driven clash-resolution: given two adjacent stressed vowels where one is a high vowel and the other is a mid vowel, the high vowel will lose stress regardless of the order of the vowels (e.g., /íó/ → [ió], /óí/ → [ói]). The modular architecture blocks such patterns, which to my knowledge are unattested.

6.2.3 Summary: universal ranking

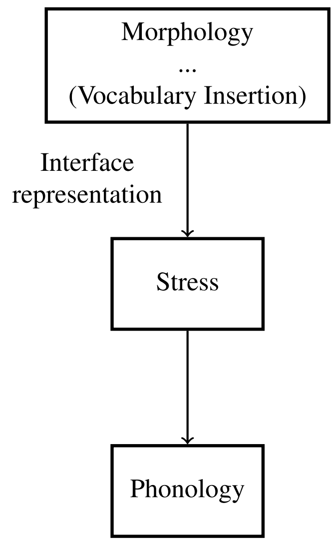
We have seen that a universal ranking of stress markedness constraints over segmental faithfulness constraints under-generates attested patterns (indirect effects of segmental features on stress) and over-generates unattested ones (quality-driven clash-resolution). The argument can be replicated for a universal ranking of stress markedness over segmental markedness constraints: such a ranking would not address the over-generation problem; regarding the under-generation problem, the argument from Latin can be restated using the candidate *[vó.lu.ptas] as a potential output of /voluptas/. Blocking such a candidate while generating [vó.lu.kris] would require ranking a segmental markedness constraint that blocks $CC_{[+liquid]}$ complex onsets over a stress constraint. I conclude that the universal-ranking approach is less successful than modularity.[18]

7 Conclusion

I started this paper with de Lacy's and Blumenfeld's observation that the interaction between stress and segmental features is asymmetrically restricted: while the distribution of segmental features is often conditioned by the position of stress, the distribution of stress is never conditioned by any segmental feature but sonority. I reviewed the literature on sonority-driven stress and showed that reference to vowel sonority can be avoided if stress is allowed to see syllable structure and the binary distinction between empty vowels and non-empty vowels. Other than a few potential counterexamples, the distribution of stress seems to never be conditioned by segmental features. I referred to this generalization as the Stress-Encapsulation Universal and argued that it supports a modular architecture of grammar, repeated in (110), where stress is severed from the rest of phonology. This is a welcome result: modularity provides a simple account of information encapsulation and makes various typological predictions regarding stress patterns and their interaction with other aspects of phonology; and as mentioned in the introduction, Heinz's (2014) discovery that the computational complexity of attested stress patterns goes beyond that of segmental patterns can now be understood in terms of separate limitations on the computational power of each module.

(110) Hypothesis about the architecture of grammar

[18]Here is a direction for a response to the under-generation problem faced by the 'stress over segmental markedness' approach. In addition to the set of constraints that mention stress but not segmental features, one could split segmental markedness constraints into two subsets – segmental markedness constraints that mention stress and segmental markedness constraints that do not – and force a universal ranking of constraints that mention stress but not segmental features over the former subset. This response would still not address the over-generation problem (which would require further commitments in order to block quality-driven clash-resolution), so I do not develop it here further.



References

Allen, William Sidney. 1973. *Accent and rhythm*. Cambridge University Press.

Anderson, Stephen R. 1982. The analysis of French schwa: or, how to get something from nothing. *Language* 58.

Baker, Brett. 2008. *Word structure in ngalakgan*. Stanford: CSLI Publications.

Blumenfeld, Lev A. 2006. Constraints on phonological interactions. Doctoral Dissertation, Stanford University.

Borowsky, T. 1986. Topics in the lexical phonology of English. Doctoral Dissertation, University of Massachusetts, Amherst.

Bowers, Dustin. 2016. Acoustic correlates of Gujarati stress: A failure to replicate. University of Alberta ms.

Canalis, Stefano. 2007. To what extent is Albanian word stress predictable? In *Proceedings of the XXXIII Incontro di grammatica generativa*, ed. Antonietta Bisetto and Francesco E. Barbieri, 1–14. Bologna: Università di Bologna.

Chomsky, Noam, and Morris Halle. 1968. *The sound pattern of English*. New York: Harper and Row Publishers.

Clements, G. N., and Samuel Jay Keyser. 1983. *CV phonology: A generative theory of the syllable.*. Cambridge MA: MIT Press.

Crowhurst, Megan J., and Lev D. Michael. 2005. Iterative footing and prominence-driven stress in Nanti (Kampa). *Language* 81:47–95.

Davies, H.J. 1980. *Kobon phonology*. Australian National University, Canberra.

Davies, H.J. 1981. *Kobon*, volume 3 of *Lingua Descriptive Series*. Amsterdam, North Holland.

Davis, Stuart. 2011. Quantity. In *The handbook of phonological theory*, ed. John Goldsmith, Jason Riggle, and Alan Yu, 103–140. Oxford: Blackwell, second edition edition.

Davis, Stuart, and Mi-Hui Cho. 2003. The distribution of aspirated stops and /h/ in American English and Korean: an alignment approach with typological implications. *Linguistics* 41:607–652.

Everett, Daniel, and Keren Everett. 1984. On the relevance of syllable onsets to stress placement. *Linguistic Inquiry* 15:705–711.

Everett, Daniel L. 1988. On metrical constituent structure in Pirahã phonology. *Natural Language and Linguistic Theory* 6:297–246.

Foley, William A. 1991. *The Yimas language of New Guinea*. Stanford University Press.

Foreman, Velma, and Helen Marten. 1973. Yessan-Mayo phonemes. *Workpapers in Papua New Guinea Languages* 2:79–108.

Gabas, Nilson. 1999. A grammar of Karo (Tupi). Doctoral Dissertation, University of California, Santa Barbara.

Giavazzi, Maria. 2010. The phonetics of metrical prominence and its consequences for segmental phonology. Doctoral Dissertation, Massachusetts Institute of Technology.

Gonzalez, Carolina. 2003. The effect of stress and foot structure on consonantal processes. Doctoral Dissertation, USC.

Gordon, Matthew. 1999. Syllable weight: phonetics, phonology, and typology. Doctoral Dissertation, UCLA.

Gordon, Matthew. 2006. *Syllable weight: phonetics, phonology, typology*. New York: Routledge.

Halle, Morris. 1990. An approach to morphology. In *Proceedings of NELS*, volume 20, 150–184.

Halle, Morris. 1998. The stress of English words 1968-1998. *Linguistic Inquiry* 29:539–568.

Halle, Morris, and Alec Marantz. 1993. Distributed morphology and the pieces of inflection. In *The view from Building 20*, ed. Kenneth Hale and Jay Keyser, 111–176. Cambridge, MA: MIT Press.

Halle, Morris, and Jean-Roger Vergnaud. 1987. *An essay on stress*. MIT Press, Cambridge MA.

Hargus, Sharon. 2001. Quality-sensitive stress reconsidered. In *University of Washington Working Papers in Linguistics*, volume 20, 25–56.

Hausenberg, Anu-Reet. 1998. Komi. *Abondolo (1998b)* 305–326.

Hayes, Bruce. 1995. *Metrical stress theory: principles and case studies*. Chicago, The University of Chicago Press.

Heinz, Jeffrey. 2014. Culminativity times harmony equals unbounded stress. In *Word stress: Theoretical and typological issues*, ed. Harry van der Hulst, 255–275. Cambridge University Press.

Hulst, H.G. van der, and Nancy Ritter. 1999. Theories of the syllable. In *The syllable: views and facts*, ed. H.G. van der Hulst and N. Ritter, 13–52. Berlin: Mouton de Gruyter.

Hyman, Larry M. 1970. How concrete is phonology? *Language* 46:58–76.

Idsardi, William James. 1992. The computation of prosody. Doctoral Dissertation, Massachusetts Institute of Technology.

Kager, René. 1990. Dutch schwa in moraic phonology. In *Papers from the 26th Regional Meeting of the Chicago Linguistic Society*, ed. M. Noske M. Ziolkowski and K. Deaton, volume II: The parasesssion on the syllable in phonetics and phonology, 189–214.

Kahn, Daniel. 1976. Syllable-based generalizations in English phonology. Doctoral Dissertation, MIT.

Kangasmaa-Minn, Eeva. 1998. Mari. In *The uralic languages*, ed. Daniel Abondolo, 219–248. Routledge.

Kenstowicz, Michael. 1997. Quality-sensitive stress. *Rivista di Linguistica* 9:157–188.

Kiparsky, Paul. 1968. How abstract is phonology? Indiana University Linguistics Club.

Kiparsky, Paul. 1982. Lexical phonology and morphology. In *Linguistics in the Morning Calm*. Linguistics Society of Korea, Seoul, Korea: Hanshin Publishing Company.

Kiparsky, Paul. 2000. Opacity and cyclicity. *The Linguistic Review* 17:351–367.

Kiparsky, Paul. 2003. Finnish noun inflection. In *Generative approaches to finnic linguistics*. CSLI.

de Lacy, Paul. 2004. Markedness conflation in optimality theory. *Phonology* 21:145–199.

de Lacy, Paul. 2007. The interaction of tone, sonority, and prosodic structure. *The Cambridge handbook of phonology* 281–307.

de Lacy, Paul. 2013. What counts as evidence for universals? Questioning sonority-driven stress. Talk given at Language Universals Workshop, Harvard University, November 7, 2013.

de Lacy, Paul V. 2002. The formal expression of markedness. Doctoral Dissertation, University of Massachusetts Amherst.

Lahiri, Aditi. 2001. Metrical patterns. *Language typology and language universals* 1347–1367.

Lehiste, Ilse. 1970. *Suprasegmentals*. MIT Press, Cambridge, MA.

Levin, Juliette. 1985. A metrical theory of syllabicity. Doctoral Dissertation, Massachusetts Institute of Technology.

Liberman, Mark, and Alan Prince. 1977. On stress and linguistic rhythm. *Linguistic inquiry* 8:249–336.

Lowenstamm, Jean. 1996. CV as the only syllable type. *Current trends in Phonology. Models and Methods, edited by Jacques Durand & Bernard Laks* 419–441.

McCarthy, John. 1979a. Formal problems in semitic morphology and phonology. Doctoral Dissertation, MIT.

McCarthy, John J. 1979b. On stress and syllabification. *Linguistic Inquiry* 10:443–465.

McCarthy, John J. 2003. Sympathy, cumulativity, and the Duke-of-York gambit. In *The syllable in optimality theory*, ed. Caroline Fery and Ruben van de Vijver, 23–76. Cambridge: Cambridge University Press.

McCarthy, John J. 2005. Taking a free ride in morphophonemic learning. *Catalan Journal of Linguistics* 4:19–56.

Mester, R. Armin. 1994. The quantitative trochee in Latin. *Natural Language and Linguistic Theory* 12:1–62.

Michael, Lev D. 2008. Nanti evidential practice: Language, knowledge, and social action in an amazonian society. Doctoral Dissertation, University of Texas at Austin.

Moore-Cantwell, Claire. 2016. The representation of probabilistic phonological patterns: Neurological, behavioral, and computational evidence from the English stress system. Doctoral Dissertation, University of Massachusetts Amherst.

Moreton, Elliott. 2008. Analytic bias and phonological typology. *Phonology* 25:83–127.

Noyer, Rolf. 2013. A generative phonology of San Mateo Huave. *International Journal of American Linguistics* 79:1–60.

Odden, David. 2011. The representation of vowel length. *The Blackwell companion to phonology* 2:465–490.

van Oostendorp, Marc. 1997. Vowel quality and phonological projection. Doctoral Dissertation, Katolieke Universiteit Brabant.

Payne, David, and Furne Rich. 1988. Sensitivity to onset in Arabela stress. *Ms, Instituto Lingüıstico de Verano, Pucallpa, Peru* .

Payne, Judith. 1990. Asheninca stress patterns. In *Amazonian linguistics*, ed. Doris Payne, 185–212. Austin: University of Texas Press.

Pesetsky, David. 1979. Russian morphology and lexical theory. Ms., MIT.

Prince, Alan. 1983. Relating to the grid. *Linguistic Inquiry* 14:19–100.

Prince, Alan, and Paul Smolensky. 1993. Optimality theory: Constraint interaction in generative grammar. Technical report, Rutgers University, Center for Cognitive Science.

Rubach, Jerzy. 1986. Abstract vowels in three dimensional phonology: the yers. *The Linguistic Review* 5:247–280.

Scheer, Tobias. 2004. *A lateral theory of phonology: What is cvcv, and why should it be?*, volume 1. Walter de Gruyter.

Scheer, Tobias. 2016. Melody-free syntax and phonologically conditioned allomorphy. *Morphology* 26:341–378.

Shih, Shu-hao. 2016. Sonority-driven stress does not exist. In *Proceedings of the Annual Meetings on Phonology*, volume 3.

Szpyra, Jolanta. 1992. Ghost segments in nonlinear phonology: Polish yers. *Language* 277–312.

Tang, Katrina Elizabeth. 2008. The phonology and phonetics of consonant-tone interaction. Doctoral Dissertation, UCLA.

Topintzi, Nina. 2005. On sonority, onsets and stress in Arabela. In *Proceedings of the University of Cambridge 3rd Postgraduate Conference in Language Research 2005*, ed. Gerasimos Chatzidamianos et al., 279–286.

Trommer, Jochen. 2013. Stress uniformity in albanian: Morphological arguments for cyclicity. *Linguistic inquiry* 44:109–143.

Vaysman, Olga. 2008. Segmental alternations and metrical theory. Doctoral Dissertation, Massachusetts Institute of Technology.

Watson, Janet CE. 2002. *The phonology and morphology of arabic*. Oxford: Oxford University Press.

Zec, Draga. 1995. Sonority constraints on syllable structure. *Phonology* 85–129.

Zoll, Cheryl. 1996. Parsing below the segment in a constraint based framework. Doctoral Dissertation, University of California at Berkeley.