The stress-encapsulation universal and phonological modularity

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1 Introduction

1.1 The universal

- Cross-linguistically, the distribution of segmental features is often conditioned on the position of stress.

- Effects of stress on segmental features in American English:
  - Flapping of [t] between a preceding stressed vowel and a following unstressed vowel
    (1) polícal, polícian
  - Aspiration of voiceless stops at the onset of a stressed syllable
    (2) oppóse, opposition
  - Reduction of stressless vowels
    (3) âtóm, âtómic
  - Deletion of [h] before an unstressed, non-initial vowel
    (4) véhícle, vehícular

- Attested stress-sensitive segmental processes (Gonzalez, 2003; Giavazzi, 2010, and references therein):
  - Consonants:
    1. Affrication
    2. Aspiration (post-aspiration, pre-aspiration)

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3. Deletion
4. Devoicing
5. Epenthesis
6. Flapping
7. Fricativization (stop-fricativization, approximant-fricativization)
8. Glottalization (pre-glottalization, post-glottalization)
9. Glottalization-attraction (secondary glottalization shifts between consonants)
10. Metathesis
11. Occlusivization (fricatives or approximants become stops)
12. Voicing

- Vowels:
  13. Lowering
  14. Reduction
  15. Vowel harmony (including metaphony, umlaut)

- Spreading:
  16. Nasal harmony

• **Question:** What happens in the other direction? Can segmental features condition the position of stress?

• Blumenfeld’s (2006) answer: no segmental feature except for sonority can condition the position of stress.
  
  – Properties stress is sensitive to: syllable weight, tone, **sonority**, ...
  
  – Properties stress is not sensitive to: voicing, continuancy, place of articulation, nasality, rounding, height, backness, ...

• **Claim (today):** sonority-sensitive stress patterns do not require direct reference to sonority.

• Result: Blumenfeld’s (2006) universal asymmetry between stress and segmental features generalizes to all features:

(5) **The Stress-encapsulation Universal**

The distribution of stress is never conditioned on segmental features.

• The universal is surprising under existing theories of phonology:

  – **Rule-based** theories of stress (e.g., Halle and Vergnaud, 1987) have used rules that make direct reference to segment quality.
    
    * Even if reference to segment quality is avoided, the fact that stress rules consistently ignore the same information in their input (segmental features) would be left as an accident.

  – In **Optimality Theory** (Prince and Smolensky, 1993), stress and segmental processes are computed in parallel: markedness constraints that trigger stress-sensitive segmental processes may be used to trigger quality-sensitive stress.

(6) *Unaspirated Voiceless Stop Before A Stressed Vowel*
Given such constraints, standard OT has no general way of banning quality-sensitive stress processes.\(^1\).

### 1.2 The hypothesis

- The universal can be derived in a theory that has the following properties:
  
  (7) The computation of stress has no access to segmental features.
  
  (8) Stress cannot be changed when segmental features are computed.

- This is a standard case of information encapsulation which is expected in modular cognitive architectures. I propose a simple decomposition of phonology into modules that can capture the universal.

\[\text{(9) The modularity hypothesis}
\]

<table>
<thead>
<tr>
<th>Phonology contains an informationally-encapsulated stress module with the following properties:</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The input to the stress module excludes representations of segmental features.</td>
</tr>
<tr>
<td>b. Outside of the stress module, stress representations cannot be changed.</td>
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</tbody>
</table>

### 1.3 Outline

- A sketch of a modular architecture
- Sonority-driven stress
  - Reported types of sonority-driven stress
  - Re-analysis of Eastern Mari (Vaysman, 2008)
  - Re-analysis of Kobon (Kenstowicz, 1997)
- Discussion
  - Open questions and predictions of the modular architecture

### 2 A sketch of a modular architecture

#### 2.1 General properties

- Properties of the modular architecture:
  
  - The stress component has no access to segmental features.
  
  - Stress can only see other supra-segmental information, which serves as the interface between the stress module and the rest of phonology.
  
  - Segmental features can only affect stress indirectly through the interface.

\(^1\)See Blumenfeld (2006) for an argument that some previous OT attempts to deal with instantiations of the 'too-many-solutions' problem cannot be applied to stress-segmental asymmetries.
A toy example: representation of the made-up word `lingkå:ro`

<table>
<thead>
<tr>
<th>Stress representation</th>
<th>line 2</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Skeletal representation</th>
<th>C</th>
<th>V</th>
<th>C</th>
<th>C</th>
<th>V</th>
<th>V</th>
<th>C</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segmental representation</td>
<td>l</td>
<td>i</td>
<td>n</td>
<td>g</td>
<td>k</td>
<td>a</td>
<td>r</td>
<td>o</td>
</tr>
</tbody>
</table>

- **Note:** the example in (10) is only used for illustration and is not meant as a concrete proposal regarding phonological architecture. The CV tier may be replaced or supplemented with other supra-segmental representations that include syllables, moras, etc.

- **Assumption:** in the toy example, the stress component has access to the skeletal CV tier but not to segmental representations.²

- The assumption separates possible statements in the stress component from impossible statements.

- A few examples (stated informally in grid-theory terms):

  (11) Some possible statements in the stress component (no reference to segmental content):
  - Every vowel projects an asterisk to line 0
  - The leftmost vowel projects an asterisk to line 2

  (12) Some impossible statements in the stress component (make reference to segmental content):
  - Every **low** vowel projects an asterisk to line 0
  - Every vowel followed by a **flap** projects an asterisk to line 1

- **Result:** if stress is conditioned on some phonological distinction, this distinction must be represented at some supra-segmental level.

### 2.2 Late projection of empty vowels

- In section 3, we will see stress patterns in which stress skips reduced vowels like schwa. A simple example:

  (13) In French, stress is final, unless the final vowel is a **schwa**, in which case stress is penultimate.

- **Note:** the statement in (13) makes reference to vowel quality (schwa), a direct counterexample to the universal.

²I ignore the visibility status of association lines.
This section introduces a mechanism (proposed elsewhere in the literature) that allows us to encode the distinction between reduced and full vowels at the interface and avoid reference to vowel quality.

- Vowels like schwa are often taken to be minimally specified: they are specified only as [-consonantal] and have no other features (Anderson, 1982; van Oostendorp, 1998, among others).

- **Empty vowel**: a vowel specified only as [-consonantal].

- In a given language, empty vowels may be invisible to some but not all processes (Kager, 1990; McCarthy and Cohn, 1998).

- **Kager’s (1990) late-projection analysis of Dutch schwa**[^1]

  - Properties of Dutch schwa:
    - *Invisible* to some syllable-sensitive processes and phonotactic restrictions:
      1. Skipped by stress.
      2. /h/, /ɛx/, and /diphthong+iy/: OK syllable-finally, before schwa; *OK before full vowels.
      3. Consonant clusters undergo epenthesis: syllable-finally, before schwa; not before full vowels.
      4. /sp/ metathesis (in some dialects): syllable-finally, before schwa; not before full vowels.
      5. ...
    - *Visible* to syllable-final devoicing (devoicing does not apply before vowels, including schwa)

  - Schwa epenthesis is insufficient: the distribution of schwa is not entirely predictable.

  - Kager’s analysis:
    1. Initially, schwa does not head a syllable (not connected to a mora)
    2. Schwa-insensitive processes and restrictions apply
    3. Schwa gets to head a syllable (gets connected to a mora)
    4. Final devoicing applies

- **Late projection of empty vowels**

  Empty vowels do not have to project at the beginning of the derivation. They may project late using the following projection rule:

  ![Projection Rule]

  - **Note**: the distinction between empty and non-empty vowels is represented at the interface as the presence vs. absence of a V-slot.

[^1]: See van Oostendorp (1997) for an alternative to Kager’s analysis of Dutch and a re-interpretation of some of the generalizations.
3 Sonority-driven stress

- Sonority-driven stress patterns are potential direct counterexamples to the stress-encapsulation universal.

- Types of reported sonority-driven stress systems (source: Gordon, 2006)\(^4\):
  - **Type I**: Distinction between full and reduced vowels; stress skips reduced vowels (20/28)
  - **Type II**: Low vowel attracts stress (5/28)
  - **Type III**: Fine-grained sonority hierarchy based on vowel height or peripherality; stress falls on the most sonorous vowel within some domain (3/28)

- Some of these cases have already been challenged and claimed not to be sonority-driven:
  - Hargus (2001) on Sahaptin and Witsuwit’en (Type I): distinction between full and reduced vowels reducible to a distinction of length.
  - Blumenfeld (2006) on Kara (Type II): low vowel attracting stress can be analyzed as bimoraic (quality-sensitivity reduces to length).
  - Shih (2015) on Gujarati (Type II): low vowels claimed to attract stress do not correlate with stress-related phonetics.
  - De Lacy (2013) on Chukchi (Type III): insufficient evidence based on conflicting sources.

- **Claim**: all cases of sonority-driven stress are not real counterexamples and can be accommodated in a modular architecture:
  - **Type I**: Interface invisibility: reduced vowels are epenthetic vowels or empty vowels that project after stress assignment.
  - **Type II**: (If it exists) Low vowels are long: they occupy two skeletal slots or bear two moras.
  - **Type III**: Impossible in a modular architecture. I will claim that there is no good evidence for such cases.

4 Re-analyses of sonority-driven stress systems

4.1 A re-analysis of Mari stress

- Type I: Distinction between full and reduced vowels, stress often skips reduced vowels.
- Reasons to look at Mari:
  - A challenging case: no one-to-one correspondence between schwas and vowels skipped by stress (some full vowels are skipped, and some schwas are stressed).
  - Reliable generalizations: claims are supported by rich data, controlled for lexical category, morphosyntactic environment, etc.

- **Note**: all monomorphemic examples to follow are of underived nouns.

\(^4\)The only exception I know of is Pirahã. Everett (1988) claims that it has onset-sensitive stress where voiceless onsets are more sonorous than voiced onsets. See Iacoponi (2013) for a critical evaluation of Everett’s generalization.
4.1.1 Monomorphemic words

- In monomorphemic words, stress generally falls on the rightmost full vowel – the rightmost vowel that is not a schwa ([ə]).

  (14) a. korgá
  b. séræf
  c. jōŋæs
  d. pariŋa

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

  (15) a. pörjö (alternant: pörjø-la)
  b. jöjo (alternant: jöjø-la)

- When every vowel in a word is a schwa, stress is initial:\(^5\)

  (16) bénær

- A simple analysis that would not work: schwa is epenthetic. Impossible to state a general schwa epenthesis rule:

  (17) a. kučém vs. ürémæ
  b. merñæ vs. paréŋa

- The basis of a modular analysis, using late projection:

  - Schwas project after rightmost stress assignment, before default initial stress is assigned.

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

- Assumptions about the lexicon:
  - Schwas do not project a V-slot.
- Rules:
  1. If no vowel is stressed, stress the rightmost vowel.
  2. Schwa rules:
     (a) Late projection: associate every schwa with a new V-slot.
     (b) Vowel harmony
  3. If no vowel is stressed, stress the leftmost vowel.

Sample derivations:

(19) Derivation of [paréŋa]

\(^5\)According to Vaysman, stressed initial vowels exhibit the same phonetic characteristics as other stressed vowels.
4.1.2 Multimorphemic words

- To demonstrate the distribution of stress in suffixed words, we consider two suffixes, -lan (dative case) and -ge (comitative case).

- When the root only contains full vowels, stress in the suffixed form is root-final:

  (22) a. paʃá, paʃá-lan  
b. paʃá, paʃá-ge

- When the root has only schwas, stress falls on the suffix:

  (23) a. rəwɔz, rəwɔz-lán  
b. rəwɔz, rəwɔz-ɡé

- When the root has non-final stress, the two suffixes behave differently: -lan attracts stress from the root, but -ge does not, keeping stress on its pre-suffix position.

  (24) a. sərəʃ, sərəʃ-lán  
b. sərəʃ, sərəʃ-ge

- Vaysman: stress attraction is a general property of Mari suffixes with the vowel [a] (as opposed to suffixes with the vowel [e]).

- However, the number of suffixes is very small. Vaysman mentions 4 suffixes with [a] and 3 suffixes with [e], and it is plausible that this distinction is lexically encoded.

- 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.
A fragment of Mari grammar (final)

- Assumptions about the lexicon:
  - Schwas do not project a V-slot.
  - The suffix -lan bears lexical stress.
  - The suffix -ge does not bear lexical stress.

- Cyclic rules:
  1. If no vowel is stressed, stress the rightmost vowel.

- Post-cyclic rules:
  2. Schwa rules:
     (a) Late projection: associate every schwa with a new V-slot.
     (b) Vowel harmony
  3. If there are two consecutive stressed vowels, destress the rightmost vowel.
  4. If there are two stressed vowels, destress the leftmost vowel.
  5. If no vowel is stressed, stress the leftmost vowel.

Sample derivations ([@] indicates that the vowel does not project a V-slot)

<table>
<thead>
<tr>
<th>Word</th>
<th>[pañá-lán]</th>
<th>[rawoz]</th>
<th>[rawoz-lán]</th>
<th>[rawoz-ge]</th>
<th>[séróf-lán]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final stress</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Final stress</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>r [ɔ]w [ɔ]z-ge</td>
<td>-</td>
</tr>
<tr>
<td>Schwa rules</td>
<td>-</td>
<td>rawoz</td>
<td>rawoz-lán</td>
<td>rawoz-ge</td>
<td>séróf-lán</td>
</tr>
<tr>
<td>Post-stress de-stressing</td>
<td>pañá-lán</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pre-stress de-stressing</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>séróf-lán</td>
</tr>
<tr>
<td>Initial stress</td>
<td>-</td>
<td>rawoz</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Output</td>
<td>[pañá-lán]</td>
<td>[rawoz]</td>
<td>[rawoz-lán]</td>
<td>[rawoz-ge]</td>
<td>[séróf-lán]</td>
</tr>
</tbody>
</table>

Conclusion: Mari stress does not require reference to vowel quality.

A re-analysis of Kobon stress

  "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:"

\[
\begin{align*}
\text{a/au/ai} &> \text{o/e/u/i} > \text{o/i}
\end{align*}
\]

- Kenstowicz’s (1997) hypothesis:

\[
\begin{align*}
\text{Stress falls on the more sonorous vowel among the final two vowels.}
\end{align*}
\]

(29) Vowels that differ in their sonority level:

| a > e | hagápe | ‘blood’ [226] |
| a > o | gále*gále | ‘to cry, of pig’ [225] |
| a > i | alágo | ‘snake species’ [226] |
| a > i | kidolmán | ‘arrow type’ [226] |
| a > i | ki.i | ‘tree species’ [220] |
| a > u | háu.i | ‘vine species’ [221] |
| a > i | ái.ud | ‘story’ [221] |
| a > i | ánín*ánín | ‘to lightening’ [225] |
| a > o | wái.oN | ‘cassowary’ [221] |
| o > u | án.án | ‘witch’ [221] |
| o > i | mó.u | ‘thus’ [220] |
| o > i | si.óg | ‘bird species’ [221] |
| i > o | gári*girá | ‘to “talk” - of mother pig to piglet’ [225] |
| i > e | galínaN | ‘bird species’ [226] |
| u > e | wi.o | ‘mango tree’ [221] |
| u > i | sud | ‘horizontal house timbers’ [221] |
| o > i | mú.is | ‘edible fungus species’ [221] |
| o > i | gisó*gisó | ‘to tap’ [225]. |

(30) Vowels of equal sonority (penultimate stress):

| u = u | dúbü*dúbü | ‘to make noise by footsteps’ [225] |
| i = u | jínü*pjínup | ‘to make squeaking noise, bird, rat’ [225] |
| i = i | kijígá | ‘tattoo’ [226]. |

Davies (1980) disagrees with the stress generalization in Davies (1981):

“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.”

To compare the two generalizations, I have re-organized the data from both sources according to lexical category, morphosyntactic environment, and syllable structure. (Davies’ 1980 includes around 500 examples marked for stress, Davies 1981 includes around 50 examples).

A challenge to both generalizations: near-minimal pairs differing in stress ([a] stands for a lower realization of [ɔ])

(31) a. φοναμ ‘wind’ [33]
    b. φονάν ‘sweet potato sp.’ [33]
Stress encapsulation and modularity

Ezer Rasin, NAPhC9

(32)  a. amβaŋ 'platform' [34]
    b. ámbaŋ 'a river name’ [34]

• A challenge to the penultimate-stress hypothesis: many examples with a final stressed syllable that has a diphthong or a complex coda: [akxáí], [sióŋkʰ].

• A revised penultimate-stress hypothesis (based on an examination of the entire data):
  – Stress falls on the final syllable if it is heavy (has a diphthong or a complex coda)
  – Otherwise, stress is penultimate
  – Stress skips [i]

• Distinguishing between the two hypotheses:
  – Final light syllable with a vowel that is more sonorous than the penultimate vowel:
    * Examples: kidolmán, jian
    * Sonority hierarchy predicts: final stress
    * Penultimate-stress hypothesis predicts: penultimate stress
  – Final heavy syllable with a vowel that is not more sonorous than the penultimate vowel:
    * Example: rálempʰ
    * Sonority hierarchy predicts: penultimate stress
    * Penultimate-stress hypothesis predicts: final stress

• **Result:** the two hypotheses are nearly equally successful.
  – Examples supporting the sonority hierarchy:⁶ kidolmán, uréf, wulamé, haŋŋaŋán, báwunt, rálempʰ, wáimant (7)
  – Examples supporting penultimate stress:
    jian, múmon, rónni, kie, wüse, múmor (6)

• Note: despite the very different predictions that the two hypotheses make, there aren’t many distinguishing examples (13/550). The reason seems to be 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).

• **Conclusion:** no clear evidence for sonority-driven stress in Kobon.

5 Discussion

• **The stress-encapsulation universal:** has it been established?
  – We started out with around 30 reported cases of sonority-driven stress as potential counterexamples.

⁶I have omitted the following examples that appear in Kenstowicz’s paper as support for the sonority hierarchy: [kiáí], because it has penultimate stress in Davies (1980); [sióŋ], because its surface form is actually reported to be [sióŋkʰ], which is a heavy syllable.
A general recipe for re-analyzing the majority of cases (late projection for Type I; vowel length for Type II, if it exists).

Two remaining Type III systems (Asheninca, Nanti) are discussed in Appendix A. No alternative accounts of the facts, but some methodological concerns are raised.

**Conclusion**: the distribution of stress is never conditioned on segmental features, up to two potential counterexamples.

- **General predictions of a modular architecture**: the interface determines the range of possible stress-segmental interactions.
  - A CV tier allows segmental features to affect stress indirectly through, e.g., length.
    
    $$\text{Segmental feature} \rightarrow \text{vowel length} \rightarrow \text{stress}$$
    
    Ancient Greek: nasality $\rightarrow$ compensatory lengthening $\rightarrow$ stress
  
  - A CV tier is not enough:
    
    $$\text{Segmental feature} \rightarrow \text{syllable structure} \rightarrow \text{stress}$$
    
    Latin: \([\text{volúptas}]\) (non-liquid) vs. \([\text{vólúkrís}]\) (liquid)

- **Open questions for a modular architecture**:
  - How do interface representations look like?
  - How do they restrict the range of possible stress-segmental interactions?

- **Prediction regarding vowel invisibility to stress**:
  - If late projection is restricted to the empty vowel (which is unique, by definition), it makes a prediction regarding invisibility to stress:
    
    $$\text{Prediction}: \text{all vowels that are invisible to stress must be either epenthetic or (underlyingly) empty}.$$

  - Mari: surface distinct vowels that are skipped for stress are underlying schwas.

  
  $$\text{(36) } \text{a. } \text{séəʃf}$$
  
  $$\text{b. } \text{pórʃfó (alternant: pórʃfó-ló)}$$

  $$\text{(37) Vowel harmony: } \text{ə} \rightarrow \tilde{\text{o}}$$

A Remaining reported cases of Type III sonority-driven stress

- **Asheninca** (Payne, 1990): tendencies to omit secondary stress obligatorily or optionally depending on vowel quality. For example:

  - A Cı syllable obligatorily loses stress before a heavy CVV syllable:

    $$\text{(38) } \text{kaŋti.mái.ta.cya}$$

    (no expected secondary stress)

  - A Ca syllable optionally loses stress before a heavy CVV syllable:

    $$\text{(39) } \text{kaŋti.mái.ta.cya}$$


\footnote{Leaving aside other options, like underlying glides undergoing vocalization or individual extrametrical suffixes.}
Some methodological concerns:

- Does “optional” mean that multiple examples were found in some body of data, or that speakers generally accept both stressed and unstressed versions of the relevant syllables? If it is the first option, could it be that Ci syllables also lose stress optionally but we simply haven’t yet encountered any examples where they are stressed? If the answer is yes, then Ci and Ca syllables would not be different and reference to vowel quality would not be needed.

- Do the data come from a single speaker or from multiple speakers? If it is the second option, is it possible that some speakers omit stress obligatorily from every CV syllable (kaN.ti.mai.ta.cya, a.ti.ri.pa.yée.ni) and some never omit stress (a.ti.ri.pà.yée.ni)? If the answer is yes, then no individual grammar would have a stress pattern that requires reference to vowel quality.


(40) Foot-level stress

\[
\begin{array}{ccccccc}
\text{Caa} & \text{CeeN, CeI N} \\
\text{CaVN} & \text{CoN, CoI N} & \text{CiI N} & \text{CaV} & \text{Coo, CoI} & \text{Ci} & \text{CiI} \\
\text{CuI I N} & \text{CeN} & \text{CaN} & \text{CoN} & \text{CiN} & \text{Ca} & \text{Co} & \text{Ci} & \text{Cui} & \text{CuI}
\end{array}
\]

- General concern: examples are not controlled for morphosyntactic or phonological environment. Most examples with unexpected stress might involve vowel deletion or potential stress-attracting affixes.

- Unexpected trochaic stress:

  (41) a. (i.tì).mi.mò.tá.kse.na 'he lived with me'
  b. (ò.tì).mi.mò.tá.kse.na 'she lived with me'

  Concern: is it the [3rd.feminine] affix that affects stress?

  (42) (nà.pe).fì.go.pi rê.já.kse 'I rested'

  Concern: we know that the [1st.sg] affix is /no-/ and that a vowel is deleted before a following vowel, suggesting underlying /no-a.../. Could the deleted vowel affect stress?

  (43) (nò.fì).pò.kà.kse.ro 'I doused it (a fire)'

  Concern: we know that one causative affix in Nanti is /-o-/, that it goes right after the subject agreement marker, and, again, that a vowel is deleted before a following vowel, suggesting underlying /no-o.../. Could the deleted vowel affect stress?
References


